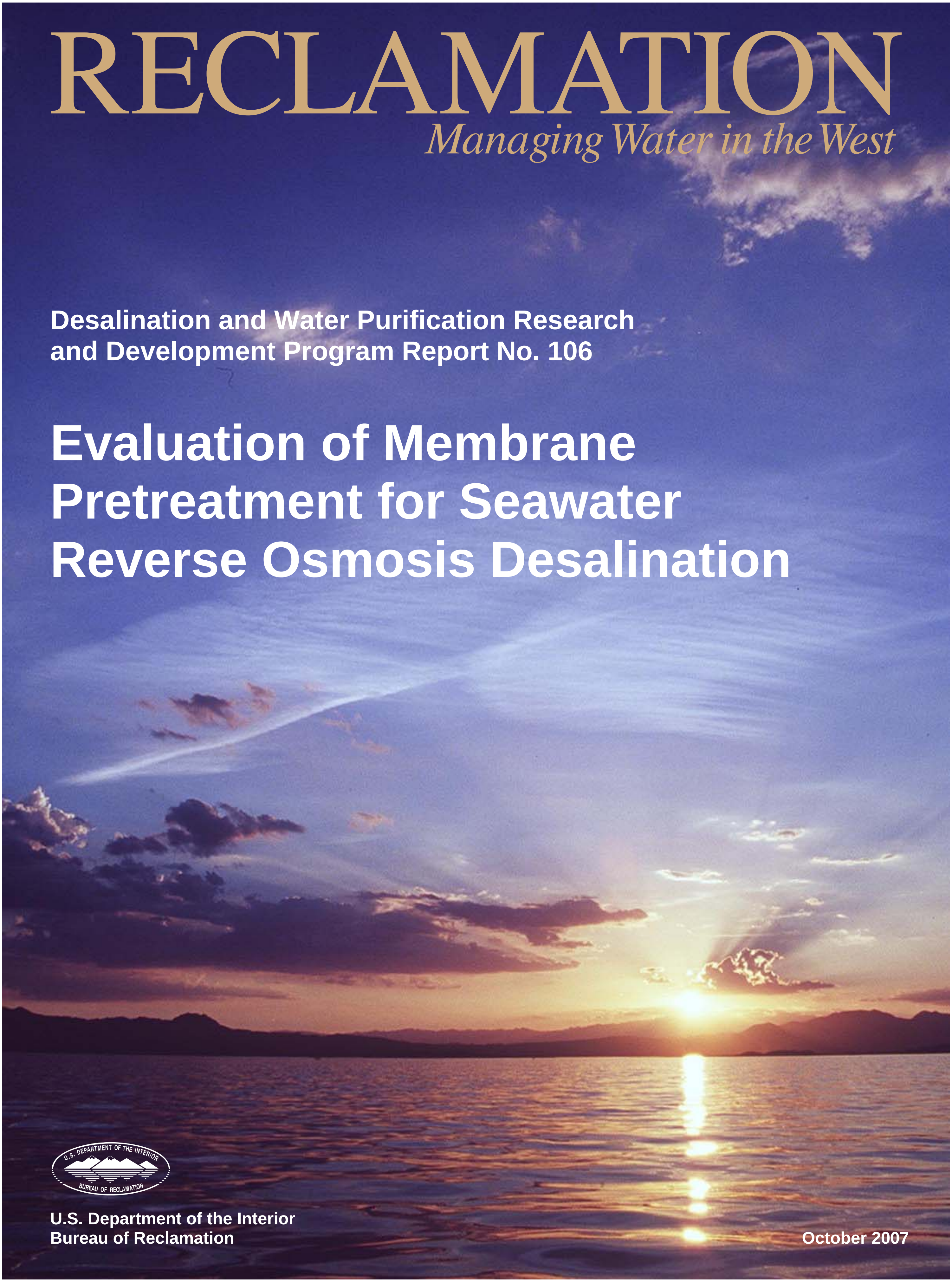

RECLAMATION

Managing Water in the West

Desalination and Water Purification Research and Development Program Report No. 106

Evaluation of Membrane Pretreatment for Seawater Reverse Osmosis Desalination

U.S. Department of the Interior
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31036 Tanoa Road
Evergreen, CO 80439

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This project was undertaken to better understand the technical and cost implications of the use of membrane filtration as pretreatment for seawater reverse osmosis (RO). The pilot study was conducted using raw feedwater from the Corpus Christi Bay in Texas, at the San Patricio Municipal Water District facility. The pilot study consisted of a side-by-side comparison of membrane filtration and conventional filtration, both followed by separate RO pilot systems, testing over an approximate 1-year period. The results indicate that membrane filtration produced far superior water quality for pretreatment, measured by reduced turbidity and by the silt density index (SDI). The resulting impact on the RO performance was a significantly lower RO cleaning frequency. The economic evaluation indicates that on a life-cycle cost analysis, the total water cost (TWC) for a plant using membrane filtration is 4-8% less than a plant using media filtration.

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Evaluation of Membrane Pretreatment for Seawater Reverse Osmosis Desalination

Prepared for Reclamation Under Agreement No. 01-FC-81-0735

By

Lisa Henthorne
Aqua Resources International

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Environmental Resources Division
Water Treatment Engineering and Research Group
Denver, Colorado

October 2007

MISSION STATEMENTS

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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The author, on behalf of Aqua Resources International (ARI), wishes to acknowledge the Desalination and Water Purification Research and Development Program, Bureau of Reclamation (Reclamation) for funding this project. Specifically, Mr. Frank Leitz of Reclamation was valuable throughout the project for technical advice.

The author also wishes to acknowledge the entire staff of the San Patricio Municipal Water District (SPMWD) for their considerable contribution to the project. Without their constant involvement in the project in terms of a site provision, operations and maintenance, data collection, water quality analyses, and day-to-day troubleshooting, the project could not have existed or succeeded. Specifically, I would like to acknowledge the management staff, Mr. Jim Naismith, P.E. and Mr. Don Roach, for their vision to undertake a project of this magnitude. Mr. Ryan Quigley was the lead for the project for San Patricio, and his unfailing dedication to the pilot for its day-to-day operations, frequent troubleshooting, data collection and overall tenacity was the key to the success and implementation of this project. The author is very grateful for all his efforts over these two years. Other SPMWD staff who played an integral role in the project include:

John Herrera
Jake Krumnow
Robert Edwards

Contribution from the membrane manufacturer's representatives was also very important to this project. These individuals were contributors in various roles from ensuring the equipment got onsite, to starting up the unit and evaluating their respective data. Note that some individuals are no longer affiliated with the specific companies listed, but this listing provides their affiliation at the time of their contribution to the project.

Dawn Guendert, USFilter Memcor
Lynn Gulizia, Toray Membrane America
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Finally, the author would like to thank the other key staff to the project. Dr. Steve Duranceau of Boyle Engineering provided quality assurance/quality control to the project and was tireless in his review of the final report. Advanced Membrane Systems (AMS) constructed the RO pilot and media filtration pilot, and Mark Thompson and Chip Harris of AMS provided expert pilot knowledge throughout the study. The author would also like to acknowledge the contribution of her ARI partner, Eric Jankel, for ensuring this project was a success through his consistent encouragement and sage advice.

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Abbreviations

AMS	Advanced Membrane Systems
AOC	assimilable organic carbon
ARI	Aqua Resources International
AWWA	American Water Works Association
CEB	chemically enhanced backwash
DABCO	diazabicyclo-octane
EFS	epifluorescence spectroscopy
$FeCl_3$	ferric chloride
ft	feet
gfd	gallons per square foot per day
gal/day	gallons per day
gfd	gallons per square foot of membrane per day
gpm	gallons per minute
gpm/ft^2	gallons per minute per square foot
HMI	human machine interface
HPC	heterotrophic plant count
km	kilometer
L/min	liters per minute
Lmh	liters per square meter per hour
m	meters
m^3/day	cubic meters per day
m^3/hr	cubic meters per hour
MF	microfiltration
Mgd	million gallons per day
mg/L	milligrams per liter
NTU	nephelometric turbidity unit
ORP	oxidation reduction potential
PLC	programmable logic control
QA/QC	quality assurance/quality control
Reclamation	Bureau of Reclamation
RO	reverse osmosis
SBS	sodium bisulfite
SDI	silt density index
SPMWD	San Patricio Municipal Water District
SWRO	seawater reverse osmosis
TOC	total organic carbon
TWC	total water cost
UF	ultrafiltration

Glossary

Assimilable Organic Carbon (AOC) – The portion of dissolved organic carbon that is easily used by microbes as a nutrient source.

Chemically Enhanced Backwash (CEB) – A backwash cycle generally utilized for membrane filtration in which chemicals such as acid or hypochlorite are added to the backwash water to enhance the removal of filtered material on the membrane surface.

Concentrate – One of the two output streams from the reverse osmosis process that has a more concentrated water quality than the feed stream.

Conventional or Media Filtration – A treatment consisting of coagulant addition followed by single or dual stage media filtration. The media filtration is generally a combination of sand, anthracite, and sometimes garnet.

Epifluorescence Spectroscopy (EFS) – An analytical technique to evaluate the bacteria population of a sample, counts per milliliter.

Feed or Feedwater – Input stream to the membrane process after pretreatment.

Flux – Volume (liters per square meter per hour [Lmh] or gallons per square foot of membrane per day [gfd]) rate of transfer through the membrane surface.

Fouling – Condition caused when natural organic matter, bacterial growth, colloidal, or particulate material form a deposit on the membrane surface.

Membrane Element – A single membrane unit containing a bound group of membrane sheets spirally wound to provide a nominal surface area for treatment.

Membrane Filtration – Filtration utilizing membrane technology with pore size ranging from approximately 0.01 (ultrafiltration) to 0.1 (microfiltration) microns. Membrane filtration can either be pressured within a pressure vessel or submerged in a tank.

Permeate – The membrane output stream that has convected through the membrane, the product water

Pressure Vessel – A single tube or housing that contains several membrane elements in series.

Productivity – The efficiency with which a membrane system produces permeate over time.

Recovery – The ratio of permeate flow to feed flow.

Rejection (mass) – The mass of a specific solute entering a membrane system that does not pass through the membrane.

Scaling – The precipitation of solids into the membrane surface due to solute concentrations on the concentrate side of the membrane exceeding solubility and precipitating onto membrane surface.

Silt Density Index (SDI) – Method to evaluate the potential fouling potential of pretreated water for reverse osmosis applications. Usually measured at 15 minutes.

Sodium bisulfite (SBS) – A reducing agent, $NaHSO_3$, used to dechlorinate water prior to RO membranes in order to prevent oxidation of the membrane polymer.

Total Organic Carbon (TOC) – A measure of the organic matter in water in terms of the organic content.

1. Executive Summary

The competitive pricing for seawater desalination, as demonstrated by the Tampa Bay Water, Florida, and Ashkelon, Israel, projects, has now made many coastal communities re-examine the possibility of augmenting their water supply from the sea. One of the most significant factors in successfully (and cost effectively) operating a reverse osmosis (RO) desalination plant is the ability of the pretreatment system to consistently produce well-filtered and relatively microbe-free water for feed to the RO system.

With the advent of microfiltration (MF) and ultrafiltration (UF) membranes (membrane filtration), the concept of utilizing these low-pressure filtration membranes for pretreatment has intrigued desalination plant developers and engineers recently. The potential benefits offered by membrane pretreatment compared to conventional pretreatments are significant:

- Improved pretreated water quality, in terms of lower suspended solids and less biological content, resulting in improved RO operation
- Fewer RO membrane cleanings with resulting cost savings in cleaning chemicals
- Lower RO pressure drops from fouling, resulting in lower energy costs
- Longer RO membrane life associated with long-term improved pretreated water quality
- Increased flux rates in the RO system due to higher quality pretreatment, though a trade-off exists with the resulting higher power requirements
- Smaller plant footprint size resulting in reduced capital investment
- Lower overall chemical and sludge handling costs if conventional technologies included lime softening or other chemically intensive conventional pretreatments
- Reduced environment impact due to reduced chemical disposal requirements

In order to more fully understand and compare the cost and performance differences between conventional pretreatment and membrane filtration pretreatment for seawater desalination processes, a study was funded by the Desalination and Water Purification Research and Development Program, Bureau of Reclamation (Reclamation). This document reports the results and findings of the study.

The principal purposes of this project are:

- To evaluate the performance of membrane pretreatment versus conventional pretreatment for seawater reverse osmosis (SWRO) desalination, in terms of improved pretreated water quality and impact on RO performance, and
- To determine the subsequent cost benefits of membrane pretreatment compared to conventional pretreatment options, through establishment of an objective life-cycle cost comparison.

In this study, several different membrane filtration technologies and conventional media filtration were evaluated at the pilot-scale as pretreatment to seawater RO. The project was implemented at the San Patricio Municipal Water District (SPMWD) water treatment facility near Corpus Christi, Texas. The feedwater to the pilot plant was seawater taken from the nearby Corpus Christi Bay, which is located in the northwestern area of the Gulf of Mexico.

The project was accomplished through two phases of piloting. The initial phase involved optimization of the membrane filtration and conventional pretreatment system. The second phase of experimentation utilized the optimized membrane filtration and conventional pretreatment systems providing pretreated feedwater for the SWRO.

The results indicate that the membrane filtration pretreatment provided superior water quality, and was able to do so during significant feedwater upsets due to weather and tidal events. The membrane filtration units were able to consistently achieve salt density index (SDI) values less than 3, while over 60 percent (%) of the conventional pretreatment unit SDI values were over 4 and none were less than 3. Additionally, RO cleaning frequencies were reduced by approximately 400% for membrane filtration pretreatment compared to conventional pretreatment.

An economic analysis evaluation included six different cost scenarios for varying RO flux rate, alternative pretreatment (membrane filtration versus conventional media), and plant capacity.

For the RO flux cases most representative of the design of RO systems using an open intake (13.6 liters per square meter per hour [Lmh], 8 gallons per square foot of membrane per day [gfd]), a cost difference between membrane and media filtration pretreatment was recognized. In this comparison, membrane filtration is approximately 8% less expensive than media filtration on a total water cost (TWC) basis.

2. Background and Introduction

2.1 Background and Literature Sources

The competitive pricing for seawater desalination, as demonstrated by the privatized Tampa Bay Water, Florida, Ashkelon, Israel, and Singapore projects, has now made many coastal communities re-examine the possibility of augmenting their water supply from the sea. Communities in California, Texas, and Florida are presently evaluating seawater desalination and are in various stages of planning and development toward this end. Indeed, it has been the dream of many inventors throughout history to cost-effectively produce potable water from seawater.

One of the most significant factors in successfully (and cost-effectively) operating a reverse osmosis (RO) desalination plant is the ability of the pretreatment system to consistently produce well-filtered and relatively particle- and microbe-free water for feed to the RO system

Pretreatment is critical in RO applications because it directly impacts fouling of the RO membranes. Fouling of the RO membranes results in increased operating cost from increased cleaning demands, increased feed pressures, and reduced membrane life. Additionally, fouling can result in reduced permeate water quality and permeate quantity, thereby impacting production from the RO facility.

The principal fouling mechanisms of RO membranes can be summarized as follows:

- Scaling – Precipitation of inorganic salts on the membrane surface when the solubility of these salts is exceeded in the process of permeating low salinity product water across the membrane surface, resulting in a concentration of salts of the reject side of the membrane.
- Particle fouling – Accumulation of particles on the membrane surface not removed from the raw water during the filtration process in the pretreatment. Indicators of sufficient reduction of suspended solids and particles are turbidity values of less than 0.2 nephelometric turbidity unit (NTU) and silt density index SDI values of less than 3.
- Colloidal fouling – Deposition of metal oxides, soaps, detergents, proteins, silicates, organic matter, and clay creating a colloidal slime on the membrane surface.
- Biofouling – Buildup of a microbial community on the membrane surface including microbes and their byproducts, resulting in a slime layer.

Disinfection has historically been utilized to reduce biofouling, but mixed results have resulted utilizing disinfection as the means to control biogrowth (Winters, 1995)

- Organic fouling – Adsorption of organic matter, particularly humic and fulvic acids, on the membrane surface, generally experienced in raw waters with total organic carbon (TOC) concentrations above 3 milligrams per liter (mg/L).

There have been hundreds of studies conducted and guidance documents prepared on pretreatment issues, both nationally and internationally. A few of the fundamental documentations of these works include the following:

- "Membrane Fouling" in *Water Treatment Membrane Processes* (Ridgway, 1996)
- *The Desalting and Water Treatment Membrane Manual*, Chapter 6 (Bureau of Reclamation [Reclamation], 1998)
- Reverse Osmosis and Nanofiltration, Chapter 2 (American Water Works Association [AWWA], 1999)
- *Desalting Handbook for Planners* (Reclamation, 2003)
- *State-of-the-Art Techniques in RO, NF, and ED* (Cote, 1996)
- *Current and Future Trends in SWRO Pretreatment* (Rovel, 2002)

Historically, for surface water desalting applications, pretreatment has generally consisted of conventional treatment. Conventional treatment is defined as coagulant addition, media filtration, antiscalant addition/pH adjustment, chlorination/dechlorination, and cartridge filtration (see figure 3.1). Media filtration has been the workhorse of the pretreatment process, acting to remove the bulk of the suspended material from the raw water. Ground water treatment scenarios and seawater facilities utilizing beachwells have reduced pretreatment schemes, generally being able to eliminate the coagulation and media filtration steps, and often the disinfection.

The more recent literature references in this regard often suggest membrane filtration as the panacea for the RO community's pretreatment woes. It is presumed that enhanced particle and microbiological and limited organic removal, afforded by microfiltration or ultrafiltration, will greatly improve RO performance and, therefore, replace conventional media filtration. Cost is perhaps the major hurdle to the acceptance of membrane filtration over conventional pretreatment.

A number of studies and pilot tests have been conducted using membrane filtration integration with RO for water reuse and water reclamation applications (Law, 2003; Seah, 2003; Truby, 2003; Gagliardo et al., 2001; Won and Shields, 1999; Mills et al., 1999; Adham et al., 1999; Wilf and Alt, 1999; Gagliardo et al., 1999; Everest et al., 1999; Chalmers et al., 2000; Mourato et al., 2000). It appears that membrane filtration could now be considered the standard pretreatment in reuse applications, as larger construction projects that include membrane filtration are becoming commonplace.

Membrane filtration integration with RO has been applied for surface water treatment in recent applications as documented (Reiss, 2001; Green et al., 2000; Duranceau et al., 2000; Jacangelo et al., 1999; Kruithof et al., 1999), with very successful performance.

Pilot data are just recently available, documenting the benefits of membrane filtration to RO applications. For seawater applications, papers include Bonnelye, 2003; Mourato, 2003; Latorre, 2003; Pearce, 2003; Glueckstern, 2002; Genkin, 2002; Mansdorf et al., 2002; Messalem et al., 2002; Henthorne, 2003, 2003, 2002, 2002; Galloway, 2003, 2003; Harris, 2001; Truby, 2000; Bates et al., 2000; Bou-Hamad et al., 1999; Goto et al., 2003, 1999; Iwahori et al.; 1999; Alawadi et al., 1999; and Wilf, 2001. At the time this project was proposed, few cost and performance publications were available that documented the practical use of membrane filtration as pretreatment in seawater RO applications.

The benefits as described in these papers for membrane filtration as pretreatment for RO are described below:

- Improved pretreated water quality, in terms of lower suspended solids and less biological content, resulting in improved RO operation
- Fewer RO membrane cleanings with resulting cost savings in cleaning chemicals
- Lower RO pressure drops from fouling, resulting in lower energy costs
- Longer RO membrane life associated with long-term improved pretreated water quality
- Increased flux rates in the RO system due to higher quality pretreatment, resulting in reduction in size of the RO system with subsequent reduction in capital cost but must consider trade-off with increased energy consumption at higher RO flux rates
- Smaller plant footprint size resulting in reduced capital investment

- Lower overall chemical and sludge handling costs if conventional technologies include coagulation, clarifiers, filtration, or other chemically intensive conventional pretreatments
- Lower operator requirements due to complete automation
- Greater plant availability due to decreased downtime related to chemical cleanings
- Reduced environment impact due to reduced chemical disposal requirements

2.2 Project Purpose and Objectives

In order to more fully understand and compare the cost and performance differences between conventional pretreatment and membrane filtration pretreatment for seawater desalination processes, a study was funded by the Desalination and Water Purification Research and Development Program, Reclamation. This document reports the results and findings of the study.

2.2.1 Project Purpose

The principal purposes of this project are:

- To evaluate the performance of membrane pretreatment versus conventional pretreatment for seawater reverse osmosis desalination, in terms of improved pretreated water quality and impact on RO performance; and
- To determine the subsequent cost benefits of membrane pretreatment compared to conventional pretreatment options, through establishment of an objective life-cycle cost comparison.

2.2.2 Project Objectives

The specific project objectives include the following:

Objective 1: Compare differences in treated water quality between membrane pretreatment and conventional media pretreatment. Evaluate turbidity, SDI, and microbiological counts to ascertain the effectiveness and limitations of the two different pretreatment methods.

Objective 2: Based on pilot testing information and observations, evaluate and determine differences between membrane filtration and conventional pretreatment with regard to the overall operation and maintenance and performance of the RO system. Evaluate cleaning and maintenance requirements, pressure drops, permeate water quality, and other operation and maintenance differences.

Objective 3: Evaluate membrane filtration integrity over the term of the piloting test period to determine its ability to fully act as the disinfection barrier for the RO process. Monitor biological growth and assess fouling impacts in the RO system throughout the evaluation and compare it to the RO system operating on the conventional pretreatment system.

Objective 4: Using life-cycle economics, perform an objective cost comparison for desalination plants using membrane pretreatment and conventional pretreatment.

2.3 Project Team and Strategy

The project team was led by Aqua Resources International (ARI) in partnership with Advanced Membrane Systems (AMS), the San Patricio Municipal Water District (SPMWD), and Boyle Engineering Corporation (Boyle), whom provided quality assurance and quality control (QA/QC) services for the project. Microbiological sampling and analysis was provided by the Texas A&M University, Corpus Christi staff. The project was highly cost-shared through contributions from the microfiltration (MF)/ultrafiltration (UF) and RO membrane manufacturers, the SPMWD, and the principal project partners.

This pilot project was accomplished at the SPMWD facility near Ingleside, Texas, located approximately 32 kilometers (km) (20 miles) northeast of Corpus Christi, Texas. This facility was ideal for this particular pilot project because:

- The site has an available seawater source.
- The SPMWD operators are trained in membrane operations from their own 30,000-cubic-meters-per-day (m^3/day) (7.8-million-gallons-per-day [Mgd]) Pall MF plant.
- They have an abundance of piloting space within their facility.
- SPMWD was very dedicated to the project.

The project was accomplished through two phases of piloting. The initial phase involved optimization of the MF/UF and conventional pretreatment system. The second phase of experimentation brought the two RO trains into operation in combination with their respective membrane or conventional pretreatment. Throughout the testing period, data were collected to evaluate overall cost of operation, water quality production, pressure drops, cleaning requirements, attainable operating flux rates, chemical usage, and overall maintenance.

3. Summary Conclusions and Recommendations

The conclusions will be provided in direct response to each of the project objectives.

3.1 Objective 1 – Pretreated Water Quality Comparison

The intent of this objective was to compare and assess differences in treated water quality between membrane filtration and conventional pretreatment. Water quality that was evaluated included turbidity, silt density indices, and microbiologcal counts to ascertain a full comparison of the effectiveness and limitations of the two different pretreatment methods.

The membrane filtration pilots consistently produced 15-minute SDI values less than 3 and turbidity values less than 0.1 NTU. The conventional media filter at no time produced a 15-minute SDI value of 3 or less and produced an average turbidity of 1.9 NTU. It should be noted that the raw feedwater at the site was an extremely challenging variable feedwater with turbidity spikes over 100 NTU and an average turbidity of 9.9 NTU over the 15-month period during which turbidity data were collected.

The microbiological testing that was conducted early in the project life, prior to arrival of the conventional media filtration unit, indicated that there was only 1-log removal of marine bacteria from the membrane filtration pilots. This low removal is partially a result of the very small size of marine bacteria compared to freshwater bacteria, as well as the ability of the marine bacteria to "squeeze" through the membrane filter pores. Due to the high cost of the epifluorescence spectroscopy (EFS) analysis to obtain accurate marine bacterial counts, and the results indicating poor microbe removal, this analysis was not continued.

It should be noted that at no time during the piloting did we chlorinate the feedwater. Biofouling was not a significant issue throughout the piloting, and we attribute this largely to the low assimilable organic carbon (AOC) levels due to not chlorinating the total organic carbon in the feedwater.

3.2 Objective 2 – Impact of Pretreatment on RO Performance

The intent of Objective 2 was to understand the impact of the two different pretreatment water qualities on the performance of the downstream RO process. The RO pilots were intentionally operated at flux rates above the standard-of-care for open intake seawater reverse osmosis (SWRO) plants, due to the pilot design. It was reasoned that this level of operation created a 'worst case' evaluation as far as cleaning frequency and operation challenges were concerned. As a result, a sensitivity analysis of cleaning frequency was performed in the economic analysis. The conventional media pretreatment pilot was found to require a 6-week cleaning frequency, at a flux of approximately 21 Lmh (12.5 gfd), as dictated by a 10–15-percent (%) increase in pressure drop across the RO. The membrane filtration pretreatment RO unit did not require cleaning during the piloting, but 6 months was used as an estimate for the economic analysis as the best estimate for a plant of this type, complemented by the sensitivity analysis.

Recent literature evaluations indicate 6 weeks to be a good average for RO cleaning frequencies at plants using conventional media filters as pretreatment and using open intake seawater feed sources.

One of the more significant operational finding from the pilot study is the extreme caution that must be practiced in using membrane filtration for RO pretreatment when chlorinated backwashes are utilized as part of the membrane filtration process operation. Though we were well aware of the potential to oxidize and destroy the RO membranes, the initial set of RO membranes experienced a reduction in salt rejection to less than 97% from chlorine damage. Even with addition of increased rinse times after the chlorinated chemically enhanced backwash (CEB) and continual addition of 1–2 mg/L sodium bisulfite (SBS), a slight decrease in salt rejection occurred later in the RO pilot study over a prolonged operating period. In this case, we experienced a salt rejection reduction from 99.6 to 99.3%. In a full-scale plant, appropriate oxidation reduction potential (ORP) analyzers would be utilized to prevent this damage from occurring. Nonetheless, it is an important result that should be strongly taken into consideration for the design of any full-scale plant.

3.3 Objective 3 – Membrane Filtration as a Disinfection Barrier

It was initially anticipated that that membrane filtration could act as a disinfection barrier in a SWRO facility to remove biofouling-causing bacteria, due to the pore size of 0.01 to 0.1 micron for the range of UF to MF pores and their success in removing freshwater bacteria. The initial month of concentrated microbiological sampling using EFS analysis to obtain accurate marine bacterial counts indicated that only a 1-log removal (from 104 to 103) of marine bacteria was achievable using UF technology. Discussions with Professor Harvey Winters of Fairleigh Dickinson University, the United States' foremost expert on the microbiology of seawater with respect to SWRO, indicated these results were consistent to those he had witnessed in the Middle East. The marine bacteria are approximately 0.1 micron in size but have the ability to "squeeze" through much smaller diameters. Note that our testing used naturally occurring marine bacteria, and we did not spike the feedwater with additional bacteria populations. Also, this study utilized epifluorescence spectroscopy analysis to measure microbial counts. According to microbiologist specializing in seawater organisms, this is a far superior method to heterotrophic plant count (HPC) analysis for seawater microorganisms because it is able to measure the total count of species, not just the viable and reproducible species seen in HPC analysis. Through the treatment process, it is suspected that many non-viable species become active and reproducible; therefore, it is important that the appropriate method be used for analysis.

Further evaluation of this objective was abandoned due to the low removal of the marine bacteria by membrane filters, even in a fully new condition. That is, there was no reason to evaluate the integrity of the membranes to act as a disinfection barrier over time when it was not achievable when the membranes were new. However, the fact that membrane filtration can remove 1-log of small marine bacteria indicates that there was sufficient membrane integrity to remove larger particles, parasites, and pathogens of concern.

3.4 Objective 4 – Economic Analysis

The primary deliverable for this project is the economic analysis comparing membrane filtration to conventional media pretreatment for SWRO. The operating parameters for the economic analysis were largely taken from those determined from the pilot testing. The actual analysis utilized WTCost™ and membrane manufacturers' software, augmented by vendor quotes and the *Desalting Handbook for Planners* (Reclamation, 2003).

Sensitivity analyses were conducted for conventional media loading rates and RO membrane cleaning frequencies. Analyses were conducted at the pilot operating RO flux rate as well as more traditional RO flux rates for SWRO plants using open intakes. Six economic "cases," or scenarios, were evaluated in which the plant capacity, pretreatment type, and RO flux was varied for each.

The overall results of the economic analysis, shown in table 7.1, indicate that on a life-cycle cost basis, the use of membrane filtration was less expensive than media filtration for pretreatment, by 3–8% depending on the specific case. We believe cases 5 and 6 are most representative of facilities to be built in the near future, using RO flux rates of 13.5 Lmh (8 gfd) and plant capacities of 95,000 m^3/day (25 Mgd). In this comparison, the total water cost (TWC) for the facility using membrane filtration was $0.55 per cubic meter (/$m^3$) ($2.08 per 1,000 gallons [/1,000 gal]) compared to the facility using conventional media filtration at $0.59/$m^3$ ($2.24/1,000 gal). Capital cost was $85.6 million for the facility using membrane filtration compared to $84.1 million for a plant using conventional media. The operating cost was $13.4 million per year for the facility using membrane filtration compared to $15.1 million per year for a plant using conventional media.

The most significant cost differential is clearly the operating cost, which for cases 5 and 6 is most strongly a function of the cleaning frequency and chemical costs differential. The cleaning frequency sensitivity analysis indicated that if membrane filtration could reduce the cleaning frequency by just one cleaning per year (from nine to eight times per year), then membrane filtration resulted in the lowest TWC.

3.5 Recommendations

The results from this pilot study indicate that membrane filtration will produce a far superior pretreated water quality compared to conventional media filtration for pretreating open intake seawater of poor quality regarding suspended solids. This superior quality results in lower operating cost due to reduced RO cleaning frequencies and reduced chemical consumption, which results in an overall lower TWC. As a result, it is recommended that membrane filtration be used for SWRO pretreatment in all open intake applications except those treating raw seawater with exceptionally and consistently low turbidity (i.e., less than 1 NTU).

4. Pilot Test Siting, Variables, and Standard Procedures

4.1 Siting and Water Quality

The pilot testing was conducted at the San Patricio Municipal Water District facility, near Corpus Christi, Texas. The seawater source was the bay located approximately 2.4 km (1.5 miles) from the pilot site. A temporary intake structure was built for the pilot project, utilizing a 4-inch pipe extending approximately 185 meters (m) (200 yards) out into the bay. The intake was placed in approximately 1.2–1.5 m (4–5 feet) of water (depending on tides), and was suspended in a plastic drum about 0.7 m (2.5 feet) from the bottom of the bay floor.

The water was pumped from the intake though a 4-inch polyvinyl chloride below-ground line approximately 2.4 km (1.5 miles) to the pilot site. The permeate and concentrate from the pilot testing were recombined at the pilot site and pumped back to the bay for discharge through a 4-inch above-ground return line. Backwash from the pretreatment units, cleaning washes, and rinses was discharged to the SPMWD discharge reservoir that was permitted for such effluents.

The pilot testing was conducted in a large building within the San Patricio property that housed a conventional filtration plant. All pilot units and tanks were maintained inside this building with the exception of the Norit pilot unit which was housed in its own self-contained trailer located adjacent to the pilot site.

The initial sampling for water quality data for the seawater is shown in table 4.1. This sample was collected the week of February 18, 2002. The water quality throughout the pilot study was characterized by severe fluctuations primarily influenced by significant rain events and winds. Because the intake was located approximately 400 feet from a freshwater influence, heavy rains impacted the raw feedwater quality as experienced by reduced salinities and turbidity spikes over 100 NTU. High winds in the area created variable and sporadic increases in feedwater turbidity.

4.2 Testing Overview and Conditions

The pilot testing was conducted in two phases. Phase 1 consisted of operating the pretreatment systems to attempt to achieve optimum conditions for each system. Optimum operating conditions to be established for the pretreatment systems include flux, recovery, backwash frequency, and operating pressures/vacuum. The pretreatment systems originally planned for testing included:

- PT-1: Zenon Zeeweed 1000 UF unit
- PT-2: Norit X-flow UF unit
- PT-3: Hydranautics Hydracap UF unit
- PT-4: Memcor CMF-S unit
- PT-5: Conventional pretreatment consisting of:
  - ♦ Coagulant addition
  - ♦ Multimedia filtration

Phase 2 testing consisted of operating the two SWRO systems following the pretreatment systems. One SWRO system was fed from combined membrane filtration pretreated feedwater, the second system from conventionally pretreated feedwater.

During Phase 1, in addition to collecting performance data, the membrane integrity of the membrane filtration systems was monitored via sampling of the filtrate for microbial content, using EFS analyses and pressure testing. During Phase 2, data important to determining the overall operating and capital cost were collected for the combined pretreatment-SWRO systems for the economic analysis.

A general process flow diagram for the pilot plant is shown in figure 4.1.

4.3 Dependent and Independent Variables

The dependent variables for Phase 1 testing are provided in table 4.2. Table 4.3 lists the additional Phase 2 dependent variables (i.e., Phase I dependent variables were also monitored in Phase 2). Table 4.4 provides the independent variables for the two phases of work.

4.4 Data Sampling and Frequency

Table 4.5 lists the operation data collection schedule used for Phase 1, with the related laboratory analysis schedule shown in table 4.6.

Table 4.7 lists the operation data collection schedule for Phase 2, with the related laboratory analysis schedule shown in table 4.8. Note that these schedules were not always adhered to due to limited operator availability and cost associated with analysis.

4.5 Standard Sampling and Analytical Procedures

For laboratory analytical requirements for monitoring of water quality of each of the process streams, the *Standard Methods for the Examination of Water and Wastewater* (*Standard Methods*), 20th edition, 1998 was used. Use of either benchtop or online field analytical equipment was acceptable. These recommended standard procedures are listed in table 4.9 for inorganic, organic, and general parameters.

When required, sample preservation was done in accordance with *Standard Methods*. The sample ports were rinsed with 70% diluted bleach solution, followed by distilled water prior to any bacteriological sampling. The bacteriological sampling was conducted by Texas A&M, Corpus Christi Microbiological Department

4.6 Data Management

The purpose of data management is to establish a structure for the recording and compilation of data such that sufficient, reliable, and accurate data are collected. The Project Manager and Operations Manager were jointly responsible for data entry into computer spreadsheets for membrane analysis. The SPMWD operations staff recorded most of the operational data and provided it electronically to the Project Manager on a periodic basis. Data collected from the membrane filtration units were downloaded or logged directly by the manufacturers and provided electronically to the Project Manager.

The database for the project was set up in spreadsheets, which were capable of storing and manipulating the water quality and operational parameters from the specific tasks, including sample location and sample time. The appropriate data from the operations data sheets and laboratory analysis sheets were entered into the spreadsheets.

5. Pilot Equipment Description

5.1 Pilot Equipment

The pilot plant was composed of multiple pretreatment units and a skid containing two independent seawater RO systems—the first received water pretreated with membrane pretreatment and the second received conventionally pretreated seawater. In addition, due to operational difficulties resulting from heavy inlet sediment and grasses, a prefilter unit was installed to treat all raw water in January 2003. A number of prescreens were utilized unsuccessfully prior to implementation of the successful prefilter. Figures 5.1 through 5.7 illustrate the actual equipment onsite.

5.1.1 Prefilter Unit

The prefilter utilized was an Arkal Spin Klin unit with capacity of approximately 303 liters per minute (L/min) (80 gallons per minute [gpm]). The unit, as shown in figures 5.1 and 5.2, utilizes plastic disk technology. The units were manufactured by A2 Water in the United States for Arkal, an Israeli company, and utilized a Plexiglas disk housing so the prefiltering and backwashing could be viewed easily.

5.1.2 Pretreatment Systems

The pretreatment systems located onsite for testing include:

- PT-1: Zenon Zeeweed 1000 UF unit
- PT-2: Norit UF unit
- PT-3: Hydranautics Hydracap UF unit
- PT-4: Memcor CMF-S unit
- PT-5: Conventional pretreatment consisting of:
    - ♦ Ferric chloride addition
    - ♦ Multimedia filtration

The specific parameters and characteristics of each of the pilot units are provided in table 5.1.

The conventional media filtration unit consisted of two 0.914-m- (3-foot- [ft]) diameter filter beds containing sand, anthracite, and garnet, in equal volumes. Total bed height was approximately 1.2 m (4 ft). The two filter beds were operated in parallel, therefore operating as a single-stage filtration unit.

Each of the membrane filtration pilot units and conventional pretreatment was monitored individually throughout the piloting program. The filtrates from the membrane filtration units were mixed ahead of the transfer tank prior to introduction to the SWRO-1 train. A standard for inclusion in the RO feed was established at a filtrate SDI value of less than 3. This standard was established to ensure that the filtrate water quality from competing MF/UF units was not diminished by poor filtrate quality from one particular unit. Using this criteria, the SDI was maintained at less than 3 in the RO feedwater from the membrane filtration units for the duration of the piloting period.

Simultaneously, pretreated seawater from the conventional pretreatment was fed to the SWRO-2 train. The standard for filtrate water quality was an SDI less than 5. This standard was higher than the membrane filtration standard due to the inability of the conventional media unit to consistently produce low SDIs.

5.1.3 SWRO Systems

The combined flow rates for the two SWRO units was 125.4 m^3/day (33,120 gallons per day [gal/day]) of feedwater producing 43.9 m^3/day (11,600 gal/day) of permeate. Each unit was designed for 35% recovery as a conservative estimate but could operate in the 35–50% recovery range. Due to restrictions on discharge of chemicals, an approximate 35% recovery was maintained throughout the study. Figures 5.6 and 5.7 are photographs of the SWRO units.

Each SWRO unit was comprised of a raw water booster pump, a cartridge filtration system, a high-pressure pump, two three-element pressure vessels 4 inches in diameter, chemical feed tank and pumping, and instrumentation. The two units shared a common frame, permeate tank (for permeate flushing upon shutdown) and control system. Each unit had analog flow, pressure, and conductivity instrumentation reporting to a common programmable logic controller (PLC) with a graphic human machine interface (HMI). The major components are as follows:

- Two raw water pumps, model PD2HE-l, as manufactured by Sta-Rite
- Four single element cartridge filter vessels, polypropylene
- Two high-pressure pumps as manufactured by Cat Pumps
- Four fiberglass three-element pressure vessels, model 40-E-100, as manufactured by Pentair/Codeline
- Twelve 4-inch seawater elements
- Two chemical (SBS dosing) feed pumps with common day tank
- One 200-gallon permeate storage tank

- One framework of aluminum or fiberglass

- One control system with GE integrated PLC/HMI with graphic display and downloadable data-logger with modem

- Instrumentation including the following:

    - ♦ Four pressure transmitters
    - ♦ Two dual input flow transmitters with four flow elements
    - ♦ Two conductivity transmitters
    - ♦ Six pressure indicators, with three-way valving to access all points
    - ♦ Four pressure switches

The pilot unit did not include an energy recovery device due to the unavailability of units of this small capacity. The economic analysis included assumptions as to the energy recovery device efficiency and subsequent overall RO energy consumption.

6. Pilot Test Performance and Results

6.1 Phase 1 – Pretreatment Optimization

6.1.1 General Observations

The initial project concept involved optimizing the membrane filtration units onsite and choosing one unit for long-term operation during Phase 2.

Phase 1 was initiated in April 2002 when the first membrane filtration unit arrived onsite, the Norit X-flow UF pilot unit. In June 2002, a second membrane filtration unit was delivered onsite and consisted of Hydranautics Hydracap UF membranes. The operational data for these units are shown in figures 6.4 through 6.7.

The Norit membrane filtration unit was operated at low-to-medium flux rates (25–30 gfd) during much of Phase 1 due to insufficient raw water capacity to operate all the onsite filtration units simultaneously at higher flux rates.

The Zenon 1000 unit arrived in July 2002 just prior to the first significant rain event in the area. Throughout their startup and early operation, heavy sediment and grass entered the raw water tank, and the screening device on the Zenon unit was not equipped to handle these heavy loadings. A new strainer device was supplied by Zenon, but it was unable to meet the prefiltering demand.

Consequently, an in-line backwashable, cleaning, and grinding 400-micron strainer was acquired and installed for treatment of all the raw seawater after the raw water tank. Additional significant rain events between August and November 2002 created severe difficulties in maintaining operation of the intake pump. The pump required manual priming; and due to the rain events, the flooding, and high water, the operations staff was unable to reach the pump. Eventually, the intake pump failed, and a new (self-priming) intake pump was acquired and installed. Though this new intake pump worked significantly better than the original pump, the intake remained the Achilles' Heel of the entire project (i.e., you can only collect pilot data if you can get water to the pilot).

As a result of the delays due to the intake pump replacement and rain events, the Zenon ultrafiltration pilot plant equipment had to be returned due to other prior commitments. Consequently, no significant data were collected on the Zenon UF pilot unit.

The conventional media filtration pilot arrived onsite in August 2002, during the period of non-operation due to heavy rains as discussed above. In December 2002, the area received another "1-in-100-years flood" event. When the lead operator was able to reach the intake site, he found that the entire slope above the intake area that housed the pumping and electrical station had moved down the hillside approximately 10 feet. Figures 6.1 through 6.2 demonstrate the damage the intake site experienced as a result. Fortunately, the new pump was not damaged, but all the electrical lines and controls had to be replaced and moved to an area at the top of the hillside. The access area (wooden steps and walkway built for the project) were permanently damaged. Testing resumed in early January, once SPMWD regained operation.

In order to deal with excessive grass and sediment loadings, an inexpensive prefiltering device was investigated for use at the facility. As a result, in mid-January, an Arkal Spin Klin disk prefilter unit was supplied to the project at no cost by Arkal/A2 Water. Operations support for the project was provided by nearby A2 Water. This unit greatly enhanced the operability of the pilots, and no further difficulties were experienced in regard to prefiltration.

The conventional media filtration operation was optimized primarily based on its backwash demand and coagulant dosage. Jar testing was performed to determine optimum ferric chloride ($FeCl_3$) dosing. Raw water quality fluctuations made it difficult to utilize an optimum $FeCl_3$ every day. In the interest of the operator's available time, the project team decided to maintain a dosage at 6–7 mg/L $FeCl_3$ throughout the study as an average "optimal" dosage for the raw water quality during periods without turbidity upsets.

The raw seawater turbidity is depicted in figure 6.3 and averaged over 9.9 NTU during the 15-month testing period. SDI measurements were not possible on the raw seawater since the filter pad would clog within 5 minutes, such that a standard 15-minute SDI measurement could not be collected.

6.1.2 Pretreatment Water Quality and Performance

The operating performance of all the pretreatment units is provided in figures 6.4 through 6.8. SDI performance of membrane filtration and conventional filtration is shown in figure 6.9.

In terms of turbidity removal, figures 6.4 and 6.6 demonstrate that membrane filtration provides extremely high quality pretreated water on a consistent basis, in terms of turbidity removal. Filtrate turbidities from the membrane filtration pilot units were consistently less than 0.1 NTU, except for a few minor upsets and erroneous turbidity data points. Membrane filtration SDIs were found to be consistently less than 3, per figure 6.9. Note that after September 2002, the membrane filtration SDI measurements were taken as composites of the operating membrane filtration systems. This was a result of the stand-alone SDI unit feed pump impeller corroding and depositing a black organic deposit on the SDI filter pad in early September 2002, which was determined after membrane filtration SDIs repeatedly indicated erroneous readings of over 5. (Note that these four SDIs were excluded from the data represented in figure 6.9.) Once the malfunctioning SDI unit was determined to be the source of the erroneous readings, it was no longer used, and SDIs were taken directly from the RO unit, upstream of the cartridge filters.

Figure 6.8 depicts the turbidity of the conventional media filtrate. The turbidity data are based on grab samples, as an on-line turbidimeter was not available for the conventional pretreatment unit. The data indicate a considerable scatter in the filtrate turbidity, with an average of 1.9 NTU over the pilot period. The conventional media filter was also incapable of consistently providing pretreated water quality with low SDI values. Of the SDI measurements for the conventional media, 40% of the values were between 3–4; 27% were between 4–5, 27% were between 5–6, and 6% were 6 or above, respectively.

The operating performance for each of the units is described below.

The Hydranautics unit achieved flux rates of 102 Lmh (60 gfd) at recoveries of 90–92%. Their coagulant dosage was varied but optimized at 0.1–0.25 mg/L $FeCl_3$. The transmembrane pressure averaged 1.75–3.0 pounds per square inch. Sodium hypochlorite was used for cleaning/enhanced backwash, and an air backwash was implemented.

The Norit unit achieved flux rates up to 102 Lmh (60 gfd) but was optimized and ran long term at 85 Lmh (50 gfd). The Norit unit did not utilize coagulant during any operation and operated at 93–94% recovery. This pilot unit was onsite throughout the entire testing period. As a result, additional optimization was possible on the flux rate, backwash frequency, and cleaning requirements. Optimized operating conditions are as follows for this unit:

- Backwash every 30 minutes for 45 seconds
- Chemically enhanced backwash (CEB1): Every 3 hours for 700 seconds utilizing muriatic acid
- Chemically enhanced backwash (CEB2): Every 12 hours for 760 seconds utilizing 200 mg/L sodium hypochlorite. (Note the CEB2 replaces the CEB1 every 12 hours.)

Challenges presented by the membrane filtration unit included the hypochlorite CEB2. Originally, the rinse cycle after the CEB2 was not sufficient to ensure all the oxidant was removed from the piping. As a result, oxidation of the RO membranes occurred during the first month of RO operation. This is further discussed in section 6.2.1 but should be noted as one of the most significant issues associated with using membrane filtration as pretreatment to RO. Numerous other pilot studies in the United States and globally have had similar experiences (Filteau et al., 2004).

As a result of the resulting oxidation of the RO membranes, efforts were initiated to eliminate the CEB2. Within 48 hours, the Norit membranes were completely plugged and required an 8-hour hypochlorite soak to return them to their original condition.

The conventional media pilot unit operated with limited maintenance needs compared to the membrane filtration pilots. The unit operated at 96% recovery, only requiring backwash on the units once per day (Unit 1 at 12 hours, Unit 2 at 24 hours). The units operated at a filter loading of approximately 4.8 cubic meters per hour per square meter ($m^3/hr/m^2$) (2 gallons per minute per square foot [gpm/ft^2]), which is conservative for seawater filtration. Note that the economic analysis includes a sensitivity analysis to evaluate impact of the media filter loading rate on the economics.

Challenges from the conventional system were a result of our initial inadequate equipment such as a mixer (mixer installed after initial operation) for the ferric storage tank and the varying feedwater quality which constantly challenged our iron dosage.

Note that data are not provided for the Zenon 1000 unit or the Memcor CMS pilot unit. As indicated earlier, the Zenon unit arrived onsite shortly before the heavy rains and flooding shut down our testing due to inoperation of the intake pump. During the Zenon 1000 brief operating period, heavy grass and sediment in the feedwater was beyond the capability of the Hayward strainers (on the Zenon unit) to handle. These difficulties acted as a primary catalyst to installing a prefilter later in the year. Unfortunately, the Zenon unit was required on another pilot site prior to the prefilter installation and, as such, was removed before long-term testing commenced.

The Memcor unit was scheduled for arrival late in the pilot testing schedule, as we had only sufficient feedwater to allow the operation of two to three operating pretreatment pilots at any time. Due to the lengthy construction time for the Memcor unit and the eventual failing of our intake system to operate after being onsite for 15 months total, there was not sufficient overlap to begin operation of the Memcor unit.

6.1.3 Pretreatment Microbiological Removal Evaluation

Table 6.1 provides the results of the microbiological sampling performed for the project. It should be noted that at no time was the raw feedwater disinfected prior to any of the pretreatment units. This was purposeful as numerous studies have shown continuous chlorination/dechlorination to greatly increase RO biofouling. During the project, the intake pipeline was disinfected once, which was thoroughly rinsed prior to re-startup of the pilots.

Table 6.1 indicates that only a 1-log removal of marine bacteria was achieved by the membrane filtration systems. It was originally assumed that since the membrane filtration pore size is 0.01 to 0.1 micron in size, most of the bacteria in the raw seawater would be removed, thereby acting as a disinfection barrier. After evaluating the table 6.1 results followed by discussions with Professor Harvey Winters, we understood that marine bacteria were extremely small compared to freshwater bacteria, on the order of 0.1 micron. In addition, marine bacteria have the ability to transform their body shape to squeeze through smaller pores than their body diameter.

As a result, we recognized that membrane filtration systems could not act as an effective disinfection barrier for marine bacteria; and, hence, the microbiological sampling was discontinued. Though the RO pilots did not experience significant biofouling during their operation, it is thought to be a function of the lack of the continuous chlorination/dechlorination process which allowed the pilots to operate without biofouling problems. For the novice on biofouling, it is now believed that chlorination acts to "break up" non-assimilable organics in the feedwater into AOCs. Once dechlorination is implemented, the remaining bacteria have an abundant nutrient source by which to thrive on the RO membrane, creating significant biofouling.

6.1.4 Prefilter Performance

As discussed in section 5.1.2, a prefilter was installed on all the raw seawater feed in January 2004. The need for this unit stemmed from the continuous loading of grit, grasses, and small marine life that entered the raw water tank. Because the intake was temporary, trash racks and adequate screening could not be performed at the intake point.

The 130-micron prefilter operated at 9–11 cubic meters per hour (m^3/hr) (40–50 gpm) and had the ability to backwash at specific time intervals or controlled by ΔP across the prefilter. Normal operation of the unit was one backwash per day for 70 seconds at 13.6 m^3/hr (60 gpm), resulting in a 99.9% recovery. The unit operated by-and-large maintenance-free except for one incident when the feed pump was sprayed with water from adjacent equipment and required replacement. After the prefilter was installed, the pretreatment units no longer exhibited clogging from grasses and grit.

As a result of this pilot application, these prefilters are being evaluated in different pilots for overall benefit in seawater applications. Most notably, the units are being evaluated in front of MF/UF pretreatment systems for SWRO which utilize powerplant effluent as feedwater and which heat-treat as part of the regular maintenance in the powerplant condensers (Filteau et al., 2004). The heat treatments dislodge considerable shell material which can cut the MF/UF membrane.

6.2 Phase 2 – RO Operation

6.2.1 General Observations

During the Phase 1 operation, it was decided that the RO units would be placed in operation just to measure baseline RO performance. No optimization would be made during this period. As a result, RO operation was initiated in April 2002 with RO membranes provided by Koch Membrane Systems, using membrane pretreated feedwater to feed both RO trains, since the media filtration unit was not onsite yet.

One of the more significant project events occurred as a result of this decision. While the Norit and Hydranautics units were being operated and optimized, it slowly became clear that the permeate water quality from the RO units was very slowly diminishing. This data is shown in figure 6.10 and is most apparent from approximately 45 through 55 days of operation. After review of the data over a few days and troubleshooting, it was determined that the Norit unit was permitting free chlorine to pass into the Transfer Tank after its CEB2 cycle, which utilized 200 mg/L of sodium hypochlorite solution as a shock disinfectant. The team quickly reacted to this information and increased the flush time after the CEB2 cycle. Additionally, a sodium bisulfite drip of 2 mg/L was added to both the membrane and conventional pretreatment RO trains to act as an insurance policy against future RO damage from free chlorine oxidation. The SBS drip was included on the media filtration train only to prevent the introduction of additional independent variables to the testing protocol which could potentially confound the results. This became an important industry result because, even though we all recognize the need to prevent RO damage from chlorine attack, it was not considered a potential problem with the membrane filtration units.

Note that the RO membranes were replaced at approximately day 55 with new membranes from Toray.

6.2.2 RO Performance

The RO pilots were designated RO #1 and #2, receiving membrane filtration pretreated water and conventional media pretreated water, respectively. Figures 6.10, 6.11, and 6.12 demonstrate the salt rejection, temperature-corrected flux, and pressure drop performance for RO #1, respectively. Figures 6.13, 6.14, and 6.15 demonstrate the salt rejection, temperature-corrected flux, and pressure drop performance for RO #2.

Cleaning was required for RO #2 after approximately 42 days of operation (6 weeks), as determined by an increase in ΔP of 10–15% from startup. Cleaning was accomplished using an initial pH 4 cleaning solution with citric acid. An initial 15-minute low flush of 19 L/min (5 gpm) was followed by a 15-minute moderate flush at 30 L/min (8 gpm). The membranes were then allowed to soak for 1 hour using a 3.8-L/min (1-gpm) gentle flush. This soak was followed by a high flush for 3 minutes at 38 L/min (10 gpm). A permeate rinse followed the low pH cleaning. An identical cleaning regime was implemented with a high pH solution of pH 10 using NaOH. As figure 6.15 indicates, RO #2 was returned to its clean condition and placed back into operation.

RO #1 did not require cleaning during the 5 months of operation of this unit. Note that the new membranes had only actually experienced less than 4 months of operation. For the purposes of the economic analysis (section 7), we estimate RO #1 would require cleaning after approximately 6 months of operation, though figure 6.12 doesn't indicate any pressure increase at the conclusion of operation.

RO #2 experienced additional run-time in addition to that shown in figures 6.13 through 6.15; but unfortunately, the remaining electronic data (approximately 1 month) was lost at the conclusion of the testing. The limited operation of RO #2 compared to RO #1 was primarily a function of the poor pretreatment quality which did not allow us to operate RO #2 when the SDIs were above 5. Additionally, the conventional media pilot unit arrived 4 months later on the site than the membrane filtration units.

Note that the RO #2 maintained very good salt rejection throughout the study, indicating RO #1 salt rejection problems were a function of the chlorine cleans in the membrane filtration pilots.

Due to the design of the RO pilots, the testing was conducted at higher than traditional RO flux rates. Today, the design of seawater RO plants generally ranges from 13.5–16.9 Lmh (8–10 gfd), while the pilots in this study primarily ranged from 20–24 Lmh (12–14 gfd). Though this was not ideal, particularly to determine accurate cleaning frequencies and fouling rates, it would be considered a worst case scenario to evaluate the impact of pretreatment quality impacts on RO performance. The cleaning frequency sensitivity analysis evaluates a range of cleaning frequencies in order to take this non-ideal feature into consideration.

7. Economic Analysis

7.1 Design Parameters and Assumptions

The economic analysis for the different case studies is provided in this section. The design parameters used for the six cases or scenarios are provided in table 7.1, while the basic process assumptions for the case studies are shown in table 7.2. The Bureau of Reclamation/Moch WTCost™ program was utilized as the primary tool for costing the various components of the system using parameters established from the pilot testing. Membrane manufacturers' cost estimates augmented the WTCost™ results to refine the economic analysis. Additionally, outside cost estimates were provided as needed from other equipment vendors to supplement the WTCost™ estimates.

The parameters developed from the pilot testing results which were directly incorporated into the economic analysis include the following:

- Optimized membrane filtration flux rates
- Pretreatment chemical dosages for ferric chloride and sodium bisulfite for both membrane filtration and media filtration
- Membrane filtration backwash frequencies and CEB frequencies and dosages
- Prefiltration requirements
- Media filtration backwash frequencies
- Media filtration loading rates
- RO flux rates for both membrane filtration and media filtration pretreatment (see below for further discussion)
- RO cleaning frequency and requirements

The remaining design and operating parameters and assumptions utilized industry standards per the WTCost™ program and the *Desalting Handbook for Planners* guidance (Reclamation, 2003). As shown in table 7.2, the TWC calculations were based on amortizing the capital investment at 5% interest over a 30-year period.

The project did not rely upon typical RO flux rates. The rates utilized in cases 1–4 of the economic analysis are the approximate rates with which the pilot plant was operated. This was primarily a function of the design of the RO pilot unit. It is understood that these RO flux rates, particular 20 Lmh (12 gfd) for the media filtration pretreatment case, are significantly higher than industry practice and contributed to the RO cleaning frequency of the media filtered pilot operation. As a result, two additional economic analyses were performed at an RO flux of 13.5 Lmh (8 gfd) for both membrane filtration and media filtration cases, cases 5 and 6.

7.2 Economic Analysis Results and Sensitivity Analyses

The overall results of the economic study described in table 7.1 are shown at the bottom of table 7.1. The more detailed results of the economic analysis are shown in table 7.3. The results indicate that for cases 1–4, membrane filtration is 3–4% less expensive than media filtration on a TWC-basis. If considering only capital cost, there is negligible difference in capital cost between cases 1 and 2 and cases 3 and 4. This cost equalization between the membrane filtration and media filtration cases is largely a function of the increased RO flux rates afforded by membrane filtration which offsets the increased capital for the membrane filtration pretreatment equipment.

For the reduced RO flux cases 5 and 6, which used an RO flux of 13.5 Lmh (8 gfd) for both cases, a more significant cost difference between membrane and media filtration pretreatment is seen. In this comparison, membrane filtration is approximately 8% less expensive than media filtration on a TWC basis. On a capital basis, the membrane filtration capital cost is approximately 2% higher than the media filtration case. Because cases 5 and 6 represent a more realistic picture of an RO plant design, the author believes these cases are most representative of the expected cost and savings. The broadening of the cost differential between the membrane and media TWC is primarily a function of the operating cost changes in the RO system. The reduced flux significantly decreases power consumption compared to cases 3 and 4. Because the power consumptions are now basically the same for the two cases (because the flux is the same for the two cases), this media filtration operating cost benefit is eliminated. Additionally, because the RO flux is reduced in cases 5 and 6, approximately 75% more RO membrane is required. RO cleaning now becomes significantly more costly, so the difference between two cleanings per year for membrane filtration and nine cleanings per year for media filtration has a more significant impact. This dependency on RO cleaning frequency is further described in the sensitivity analyses below.

During the economic analysis, it became apparent that the final capital and TWC numbers were dependent on the media loading rate and the RO membrane cleaning frequency. As a result, sensitivity analyses were performed for these parameters for the 25-Mgd case studies. Figures 7.1 through 7.3 demonstrate the effect of each of these parameters on the TWC.

Figure 7.1 demonstrates that for the range of media loading rates of 2–9 gpm/ft^2, the TWC for media filtration does not approach the membrane filtration TWC of $2.06/1,000 gal.

The RO membrane cleaning frequency is a significant operating cost ranging from 2–15% of the total plant operating cost between cases 1 through 6. The pilot plant data indicated we could achieve significant fewer cleanings using membrane filtration. From this data, we determined roughly two cleanings per year would be required using membrane filtration, and nine cleanings per year using media filtration. Note that nine cleanings per year is not abnormal for media filters installed in SWRO operations using open intake seawater. Because the pilot RO system did not have years of data to back up these assumptions, a sensitivity analyses was performed maintaining the media filtration RO cleanings at nine per year and varying the cleanings of the RO in the cases using membrane filtration from two to nine per year. Figure 7.2 provides this analyses graphically for the case 3 and 4 scenario which represent the higher RO flux cases for a 25-Mgd plant. The crossover point for TWC for the two cases is six cleanings per year for case 3. That is, if six RO cleanings are required when membrane filtration is used as pretreatment, there is no cost savings over media filtration which requires nine cleanings per year.

The same analyses were performed for the case 5 and 6 comparison which utilize a consistent RO flux of 8 gfd for each case. This sensitivity analyses is presented in figure 7.3. This analyses indicates that the crossover point occurs at between eight and nine RO cleanings per year. In effect, the cost of membrane filtration approaches media filtration TWC as the RO cleaning frequency for the membrane filtration pretreatment approaches that of media filtration.

8. Conclusions

The original project objectives were as follows, as presented in section 2.2.2:

Objective 1: Compare differences in treated water quality between membrane pretreatment and conventional media pretreatment. Evaluate turbidity, silt density indices, and microbiological counts to ascertain the effectiveness and limitations of the two different pretreatment methods.

Objective 2: Based on pilot testing information and observations, evaluate and determine differences between membrane filtration and conventional pretreatment with regard to the overall operation and maintenance and performance of the RO system. Evaluate cleaning and maintenance requirements, pressure drops, permeate water quality, and other operation and maintenance differences.

Objective 3: Evaluate membrane filtration integrity over the term of the piloting test period to determine its ability to fully act as the disinfection barrier for the RO process. Monitor biological growth and assess fouling impacts in the RO system throughout the evaluation and compare it to the RO system operating on the conventional pretreatment system.

Objective 4: Using life-cycle economics, perform an objective cost comparison for desalination plants using membrane pretreatment and conventional pretreatment.

The conclusions are provided in direct response to each of the project objectives.

8.1 Objective 1 – Pretreated Water Quality Comparison

Membrane filtration produces much clearer water than conventional filtration. As demonstrated in section 6.1.2, the membrane filtration pilots consistently produced 15-minute SDI values less than 3 and turbidity values less than 0.1 NTU. The conventional media filter never produced a 15-minute SDI value of 3 or less and produced an average turbidity of 1.9 NTU. It should be noted that the raw feedwater at the site was an extremely challenging feedwater with turbidity spikes over 100 NTU and an average turbidity of 9.9 NTU over the 15-month period turbidity data were collected.

The microbiological testing that was conducted early in the project life, prior to arrival of the conventional media filtration unit, indicated that there was only 1-log removal of marine bacteria from the membrane filtration pilots. This resulted from the very small size of marine bacteria compared to freshwater bacteria, as well as the ability of the marine bacteria to “squeeze” through the membrane filter pores. Due to the high cost of the EFS analysis to obtain accurate marine bacterial counts and the results indicating poor microbe removal, this analysis was not continued.

It should be noted that at no time during the piloting was the feedwater chlorinated. Biofouling was not a significant issue throughout the piloting, and we contribute this largely to not chlorinating the TOCs in the feedwater and creating AOCs.

8.2 Objective 2 – Impact of Pretreatment on RO Performance

The intent of Objective 2 was to understand the impact of the pretreatment water quality on the performance of the downstream RO. As indicated in sections 6 and 7, the RO pilots were operated at flux rates above the norm for open intake SWRO plants, due to the pilot design. In fact, this created a 'worst case' evaluation as far as cleaning frequency is concerned. As a result, a sensitivity analysis of cleaning frequency was performed. The conventional media pretreatment pilot resulted in a 6-week cleaning frequency, at a flux of approximately 21 Lmh (12.5 gfd), as dictated by a 10–15% increase in pressure drop across the RO. The membrane filtration pretreatment RO unit did not require cleaning during the piloting, but 6 months was used as an estimate for the economic analysis as the best estimate for a plant of this type, complimented by the sensitivity analysis.

Recent literature evaluations indicate 6 weeks to be a good average for RO cleaning frequencies at plants using conventional media filters as pretreatment using an open intake seawater feed source.

One of the more important findings from the pilot study is the caution that must be practiced in using membrane filtration for RO pretreatment when chlorinated backwashes are utilized in the filters. Though it is understood that there existed the potential to oxidize the RO membranes, the initial set of RO membranes experienced a reduction in salt rejection to less than 97% from chlorine damage. Even with addition of increased rinse times after the chlorinated CEB and continual addition of 1–2 mg/L SBS, a slight decrease in salt rejection occurred later in the RO pilot study over a prolonged operating period. In this case, we experienced a salt rejection reduction from 99.6 to 99.3%. In a full-scale plant, appropriate oxidation reduction potential analyzers would be utilized to prevent this damage from occurring. Nonetheless, it is an important result that should be strongly taken into consideration into the design of full-scale plants.

8.3 Objective 3 – Membrane Filtration as Disinfection Barrier

It was originally expected that membrane filtration could act as a disinfection barrier in a SWRO facility to remove biofouling-causing bacteria due to the pore size of 0.01 to 0.1 micron for the range of ultrafiltration to microfiltration. The initial month of concentrated microbiological sampling using EFS analysis to obtain accurate marine bacterial counts indicated that only a 1-log removal (from 10^4 to 10^3) of marine bacteria was achievable using ultrafiltration technology. The marine bacteria are approximately 0.1 micron in size but have the ability to "squeeze" through much smaller diameters.

As a result, this objective was abandoned due to the lack of removal of the marine bacteria by membrane filters, even in a fully new condition.

8.4 Objective 4 – Economic Analysis

The primary deliverable for this project is the economic analysis comparing membrane filtration to conventional media pretreatment for SWRO. The operating parameters for the economic analysis were largely taken from those determined from the pilot testing. The actual analysis utilized WTCost™ and membrane manufacturers' software, augmented by vendor quotes and the *Desalting Handbook for Planners* (Reclamation, 2003).

Sensitivity analyses were conducted for conventional media loading rates and RO membrane cleaning frequencies. Additionally, analyses were conducted at the pilot operating RO flux rate as well as more traditional RO flux rates for SWRO plants using open intakes.

The overall results of the economic analysis are shown in table 7.1, indicating that, on a life-cycle cost basis, the scenarios using membrane filtration were less expensive than those using media filtration, by 3–8% depending on the specific case study. We believe cases 5 and 6 are most representative of facilities to be built in the near future, using RO flux rates of 13.5 Lmh (8 gfd) and 95,000 m^3/day (25 Mgd). In this comparison, the TWC for the facility using membrane filtration was $0.55/$m^3$ ($2.08/1,000 gal) compared to the facility using conventional media filtration at $0.59/$m^3$ ($2.24/1,000 gal). Capital cost was $85.6 million for the facility using membrane filtration compared to $84.0 million for a plant using conventional media. The operating cost was $13.4 million per year for the facility using membrane filtration compared to $15.0 million per year for a plant using conventional media.

The cost evaluation indicates that the operating costs for desalination facilities using membrane filtration is consistently less than the operating cost for facilities using media filtration as pretreatment. Recognizing that capital cost for facilities are often subsidized by government entities, it is important to recognize the reduced operation and maintenance cost afforded by membrane filtration pretreatment.

The most significant cost differential is clearly the operating cost, which for cases 5 and 6 is most strongly a function of the cleaning frequency and chemical costs differential. The cleaning frequency sensitivity analysis indicated that if membrane filtration could reduce the cleaning frequency by just one cleaning per year (from nine to eight times per year), then membrane filtration resulted in the lowest TWC.

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Figures

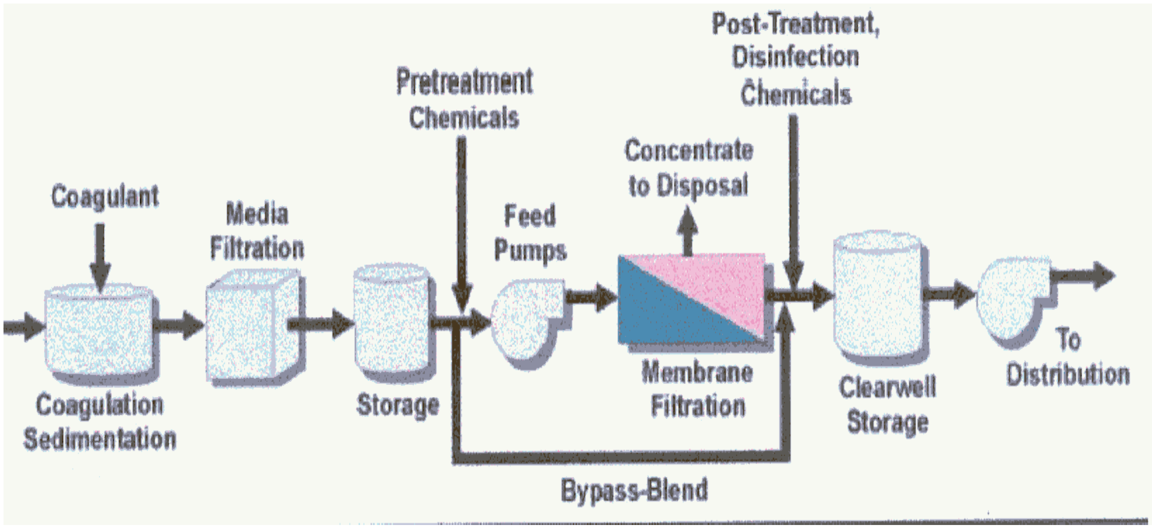

Figure 3.1. Conventional pretreatment and RO process flow diagram for surface water treatment.

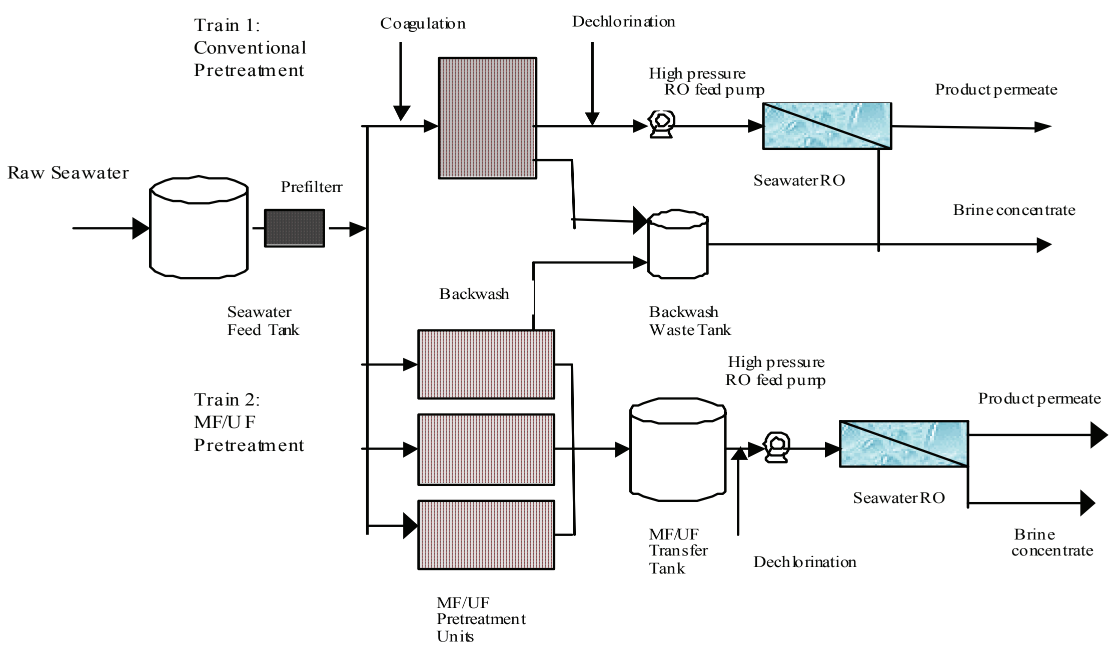

Figure 4.1. Process flow diagram of the overall pilot plant.

Figure 5.1 Close-up photograph of disc pre-filtration technology, supplied by Arkal/ A2 Water.

Figure 5.2. Installed disc pre-filtration technology.

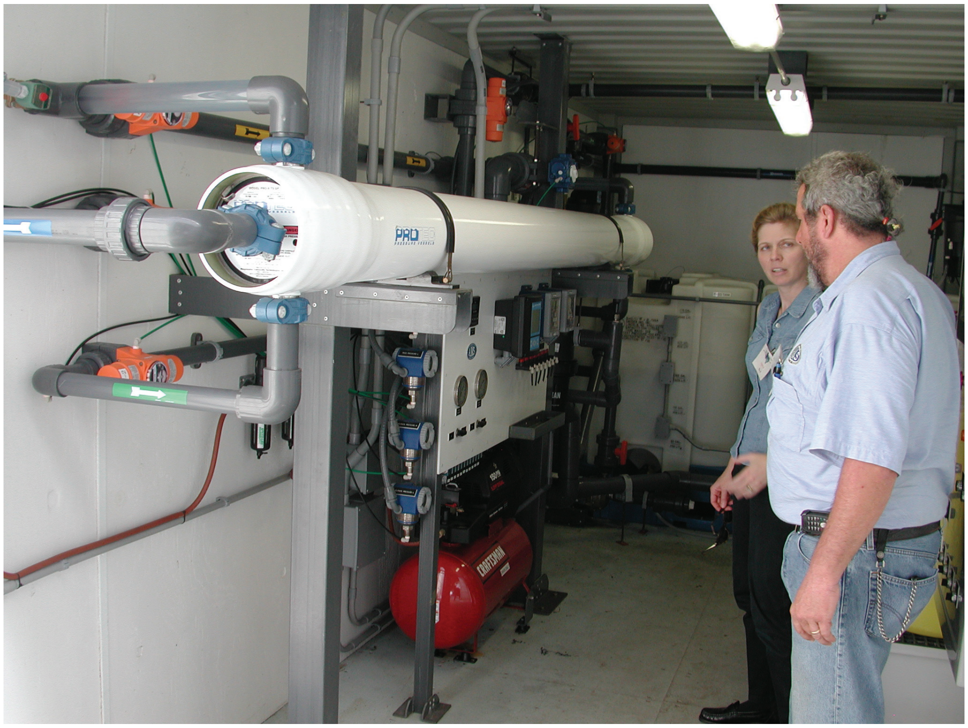

Figure 5.3. Membrane filtration X-Flow pilot unit provided by Norit Americas.

Figure 5.4. Membrane filtration Hydracap pilot unit provided by Hydranautics.

Figure 5.5. Conventional media filtration pilot unit.

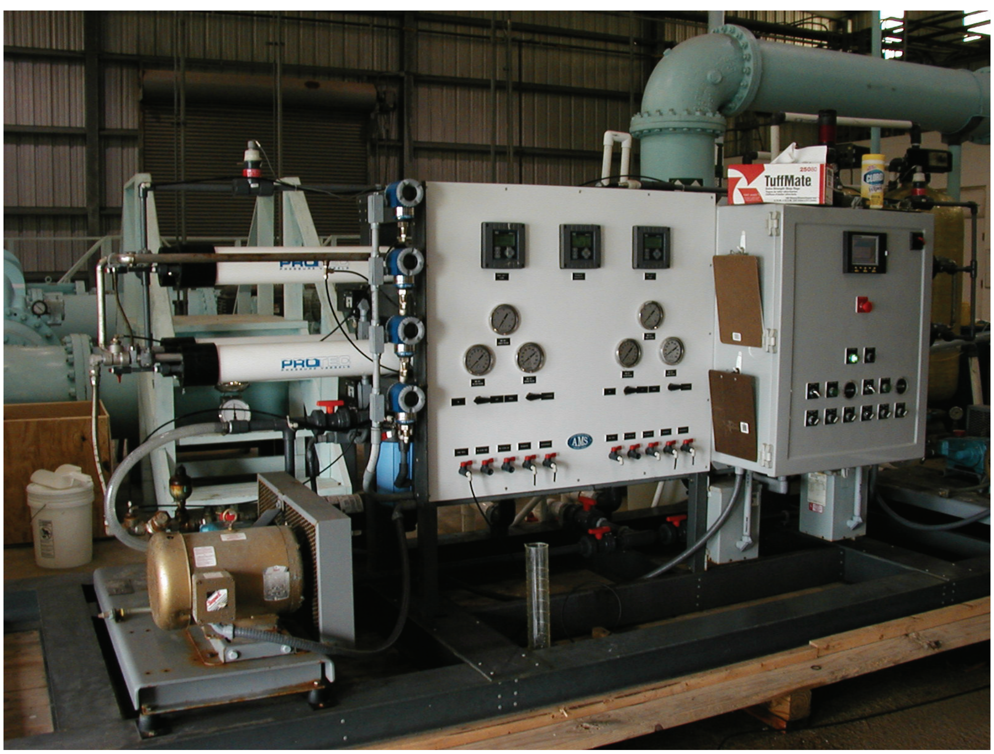

Figure 5.6. Frontal view of RO pilot unit.

Figure 5.7. Back view of RO pilot system.

Figure 6.1. Damage sustained in December 2002 due to flooding at San Patricio.

Figure 6.2. Photograph showing instability of hillside where intake pump is located after flooding.

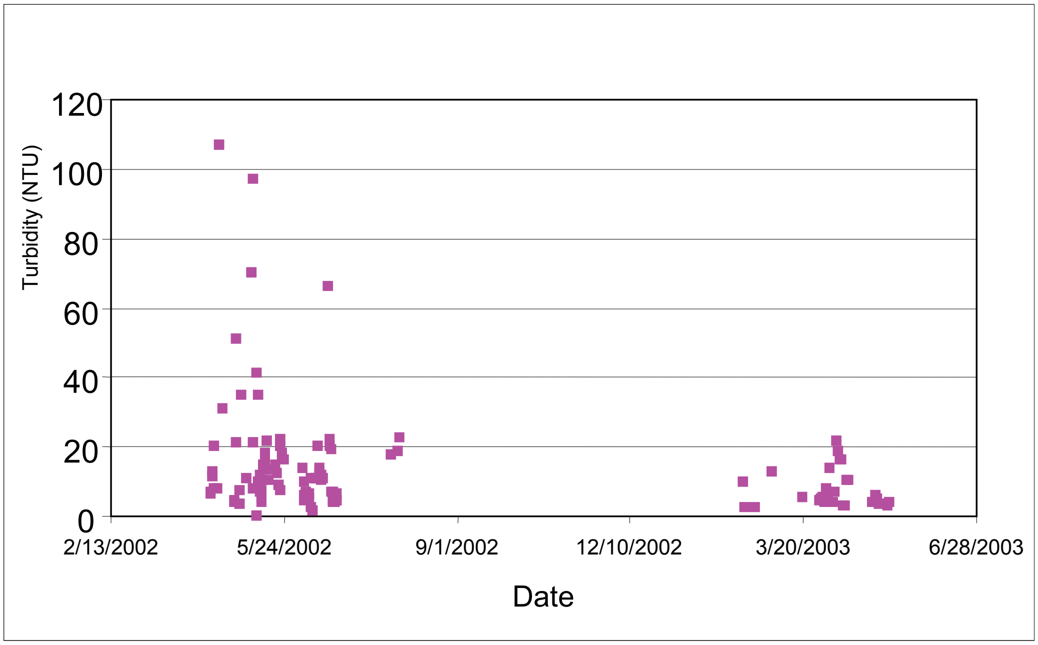

Figure 6.3. Raw water turbidity quality.

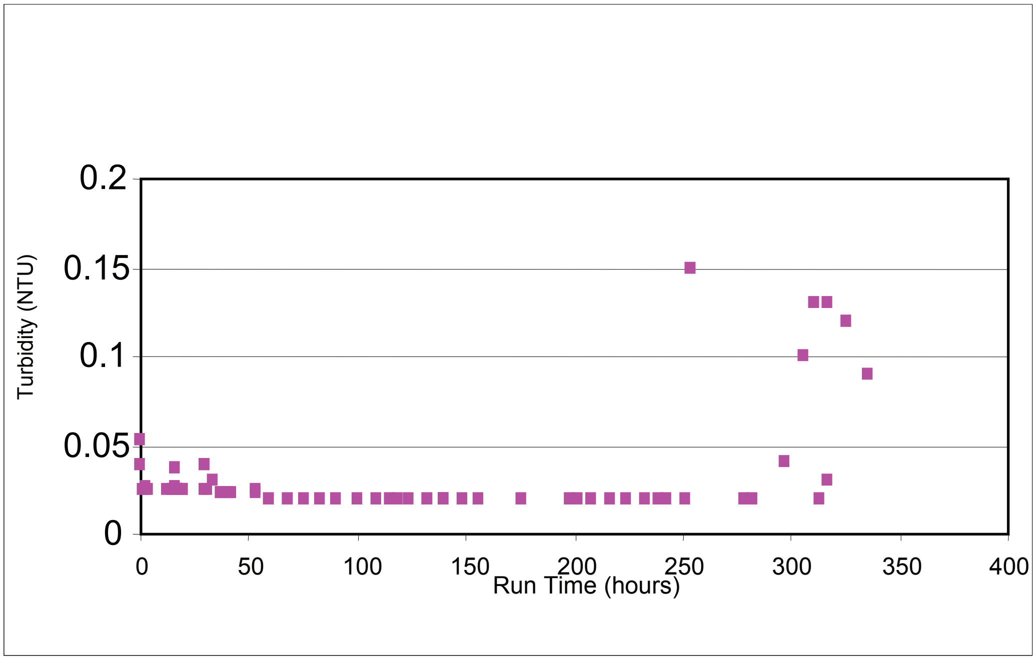

Figure 6.4. Hydracap pilot unit performance as depicted by turbidity removal.

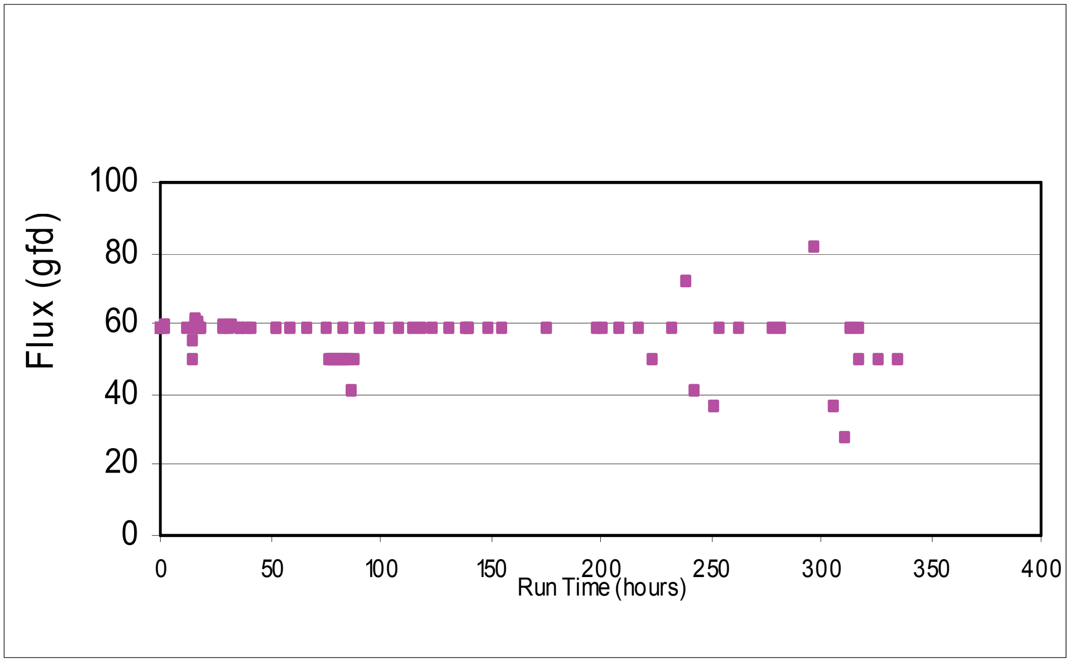

Figure 6.5. Hydracap pilot unit performance as depicted by temperature-corrected flux rate during operation.

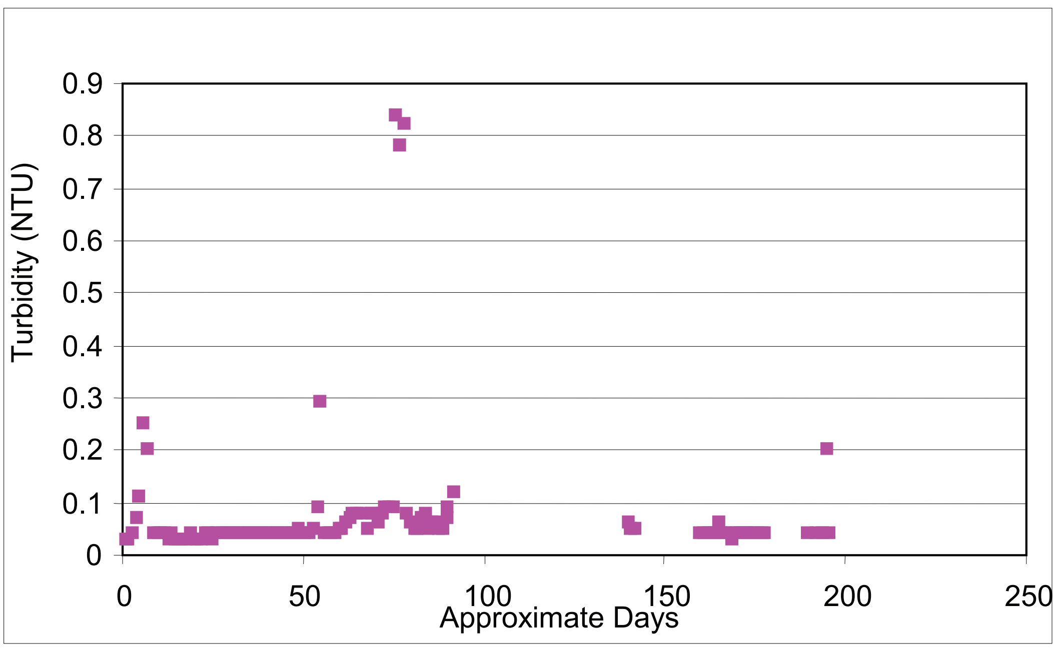

Figure 6.6. Norit pilot unit performance as depicted by turbidity removal.

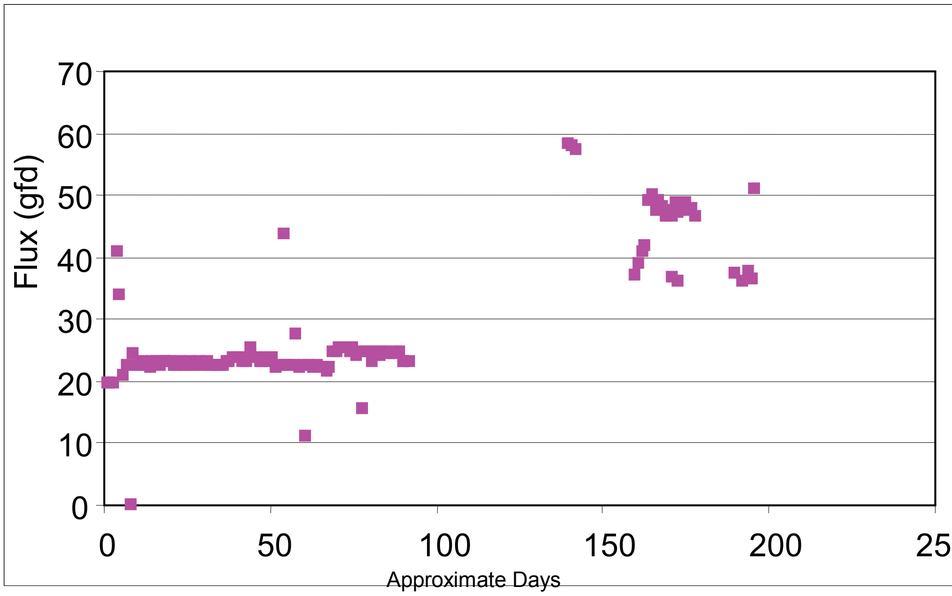

Figure 6.7. Norit pilot unit performance as depicted by temperature-corrected flux rate during operation.

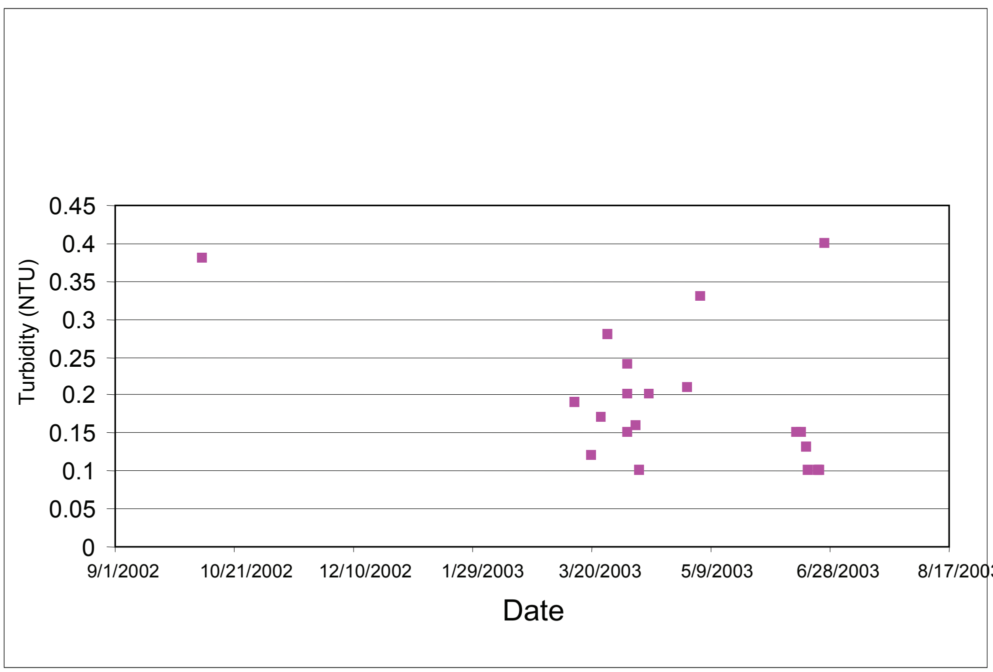

Figure 6.8. Conventional media pilot unit performance as depicted by turbidity removal.

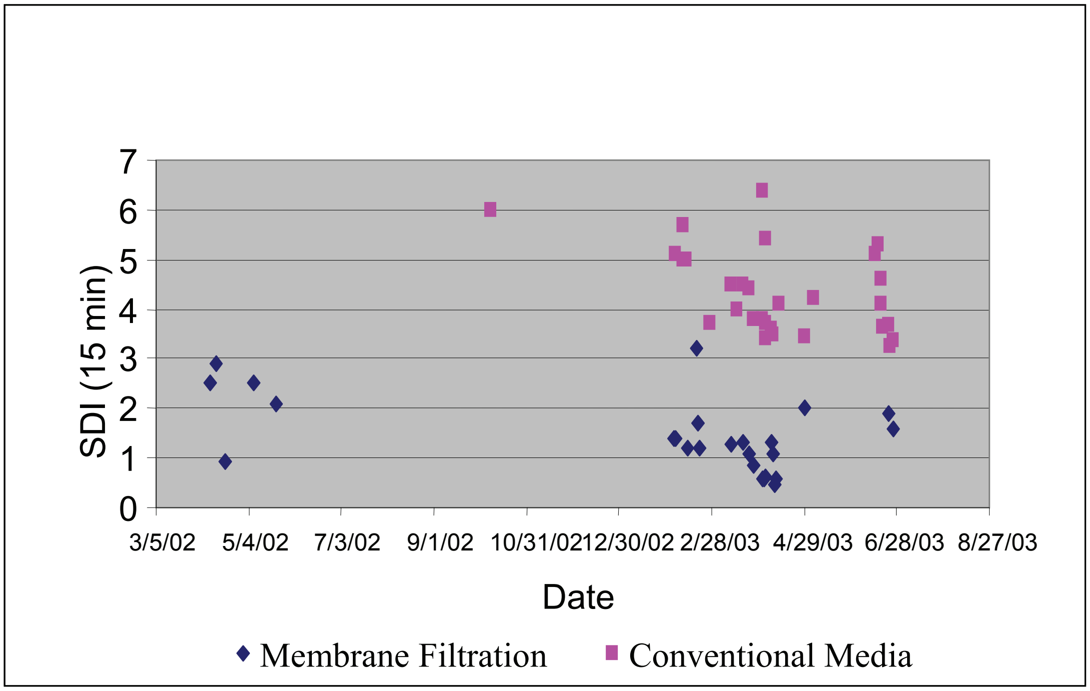

Figure 6.9. SDI results from the membrane filtration and conventional media pretreatment.

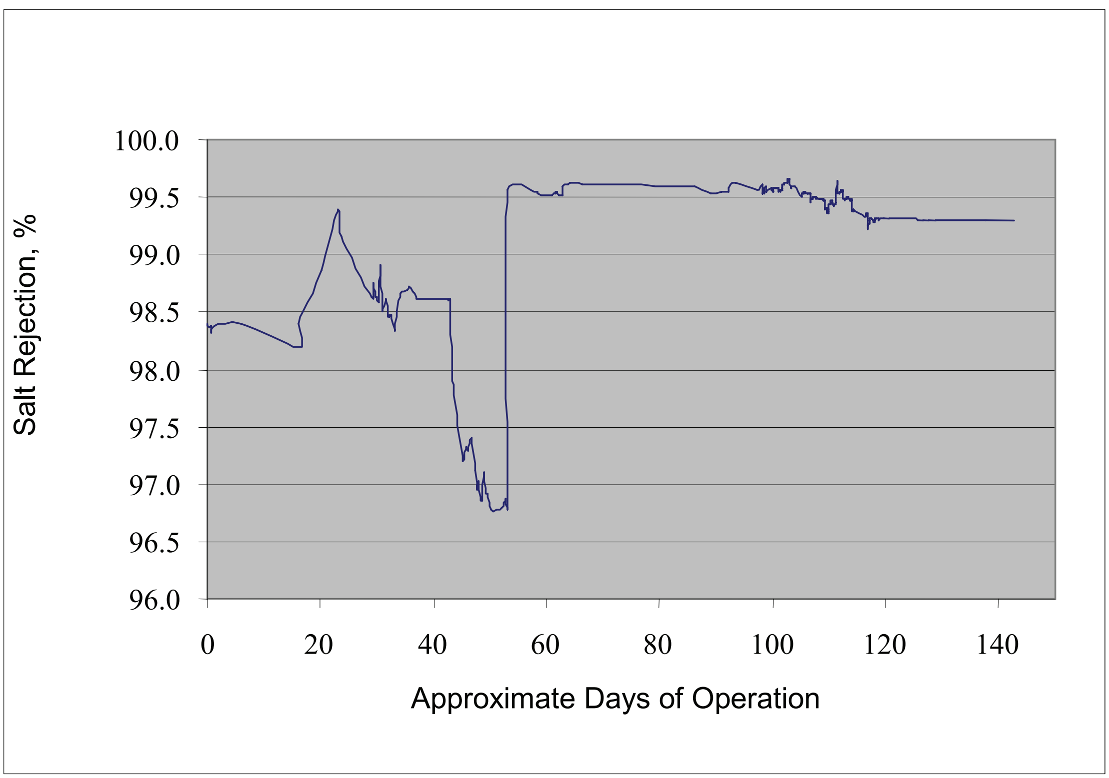

Figure 6.10. Salt rejection results from operation of RO train #1, receiving membrane filtration pretreated water.

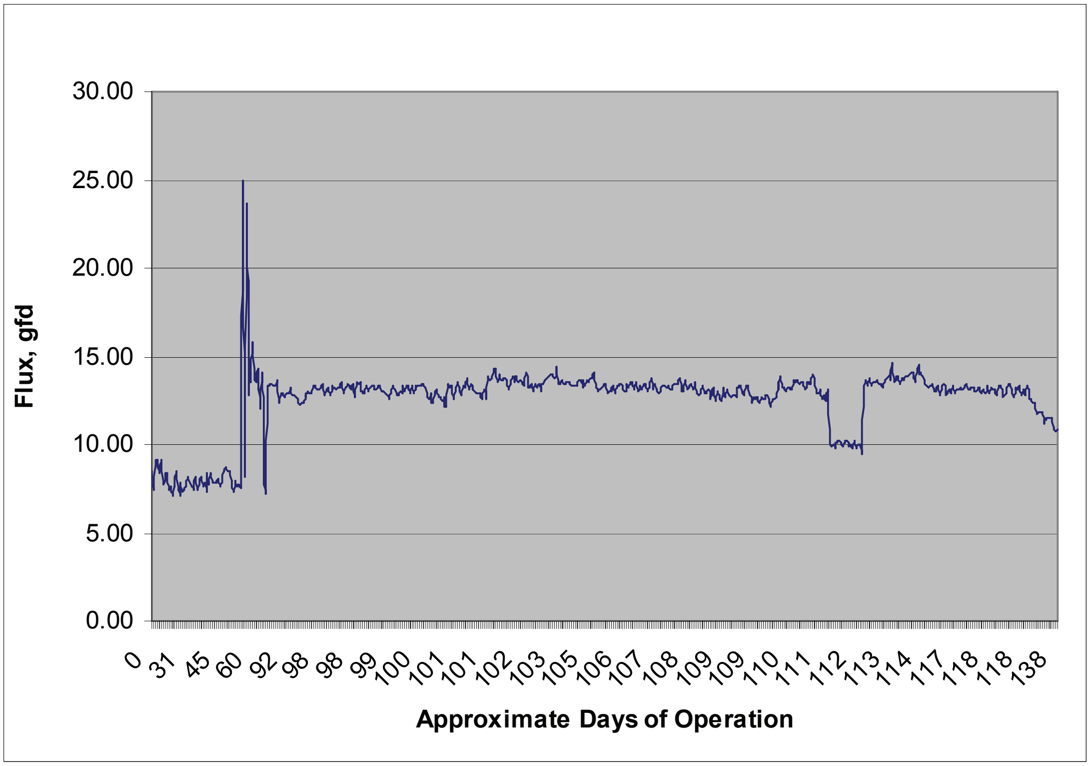

Figure 6.11. Temperature-corrected flux results from operation of RO train #1, receiving membrane filtration pretreated water.

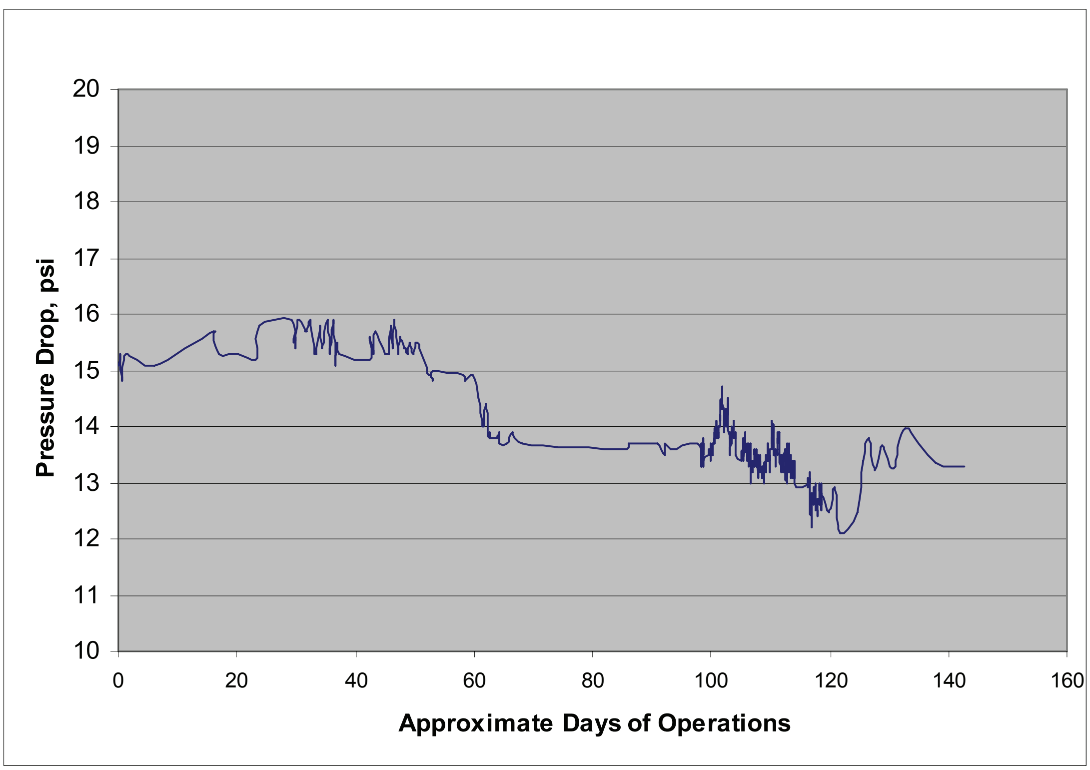

Figure 6.12. Pressure drop results from operation of RO train #1, receiving membrane filtration pretreated water.

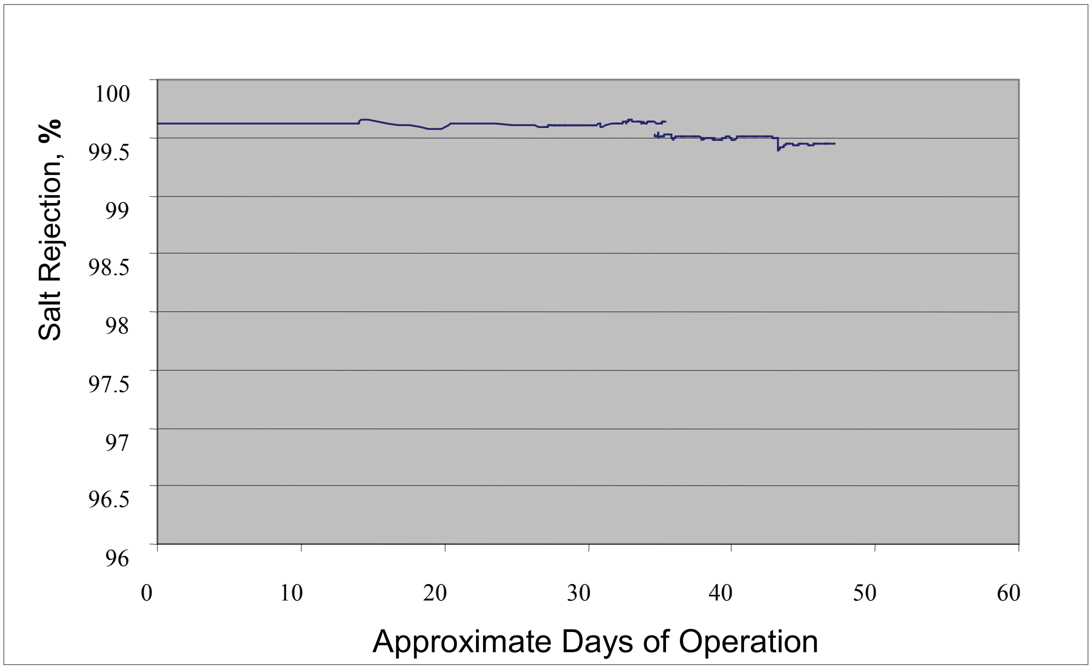

Figure 6.13. Salt rejection results from operation of RO train #2, receiving conventional media pretreated water.

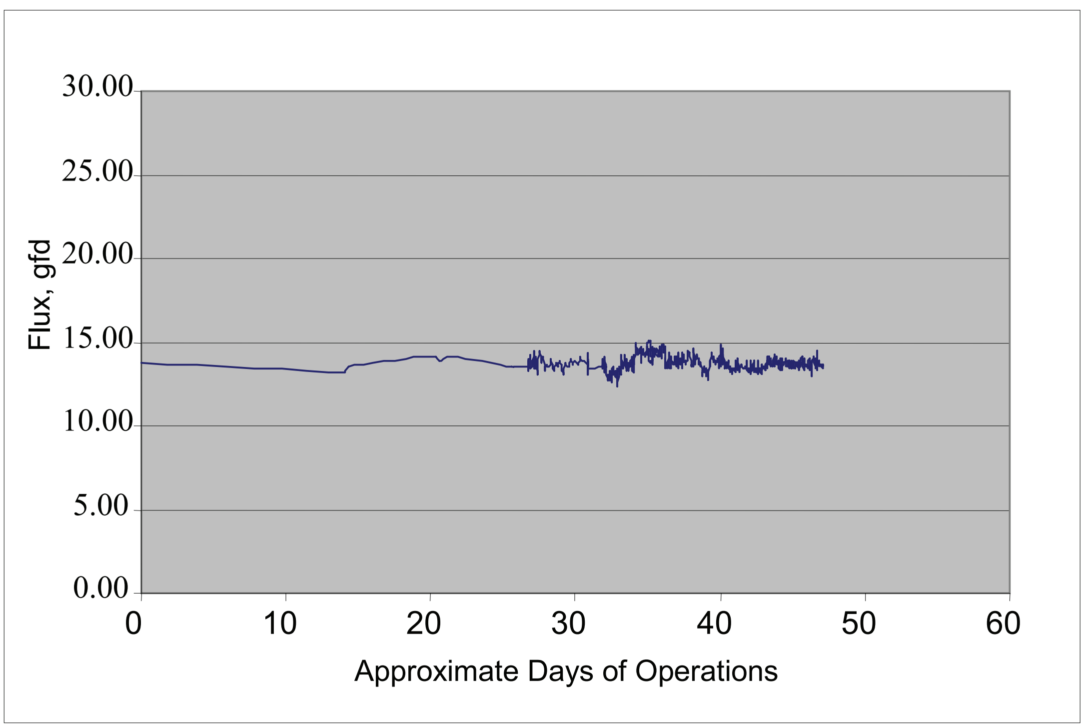

Figure 6.14. Temperature-corrected flux results from operation of RO train #2, receiving conventional media pretreated water.

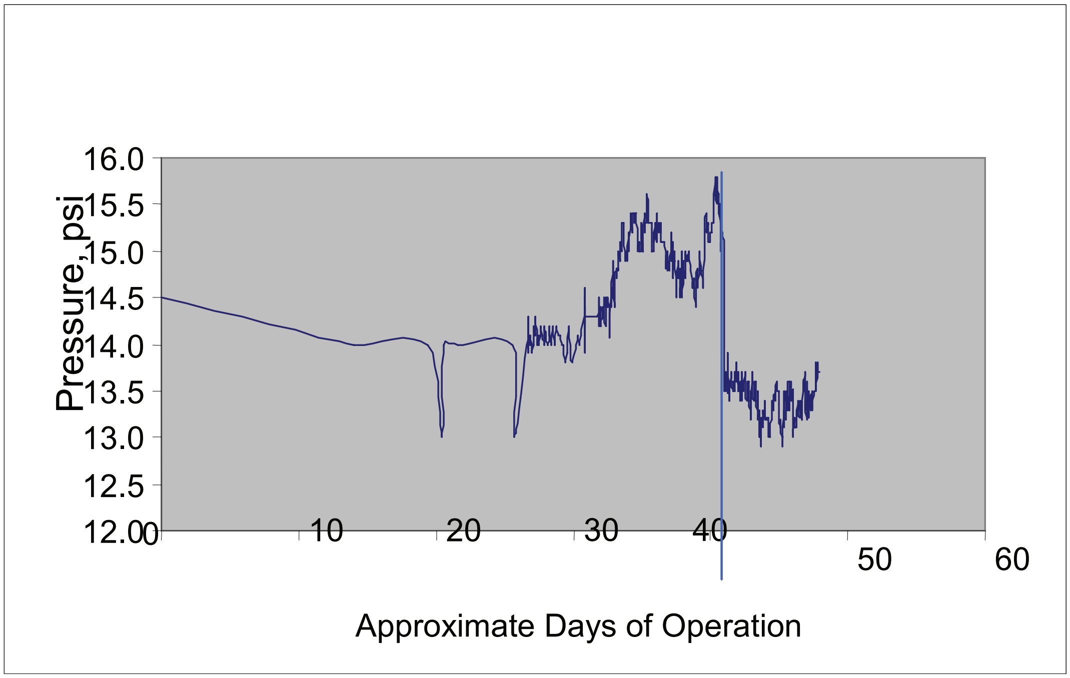

Figure 6.15. Pressure drop results from operation of RO train #2, receiving conventional media pretreated water. Cleaning is shown at day 42.

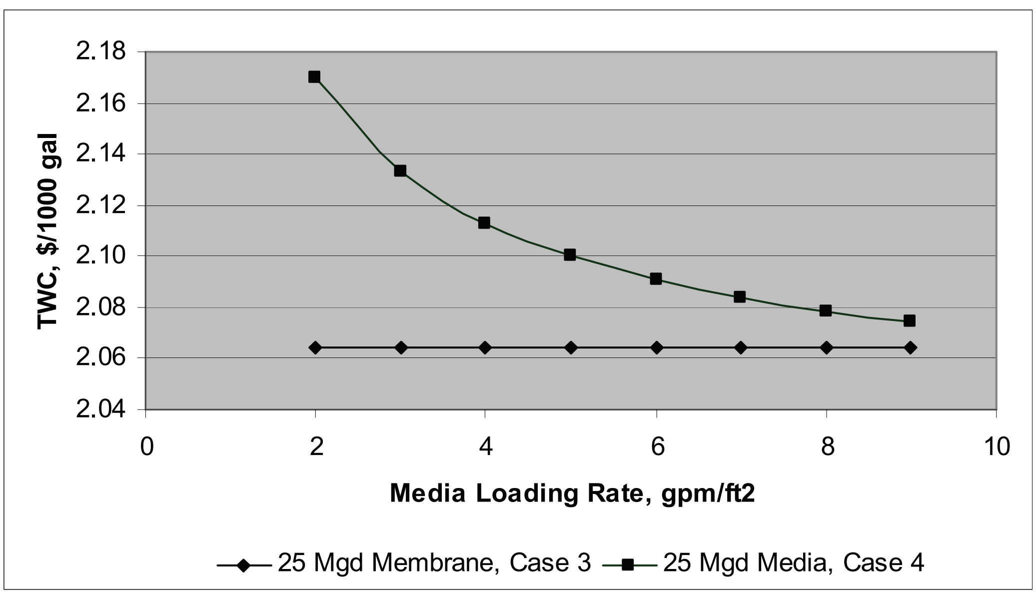

Figure 7.1. Sensitivity study to evaluate impact of media load rate on the TWC.

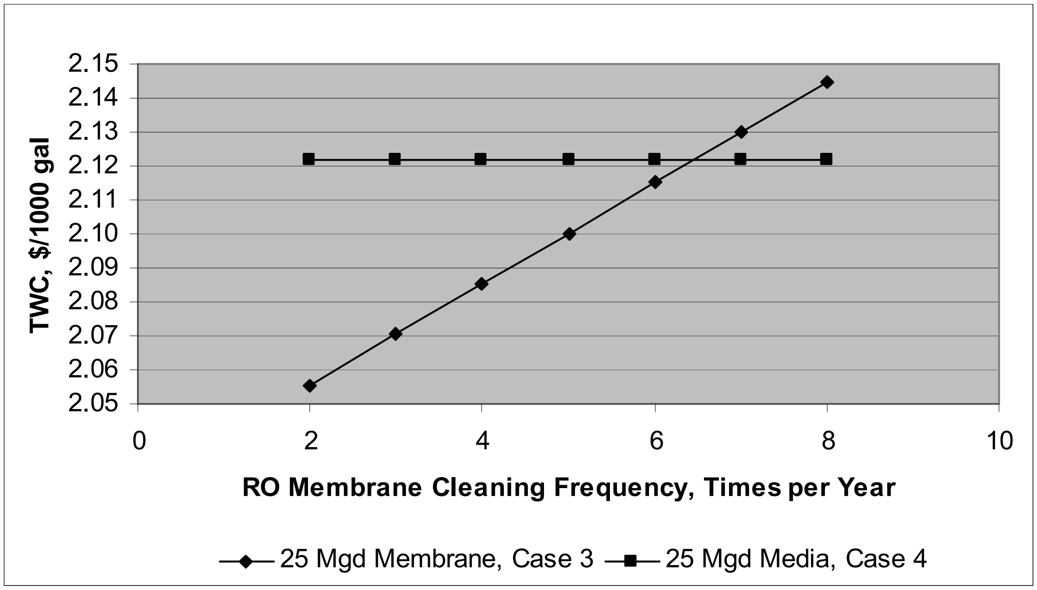

Figure 7.2. Sensitivity study to evaluate the impact of cleaning frequency on the TWC for the high flux cases of 3 and 4.

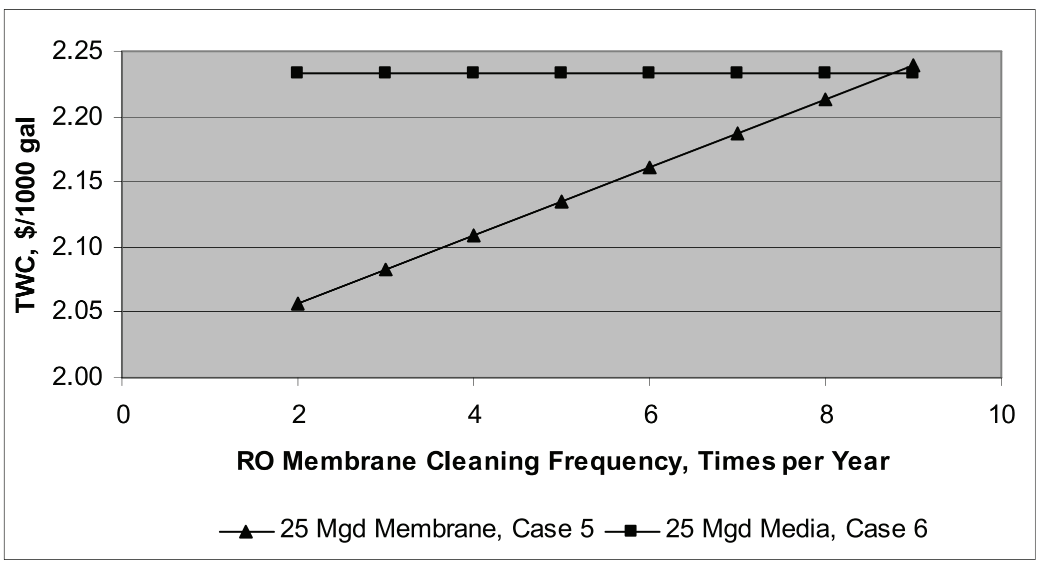

Figure 7.3. Sensitivity study to evaluate the impact of cleaning frequency on the TWC for the more common RO flux of 13.5 Lmh (8 gfd).

Tables

Table 4.1.
Initial Water Quality of SPMWD Feedwater

Constituent	Measurement
Temperature of Sample (^{o} C)	17
pH	8.4
Turbidity (NTU)	1.7-1.93
Total Alkalinity (mg/L)	143
Total Hardness (mg/L)	5,060
Calcium Hardness (mg/L)	986
Chlorides (mg/L)	15,700
Conductivity (µS)	40.9-43.9
Total Solids (mg/L)	32,000-36,000
Total Dissolved Solids (mg/L)	30,200
Total Suspended Solids (mg/L)	10-70
Fluoride (mg/L)	0.86
Silica (mg/L)	<1
Total Iron (mg/L)	0.03
Dissolved Iron (mg/L)	<0.01
Sulfate (mg/L)	2,230
Ammonia (mg/L)	0.11
Nitrate (mg/L)	<0.01
Total Phosphorous (mg/L)	0.05
Copper (ppb)	5.5
Bromide (mg/L)	90
Total Organic Carbon (mg/L)	4
UV-254	0.051-0.056
Heterotropic Plate Count	94
Calcium (mg/L)	395
Magnesium (mg/L)	990
Sodium (mg/L)	9,100
Potassium (mg/L)	355
Carbonate (mg/L)	11
Bicarbonate (mg/L)	153
Ion Balance	1.028
Aluminum (mg/L)	0.1
Barium (mg/L)	0.03
Manganese (mg/L)	0.01
Strontium (mg/L)	5.7
Lead (mg/L)	<0.001

Table 4.2
Phase I Dependent Variables

Water Quality:
1. Filtrate Epifluorscent Bacterial Counts, counts/mL
2. Filtrate turbidity, NTU, measured by online turbidimeters
3. Filtrate TOC, limited
4. Filtrate SDI
Process:
5. Filtrate run time, between backwashes and cleaning at specific flux rate, hours
6. Water recovery, %
7. Cleaning frequency, hrs^{-1}
8. Ability to operate w/wo chemical pretreatment
Cost:
11. Chemical assumption, $/day
12. Power cost, $/day
13. Feed and backwash pressures and volumes
14. O&M time required, estimates

Table 4.3
Phase II Dependent Variables

Water Quality:
1. Salt transport coefficient, B
2. Salt passage, %
3. Permeate TDS estimated from conductivity, mg/L
4. TOC, mg/L, limited
5. UV absorbence at 254 nm, limited
Process:
6. Water transport coefficient, A, gfd/psig
7. Fouling rate, decrease in A
Cost:
8. Power cost, $/day
9. Cleaning frequency and requirements
10. O&M time required, estimates

Table 4.4
Phase I and II Independent Variables

Phase I and II	
Pretreatment Systems	PT-1: Zenon Zeeweed 1000 UF
	PT-2: Norit X-Flow UF
	PT-3: Hydranautics Hydracap UF
	PT-4: Memcor CMF
	PT-5: Conventional
MF/UF Water flux (gal-ft^{-2}day^{-1})	Low, medium and high
Coagulant addition and dosage	Low and high
Operating Time	As results dictate

Table 4.5
Phase I – Operation Data Collection
(to be collected for each pretreatment unit)

Frequency: Continuous if automatic; 1 time a day if manual (M-F)			
Parameter	Process Streams		
	Raw Feed Water	Filtrate	Backwash Waste
Operation Time			
Temperature, ^{o}C	X		
Pressure, psi		X	
Flow, gal/min	X	X	X
Turbidity, NTU	X	X	
SDI (weekly collection)	Not possible	X	
Backwashing frequency			
Aeration frequency			

Table 4.6
Phase I – Weekly Laboratory Data

Frequency: Once per week			
Parameter	Process Streams		
	Raw Water Feed	Filtrate	Backwash Waste
Operation Time			
Temperature, ^oC	X		
pH	X		
TSS, mg/L	X		X
EFS, no./mL	X	X	
Turbidity, NTU	X	X	

Table 4.7
Phase II - Operation Data Collection

Frequency: Continuous if automatic; 1 times a day if manual (M-F)					
	Process Streams				
Parameter	Raw Water Feed	Pretreated Streams (each)	Transfer Tank (for MF/UF)	Concentrate	Permeate
Operation Time					
Temperature, ^oC	X				
pH	X	X			
SDI (weekly)		X	X		
Turbidity, NTU	X	X	X		
Pressure, psi	X	X	X[1]	X	
Flow, gal/min		X	X	X	X
Conductivity, µS/cm			X	X	X
Backwash Frequency		X			
Aeration Frequency		X			

[1]Outlet of high pressure pumps

Table 4.8
Phase II – Laboratory Data

Frequency: Once per week					
Parameter	Process Streams				
	Raw Feed	Backwash	Transfer Tank	Concentrate	Permeate
Temperature, °C	X		X		
pH	X		X		
Turbidity, NTU	X		X		
EFS, no./mL	X		X	X	X
Frequency: As time and budget permits					
Temperature, °C	X		X		
Conductivity, μS/cm			X	X	X
Inorganic Analyses (see attached)			X	X	X
TOC, mg/L	X		X		
UV absorbance at 254 nm			X		
TSS, mg/L	X		X		

Table 4.9
Recommended Analytical Procedures

Inorganic Analysis Parameter	Suggested Method
TDS @ 180 °C	SM 2540C
Total Alkalinity	SM 2320
Total Hardness	SM 2340
Calcium Hardness	SM 3500-Ca-D
Sodium	SM 3120B
Iron, dissolved and total	SM 3120B
Chloride	SM 4500-Cl-F
Sulfate	EPA 300
Silica (SiO_2)	SM 3120B
Phosphate	SM 4500-F-C
Nitrate	SM 4500-NO3-C
Organic Analysis Parameter	
TOC	SM 5310B
UV absorbance at 254 nm	SM 5910B
Other Parameters	Suggested Method
Temperature	SM 2550B
PH	SM 4500-H-B
TSS	SM 2540D
Specific conductance	SM 2510
Turbidity	EPA 180.1

Table 5.1
Comparison of Pretreatment Units

Parameter	PT-1 Zenon	PT-2 Norit	PT-3 Hydranautics	PT-4 Memcor	PT-5 Conven-tional
Unit	Zeeweed 1000 UF	X-Flow	Hydracap	CMF-S	Media Filtration
Number of modules	3	2	1	4	2 filter beds
Nominal membrane pore size, microns	0.02 microns	150,000 MWCO	150,000 MWCO	0.1 micron	NA
Filter loading, gpm/ft^2	NA	NA	NA	NA	1.5
Nominal surface area, ft^2		754		272	NA
Feed pressure max, psig	NA	NA	73	NA	
Transmembrane pressure range, psig	1-8	2-30	4-22	3-12.5	NA
Raw water feed, min, gpm	9	20	11.5	8	10
Raw water feed, max, gpm	26	60	30	40	40
Filtrate flow min, gpm		20	11.5	4	10
Filtrate flow max, gpm		60	30	38	40
Tank size, gal		NA	NA	132	2-300 gal
Compressed air supply, psi	100 psi	80 psi, included	80 psi	90 psi	NA
Process chemicals	NaOCl	NaOCL, acid	NaOCl, NaOH $FeCl_3$	NaOCl	NaOCl, $NaHSO_3$, coagulant possibly

Table 6.1
Results of Microbiological Testing

Sample Location	Date	Pilot Unit	Bacterial Counts, cells/mL
Raw feedwater	5/10/2002	NA	1.99×10^4
Raw feedwater	5/14/2002	NA	2.08×10^4
Raw feedwater	5/29/2002	NA	6.06×10^4
Raw feedwater	6/7/2002	NA	7.69×10^4
Raw feedwater	6/7/2002	NA	4.16×10^4
Pretreated water	5/10/2002	Norit	1.68×10^3
Pretreated water	5/14/2002	Norit	4.64×10^3
Pretreated water	5/29/2002	Norit	4.98×10^3
Pretreated water	5/29/2002	Hydracap	2.94×10^3
Pretreated water	6/7/2002	Norit	4.03×10^3
RO permeate	5/10/2002	RO #1	7.69×10^3
RO permeate	5/14/2002	RO #2	4.30×10^3
RO permeate	5/29/2002	RO #1	4.07×10^3
RO permeate	5/29/2002	RO #2	2.70×10^3
RO permeate	6/7/2002	RO #1	5.4×10^3
RO permeate	6/7/2002	RO #2	4.97×10^3
RO concentrate	5/10/2002	NA	3.05×10^3
RO concentrate	6/7/2002	NA	7.2×10^3

Table 7.1
Design Parameters and Case Studies for Economic Analysis

Parameter	Case Study 1	Case Study 2	Case Study 3	Case Study 4	Case Study 5	Case Study 6
Plant production (mgd)	10	10	25	25	25	25
Pretreatment	Membrane	Media	Membrane	Media	Membrane	Media
Salinity (mg/L)	35,000	35,000	35,000	35,000	35,000	35,000
Average RO flux (gfd)	14	12	14	12	8	8
RO cleaning frequency* (times per year)	2	9	2	9	2	4
RO membrane replacement (%/per year)	12	15	12	15	12	15
RO fouling factor (%)	0.90	0.85	0.90	0.85	0.90	0.85
Ferric chloride dosage (mg/L)	0.25	7	0.25	7	0.25	7
Media filter loading** (gpm/ft^2)	NA	4	NA	4	NA	4
Membrane filtration flux (gfd)	55	NA	55	NA	55	NA
Plant Capital Cost ($)	39,414,347	40,252,532	76,468,544	76,020,737	85,637,421	84,087,254
Yearly Operating Cost ($/year)	6,317,686	6,606,103	14,018,539	14,570,828	13,458,879	15,084,788
Total Water Cost ($/1000 gal)	2.40	2.49	2.06	2.12	2.07	2.23
Total Water Cost ($/m^3)	0.63	0.66	0.55	0.56	0.55	0.59

*Sensitivity analyses performed for range of 2-9 RO cleanings per year.
**Sensitivity analyses performed for range of media loading of 2-9 gpm/ft^2.

Table 7.2
Design and Operating Assumptions for Economic Analysis

Parameter	Assumption
Feedwater temperature (^oC)	25
Feedwater salinity (mg/L)	35,000
Prefilter screening (micron)	130
Pre-chlorination/dechlorination	Shock chlorination in feed; CEB in membrane filtration using 200 mg/L
Cartridge filtration (micron)	5
Membrane filtration recovery	93%
Media filtration recovery	96%
RO recovery	45%
Elements per vessel	7
RO Staging/Pass	Single stage
Intake	Open
Outfall	Open, piped 2,000 ft
Storage	
10 mgd, million gallons of storage	2.5
25 mgd, million gallons of storage	5.0
Labor requirements	
10 mgd, number of personnel, membrane	14
10 mgd, number of personnel, media	15
25 mgd, number of personnel, membrane	19
25 mgd, number of personnel, media	20
Operational labor cost, $/year, fully loaded	50,000
Power costs ($/kwhr)	0.05
Labor costs for construction	ENR 12/2003 indices
Chemical dosages	
Pre-hypochlorite, shock intermittent, mg/L	10
Sulfuric acid, mg/L	0.5
Sodium bisulfite, mg/L	Based on 0.1 Cl_2 continuous to maintain in reducing environment, shock as function of Cl_2
Post-hypochlorite, continuous, mg/L	1
Lime, 93%, mg/L	2
Chemical costs	
Hypochlorite ($/ton), as Cl_2	365
Sulfuric acid ($/ton), as 93%	120
Sodium bisulfite ($/ton)	300
Ferric chloride ($/ton), as 37%	360
Lime ($/ton)	260
Cleaning costs per clean ($/element)	18
Construction costs	ENR 12/2003 indices
Raw capital costs	ENR 12/2003 indices
Membrane filtration replacement (%/year)	20
Membrane filtration type	Pressurized ultrafilter
RO membrane elements cost ($/element)	600
RO membrane vessel cost ($/vessel)	2,000
Capital recovery interest rate (%)	5
Capital recovery period (years)	30
Interest during construction (% of construction)	5
Construction contingencies (% of construction)	6
Engineering fee factor (% of construction)	12
Insurance and bonds (% of construction)	4

Table 7.3
Detailed Economic Analysis

	Case 1 10 mgd Membrane RO flux 14 gfd	Case 2 10 mgd Media RO flux 12 gfd	Case 3 25 mgd Membrane RO flux 14 gfd	Case 4 25 mgd Media RO flux 12 gfd	Case 5 25 mgd Membrane RO flux 8	Case 6 25 mgd Media RO flux 8
Pretreatment Disinfection						
Capital Cost, $	50,150	50,150	82,898	82,898	82,898	82,898
O&M Cost, $/year	25,013	25,013	48,177	48,177	48,177	48,177
Operating Cost, $/1000 gal	0.007	0.007	0.005	0.005	0.005	0.005
Prefilter						
Capital Cost, $	340,000	340,000	868,000	868,000	868,000	868,000
O&M Cost, $/year	23,000	23,000	57,000	57,000	57,000	57,000
Operating Cost, $/1000 gal	0.006	0.006	0.016	0.016	0.016	0.016
Chemical Feed Systems						
Capital Cost, $	64,429	179,245	127,656	355,147	127,656	355,147
O&M Cost, $/year	12,642	106,466	31,600	265,904.00	31,600	265,904.00
Operating Cost, $/1000 gal	0.003	0.029	0.003	0.029	0.003	0.029
Filtration						
Capital Cost, $	7,000,000	6,926,000	14,000,000	11,838,905	14,000,000	11,838,905
O&M Cost, $/year	701,112	418,000	1,393,025	592,000	1,393,025	592,000
Operating Cost, $/1000 gal	0.192	0.115	0.153	0.065	0.153	0.065
Dechlorination						
Capital Cost, $	36,340	36,340	38,000	38,000	38,000	38,000
O&M Cost, $/year	35,000	34,000	39,000	38,000	39,000	38,000
Operating Cost, $/1000 gal	0.010	0.009	0.004	0.004	0.004	0.004
Desalting						
Capital Cost, $	14,032,000	14,651,172	25,978,898	27,559,898	33,198,486	33,911,486
O&M Cost, $/year	5,343,919	5,822,624	12,103,737	13,223,747	11,544,077	13,737,707
Operating Cost, $/1000 gal	1.464	1.595	1.326	1.449	1.265	1.506
Post-treatment						
Capital Cost, $	249,000	249,000	313,000	313,000	313,000	313,000
O&M Cost, $/year	117,000	117,000	200,000	200,000	200,000	200,000
Operating Cost, $/1000 gal	0.032	0.032	0.022	0.022	0.022	0.022
Intake/Outfall/Storage/Pumping						
Capital Cost, $	9,263,000	9,263,000	18,803,000	18,803,000	18,803,000	18,803,000
O&M Cost, $/year	60,000	60,000	146,000	146,000	146,000	146,000
Operating Cost, $/1000 gal	0.017	0.017	0.016	0.016	0.016	0.016
Total Direct Capital, $	31,034,919	31,694,907	60,211,452	59,858,848	67,431,040	66,210,436
Total Indirect Capital, $	8,379,428.13	8,557,624.89	16,257,092.04	16,161,888.96	18,206,380.80	17,876,817.72
Total Capital, $	39,414,347	40,252,532	76,468,544	76,020,737	85,637,421	84,087,254
Annual Capital Payment, $	-2,441,867	-2,493,795	-4,737,513	-4,709,770	-5,305,559	-5,209,521
Capital Recovery, $/1000 gal	0.669	0.683	0.519	0.516	0.581	0.571
Yearly Operating Cost, $/year	6,317,686	6,606,103	14,018,539	14,570,828	13,458,879	15,084,788
TWC, $/1000 gal	2.40	2.49	2.06	2.12	2.07	2.23
TWC, $/m3	0.63	0.66	0.55	0.56	0.55	0.59
WC, $/AF	782	813	673	691	673	728

Appendices

Appendix 1 – Testing Protocol

Evaluation of Membrane Pretreatment for Seawater Reverse Osmosis Desalination Pilot Study

Testing Protocol

Conducted at the San Patricio Municipal Water District Site

Led by: **Aqua Resources International, LLC**

In partnership with: **Advanced Membrane Systems, Inc.**
Boyle Engineering Corporation
San Patricio Municipal Water District

Edited April 8, 2002

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1.0 INTRODUCTION

1.1 Background

The competitive pricing for seawater desalination, as demonstrated by the privatized Tampa Bay Water and Ashkelon, Israel projects, has now made many coastal communities re-examine the possibility of augmenting their water supply from the sea. Indeed it has been the dream of many inventors throughout history to cost-effectively produce potable water from seawater. One of the most significant factors in successfully (and cost-effectively) operating a reverse osmosis (RO) desalination plant is the ability of the pretreatment system to consistently produce well-filtered and relatively microbe-free water for feed to the RO system.

With the advent of microfiltration (MF) and ultrafiltration (UF) membranes, the concept of utilizing these low pressure filtration membranes for pretreatment has intrigued desalination plant developers and engineers over the last couple of years. The potential benefits offered by membrane pretreatment compared to conventional pretreatments are significant:

- improved pretreated water quality, in terms of lower suspended solids and less biological content, resulting in improved RO operation;
- fewer RO membrane cleanings with resulting cost savings in cleaning chemicals;
- lower RO pressure drops from fouling, resulting in lower energy costs;
- longer RO membrane life associated with long-term improved pretreated water quality;
- increased flux rates in the RO system due to higher quality pretreatment;
- smaller plant footprint size resulting in reduced capital investment;
- lower overall chemical and sludge handling costs if conventional technologies included lime softening or other chemically intensive conventional pretreatments.

Unfortunately, to date, there has been very little piloting of membrane pretreatment for seawater reverse osmosis applications. As a result, there is little to no verification as to the degree these benefits will be realized and what specific cost savings will result. It is vital to the desalting community that these benefits be quantified, in order to utilize the most cost-effective and appropriate technologies for future desalination applications in the U.S. and around the world.

This pilot project will be accomplished at the San Patricio Municipal Water District (SPMWD) facility near Corpus Christi, Texas. This facility is ideal for this particular pilot project because:

- their site is an ideal piloting site in that they have an available seawater source,

- their operators are trained in membrane operations from their own 7.8 Mgal /day Pall MF plant,
- they have an abundance of piloting space within their facility,
- and most importantly, SPMWD is enthusiastic to participate due to their potential future water supply needs.

This pilot project is funded by the U.S. Bureau of Reclamation, through their Desalination R&D Program. The project team is led by Aqua Resources International (ARI) in partnership with Advanced Membrane Systems (AMS), the San Patricio Water District, and Boyle Engineering, who will provide QA/QC services for the project. The team is highly experienced in membrane applications and pilot studies, and brings a depth of knowledge and commitment to this subject matter. The Project Manager, Ms. Lisa Henthorne, will be assisted by Mr. Mark Thompson (AMS), Dr. Steve Duranceau (Boyle), Mr. Chip Harris (AMS) and Mr. Eric Jankel (ARI). The project is highly cost-shared through contributions from the MF/UF and RO membrane manufacturers, the SPMWD, and the principal project partners.

The project will be accomplished through two phases of piloting. The initial phase will involve optimization of the MF/UF and conventional pretreatment system. The second phase of experimentation will utilize the optimized MF/UF units providing pretreated feedwater for the seawater reverse osmosis (SWRO) for a 6-9 month period. Simultaneously, a conventional pretreatment system will operate with SWRO for the same period. Throughout the period, data will be collected to evaluate overall cost of operation, water quality production, pressure drops, cleaning requirements, attainable operating flux rates, impact on membrane life, membrane integrity, and membrane biofouling.

1.2 Project Purpose

The principal purpose of this project is:

- to evaluate the performance of membrane pretreatment versus conventional pretreatment for seawater reverse osmosis desalination, in terms of improved pretreated water quality and impact on RO performance; and
- to determine the subsequent cost benefits of membrane pretreatment compared to conventional pretreatment options, through establishment of an objective life-cycle cost comparison.

1.3 Project Objectives

The specific project objectives include the following:

Objective 1: Conduct a pretreated water quality comparison between membrane pretreatment and conventional pretreatment options. Evaluate total suspended solids (TSS), turbidity, silt density indices (SDI), total organic carbon (TOC), and heterotrophic plate counts (HPC) to conduct a full comparison of the effectiveness of the pretreatment methods.

Objective 2: Over the term of the piloting test period, evaluate the impact of membrane versus conventional pretreatment on the overall operation of the RO system. Evaluate cleaning and maintenance requirements, pressure drops, permeate water quality, etc.

Objective 3: Evaluate pretreatment membrane integrity over the term of the piloting test period to determine its ability to fully act as the disinfection barrier for the RO process. Monitor biofouling in the RO system throughout the evaluation and compare it to the RO system operating on the conventional pretreatment system.

Objective 4: Establish an objective cost comparison of membrane pretreatment compared to a range of conventional pretreatment options for the overall desalination process, ensuring overall life-cycle economics are assessed.

2.0 PILOT TEST SITING, VARIABLES, AND PROCEDURES

2.1 Siting and Water Quality

The pilot testing will be conducted at the San Patricio Municipal Water District facility, near Corpus Christi, Texas. The seawater source will be the bay adjacent to the facility. The SPMWD presently utilizes MF technology for treatment of surface water for their municipal and industrial customers and they have sufficient interior space within their facility to house this pilot testing.

Water quality data for the seawater feedstream is shown in Table 1. This sample was collected the week of February 18, 2002.

2.2 Testing Overview and Conditions

The pilot testing will be conducted in two general phases. Phase I will consist of operation of the pretreatment systems to attempt to achieve optimum conditions for each system. Optimum operating conditions to be established for the pretreatment systems include flux, recovery, backwash frequency, operating pressures/vacuum, and bleed rates for each unit, as appropriate. The pretreatment systems to be tested include:

- PT–1: Zenon Zeeweed 1000 UF unit
- PT–2: Norit UF unit
- PT-3: Hydranautics Hydracap UF unit
- PT-4: Memcor CMF MF unit
- PT-5: Conventional pretreatment consisting of:
  - ♦ Chlorination/dechlorination
  - ♦ Coagulant addition, if appropriate
  - ♦ Dual media filtration

Phase II testing will consist of adding two seawater reverse osmosis (SWRO) systems to follow the pretreatment systems. One SWRO system will be fed from combined MF/UF pretreated feedwater, the second from conventionally pretreated feedwater. Optimum conditions to be established include flux, recovery, and cleaning frequency (if needed).

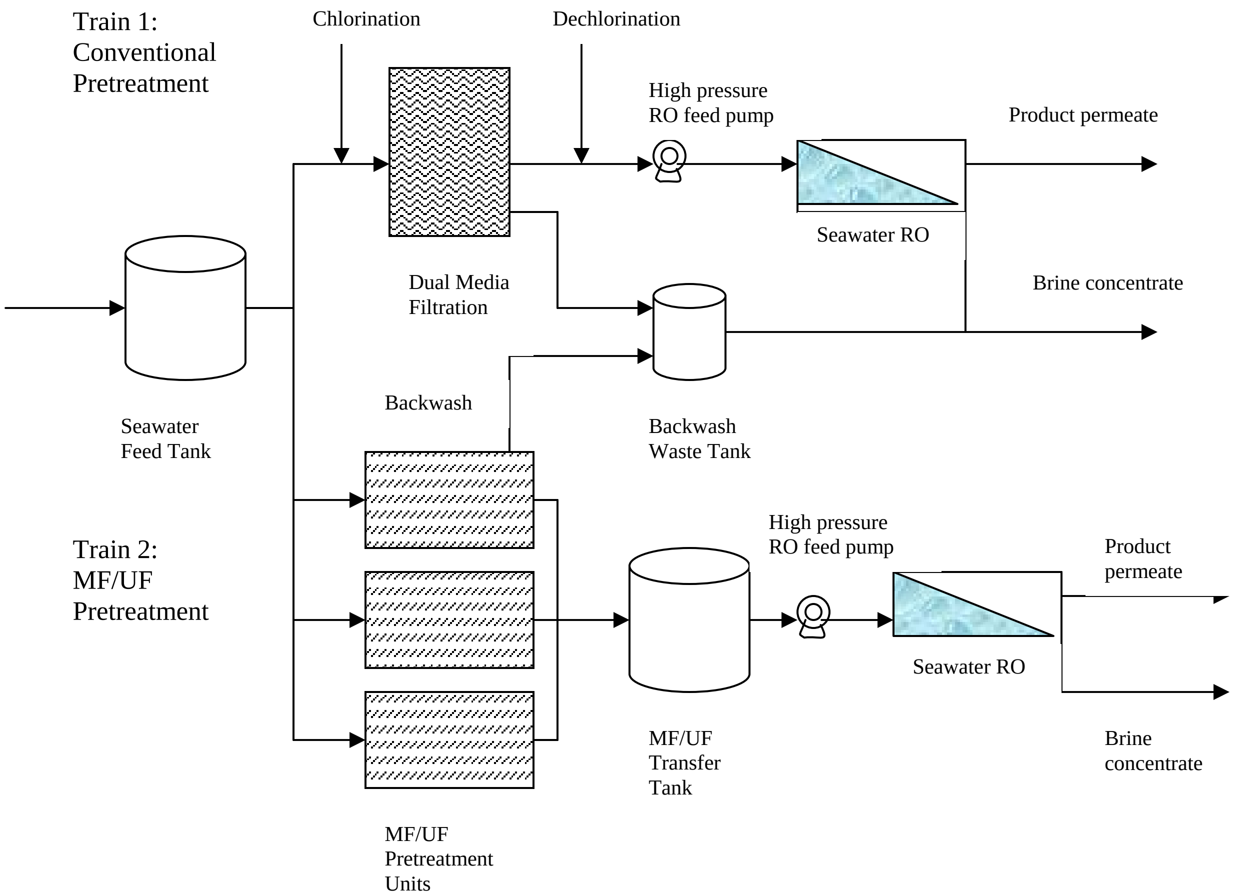
During Phase I, in addition to performance data, the membrane integrity of the MF/UF systems will be monitored. During Phase II, overall cost data will be collected for the combined pretreatment-SWRO systems.

A general flow diagram for the pilot plant is shown in Figure 1.

Table 1.
Water Quality of Seawater Feed

Constituent	Measurement
Temperature of Sample (^{o} C)	17
pH	8.4
Turbidity (NTU)	1.7-1.93
Total Alkalinity (mg/L)	143
Total Hardness (mg/L)	5,060
Calcium Hardness (mg/L)	986
Chlorides (mg/L)	15,700
Conductivity (μS)	40.9-43.9
Total Solids (mg/L)	32,000-36,000
Total Dissolved Solids (mg/L)	30,200
Total Suspended Solids (mg/L)	10-70
Fluoride (mg/L)	0.86
Silica (mg/L)	<1
Total Iron (mg/L)	0.03
Dissolved Iron (mg/L)	<0.01
Sulfate (mg/L)	2,230
Ammonia (mg/L)	0.11
Nitrate (mg/L)	<0.01
Total Phosphorous (mg/L)	0.05
Copper (ppb)	5.5
Bromide (mg/L)	90
Total Organic Carbon (mg/L)	4
UV-254	0.051-0.056
Heterotropic Plate Count	94
Calcium (mg/L)	395
Magnesium (mg/L)	990
Sodium (mg/L)	9,100
Potassium (mg/L)	355
Carbonate (mg/L)	11
Bicarbonate (mg/L)	153
Ion Balance	1.028
Aluminum (mg/L)	0.1
Barium (mg/L)	0.03
Manganese (mg/L)	0.01
Strontium (mg/L)	5.7
Lead (mg/L)	<0.001

Figure 1.
Pilot Study Flow Diagram



2.3 Dependent and Independent Variables

The dependent variables for Phase I testing are shown in Table 2. Table 3 lists the additional Phase II dependent variables, i.e. Phase I dependent variables will also be measured in Phase II.

The independent variables for Phases I and II are listed in Table 4.

Table 2.
Phase I Dependent Variables

Water Quality:
1. Filtrate particle counts, as particles/mL, measured by particle counter.
2. Filtrate heterotrophic plate count (HPC), counts/mL
3. Filtrate turbidity, NTU, measured by online turbidimeters
4. Filtrate TOC, limited
5. Filtrate SDI
Process:
6. Filtrate run time, between backwashes and cleaning at specific flux rate, hours
7. Water recovery, %
8. Fouling rate of downstream RO elements
9. Cleaning frequency, hrs^{-1}
10. Ability to operate w/wo chemical pretreatment
Cost:
11. Chemical assumption, $/day
12. Power cost, $/day
13. Feed and backwash pressures and volumes
14. O&M time required, estimates

Table 3.
Phase II Dependent Variables

Water Quality:
1. Salt transport coefficient, B
2. Salt passage, %
3. Permeate TDS estimated from conductivity, mg/L
4. TOC, mg/L
5. UV absorbence at 254 nm, limited
Process:
6. Water transport coefficient, A, gfd/psig
7. Fouling rate, decrease in A
8. Membrane degradation, increase in A and B
9. Maximum sustainable water recovery, %
10. Salt concentrations in permeate at maximum recovery, mg/L
11. Salt concentrations in reject at maximum recovery, mg/L
Cost:
12. Power cost, $/day
13. Cleaning frequency and requirements
14. O&M time required, estimates

Table 4.
Phase I and II Independent Variables

Phase I and II	
Pretreatment Systems	PT-1: Zenon Zeeweed 1000 UF
	PT-2: Norit UF
	PT-3: Hydranautics Hydracap UF
	PT-4: Memcor CMF MF
	PT-5: Conventional
MF/UF Water flux (gal-ft^{-2}day^{-1})	Low, medium and high
RO Water flux (gal-ft^{-2}day^{-1})	Low and high
RO Recovery	Low and high
Operating Time	As results dictate

2.4 Data Sampling and Frequency

Example data sheets are included in Section 2.6 for operator use for Phase I and II.

Table 5 lists the Operation Data Collection schedule for Phase I, with the related Laboratory analysis schedule shown in Table 6.

Table 7 lists the Operation Data Collection schedule for Phase II, with the related Laboratory analysis schedule shown in Table 8.

Table 5.
Phase I – Operation Data Collection
(to be collected for each MF/UF Unit)

Frequency: Continuous if automatic; 1 time a day if manual (M-F)			
Parameter	Process Streams		
	Raw Feed Water	Filtrate	Backwash Waste
Operation Time			
Temperature, ^{o}C	X		
Pressure, psi	X	X	
Flow, gal/min	X	X	X
Turbidity, NTU	X	X	
Particle Count (if instrumented)		X	
SDI (weekly collection)	X	X	
Backwashing frequency			
Aeration frequency			

Table 6.
Phase I – Weekly Laboratory Data

Frequency: Once per week			
Parameter	Process Streams		
	Raw Water Feed	Filtrate	Backwash Waste
Operation Time			
Temperature, ^oC	X		
pH	X		
TSS, mg/L	X		X
HPC, no./mL	X	X	
Turbidity, NTU	X	X	
Dissolved O_2, mg/L	X		

Table 7.
Phase II - Operation Data Collection

Frequency: Continuous if automatic; 1 times a day if manual (M-F)					
	Process Streams				
Parameter	Raw Water Feed	Pretreated Streams (each)	Transfer Tank (for MF/UF)	Concentrate	Permeate
Operation Time					
Temperature, ^oC	X				
pH	X	X	X		
SDI (weekly)	X	X	X		
Turbidity, NTU	X	X	X		
Pressure, psi	X	X	X[1]	X	
Flow, gal/min		X	X	X	X
Conductivity, μS/cm			X	X	X
Particle Count (if instrumented)		X	X		
Backwash Frequency		X			
Aeration Frequency		X			

[1]Outlet of high pressure pumps

Table 8.
Phase II – Laboratory Data

Frequency: Once per week					
Parameter	Process Streams				
	Raw Feed	Backwash	Transfer Tank	Concentrate	Permeate
Time					
Temperature, ^oC	X		X		
pH	X		X		
Turbidity, NTU	X		X		
HPC, no./mL	X		X	X	X
Frequency: Once every two weeks					
Time					
Temperature, ^oC	X		X		
Conductivity, µS/cm			X	X	X
Inorganic Analyses (see attached)			X	X	X
TOC, mg/L	X	X	X	X	X
UV absorbance at 254 nm			X		
Frequency: Once per month					
TSS, mg/L	X		X		

2.5 Standard Sampling and Analytical Procedures

For laboratory analytical requirements presented in Section 2.3 for monitoring of water quality of each of the process streams, the *Standard Methods for the Examination of Water and Wastewater* (*Standard Methods*), 20th edition, 1998 shall be used. Use of either bench-top or on-line field analytical equipment is acceptable. These recommended standard procedures are listed in Table 9, for inorganic, organic, and general parameters. Alternative methods may be used due to limited analytical instrumentation at SPMWD, but these methods should be discussed and approved by the team members prior to use.

When required, sample preservation should be done in accordance with *Standard Methods.* Adherence to protocol set forth in *Standard Methods* is essential for obtaining accurate, meaningful results. The sample ports should be rinsed with 70% diluted bleach solution, followed by distilled water prior to any bacteriological sampling. Bacteriological samples should be the last sample collected during a sampling period.

Table 9.
Recommended Analytical Procedures

Inorganic Analysis Parameter	Suggested Method
TDS @ 180 ^oC	SM 2540C
Total Alkalinity	SM 2320
Total Hardness	SM 2340
Calcium Hardness	SM 3500-Ca-D
Sodium	SM 3120B
Iron, dissolved and total	SM 3120B
Chloride	SM 4500-Cl-F
Sulfate	EPA 300
Silica (SiO_2)	SM 3120B
Phosphate	SM 4500-F-C
Nitrate	SM 4500-NO3-C
Organic Analysis Parameter	
TOC	SM 5310B
UV absorbance at 254 nm	SM 5910B
Other Parameters	Suggested Method
Temperature	SM 2550B
PH	SM 4500-H-B
TSS	SM 2540D
Specific conductance	SM 2510
Turbidity	EPA 180.1
Heterotrophic plate count (HPC)	SM 9215B

The necessary sampling and monitoring instruments shall be calibrated prior to each day’s use. Fresh pH buffers should be used for calibration of the pH meter.

A chain-of-custody form should accompany any groups of samples that are sent outside of SPMWD for analysis. This form should include the temperature and pH of the sample at the time of collection and note any variance from typical operations of the pilot plant.

Each sample taken for analysis both at SPMWD and outside, should include the following information:

- Sample location
- Sample identification number
- Date
- Time of collection

- Type of preservative, if any
- Initials of sample collector, and
- Any special notes or deviations

The sample collector should use protective eyewear and latex gloves dedicated to this purpose, for safety purposes and to avoid sample contamination. Probes should not be inserted directly into the bulk sampling containers, to prevent contamination of the bulk samples. Separate samples appropriately sized for both pH and conductivity probing should be used, which may be poured from the bulk sample container.

Additional, specific sampling guidance is provided below for particular constituents.

Organic Parameters: TOC, UV-254 Absorbance

Samples for TOC and UV-254 absorbance should be collected in glass bottles, and held at temperatures of approximately 2-8 ^{o}C until analysis. Samples should be processed for analysis within 24 hours of collection.

Turbidity and Conductivity

Turbidity analyses should be performed according to EPA 180.1 with either in-line or bench-top turbidimeters. Most of the MF/UF systems have in-line systems. Conductivity measurements should be made using instruments calibrated prior to each use. Probes should not be inserted into bulk sample containers, but into samples specifically for conductivity measurements.

Membrane Integrity Monitoring (This is under consideration to determine if challenging is really necessary)

During the initial Phase I testing of the MF/UF systems, microbial challenge studies will be conducted for each system to determine microbe rejection. A protocol for the challenge test is included in Appendix B. Prior to the microbial challenge study, a tracer study will be conducted for each MF/UF system to establish the hydraulic stabilization of the system, i.e. contaminant level in = contaminant level out. A protocol for the tracer experiments is being prepared, and will probably utilize sodium chloride, allowing conductivity to be the measurement indicator.

2.6 Data Management

The purpose of data management is to establish a structure for the recording and dispersal of data such that sufficient, reliable, and accurate data is collected. The

Project Manager, Ms. Lisa Henthorne, is responsible for all data entry into computer spreadsheets for membrane analysis. The SPMWD operations staff will record most of the operational data, with support from the project team.

The database for the project is being set up in spreadsheets, which are capable of storing and manipulating the water quality and operational parameters from the specific tasks, including sample location and sample time. The appropriate data from the operations data sheets and laboratory analysis sheets will be entered into the spreadsheets. All team members and SPMWD will have access to monitor the piloting progress via these spreadsheets throughout the project.

Hand-recorded operational data should be documented once per shift (assuming 8-hour shifts) on the provided daily log sheet, as shown in Tables 10 -12, for Phase I and II respectively. The originals should be maintained in 3-ring binders at the SPMWD facility, and faxed to the Project Manager weekly. Additionally, the MF/UF system manufacturers provide suggested data collection forms that contain some data entries unique to the specific equipment. These are being evaluated to determine how best to incorporate this information into the log sheets shown in Tables 10 and 11, or to determine if both sets of collection forms are necessary.

Power costs for operation of the MF/UF systems and the SWRO systems must also be closely monitored and recorded during the pilot testing. Power usage shall be measured by SPMWD operations staff and recorded by shift on the daily log sheet.

Table 10.
Example Phase I – Daily Operational Data Collection Sheet

MF/UF System (Circle One): Zenon Norit Memcor Hydracap Conventional

Parameter	Shift 1	Shift 2
Time		
Operator Initials		
Feed		
T_{feed} (^oC)		
P_{feed} (psi)		
Q_{feed} (gpm)		
pH_{feed}		
$Turbidity_{feed}$(NTU)		
Particle $counts_{feed}$		
SDI_{feed} (weekly)		
Filtrate		
$T_{filtrate}$ (^oC)		
$P_{filtrate}$ (psi)		
$Q_{filtrate}$ (gpm)		
$pH_{filtrate}$		
$Turbidity_{filtrate}$(NTU)		
Particle $counts_{filtrate}$		
$SDI_{filtrate}$ (weekly)		
Backwash		
Q_{bw}(gpm)		
Backwash frequency		
Aeration frequency		
Power usage rate		
Chemical usage (rate)		

Comments____

Table 11.
Example Phase II – Daily Operational Data Collection Sheet

MF/UF System (Circle One): Zenon Norit Memcor Hydranautics

Parameter	**Shift 1**	**Shift 2**
Time		
Operator Initials		
MF/UF Feed		
T_{feed} (^{o}C)		
P_{feed} (psi)		
Q_{feed} (gpm)		
pH_{feed}		
$Turbidity_{feed}$(NTU)		
Particle $counts_{feed}$		
SDI_{feed} (weekly)		
MF/UF Filtrate		
$T_{filtrate}$ (^{o}C)		
$P_{filtrate}$ (psi)		
$Q_{filtrate}$ (gpm)		
$pH_{filtrate}$		
$Turbidity_{filtrate}$(NTU)		
Particle $counts_{filtrate}$		
$SDI_{filtrate}$ (weekly)		
Backwash		
Q_{bw}(gpm)		
Backwash frequency		
Aeration frequency		
Power usage rate		
Chemical usage (rate)		

Comments____

Table 12 - Phase II – Daily Operational Data Collection Sheet – SWRO Systems

Parameter	Shift 1	Shift 2
Time		
Operator Initials		
Transfer Tank Feed		
T_{sw1} (^oC)		
P_{sw1} (psi)		
Q_{sw1} (gpm)		
pH_{sw1}		
$Turbidity_{sw1}$(NTU)		
$Conductivity_{sw1}$ (µS/cm)		
SDI_{sw1} (weekly)		
Concentrate – 1		
P_{conc1} (psi)		
Q_{conc1} (gpm)		
pH_{conc1}		
$Conductivity_{conc1}$ µS/cm)		
Permeate – 1		
P_{perm1} (psi)		
Q_{perm1} (gpm)		
pH_{perm1}		
$Conductivity_{perm1}$ (µS/cm)		
RO Feed Pump Speed - 1		
Conventional Feed		
T_{sw1} (^oC)		
P_{sw1} (psi)		
Q_{sw1} (gpm)		
pH_{sw1}		
$Turbidity_{sw1}$(NTU)		
$Conductivity_{sw1}$ (µS/cm)		
SDI_{sw1} (weekly)		
Concentrate – 2		
P_{conc2} (psi)		
Q_{conc2} (gpm)		
pH_{conc2}		
$Conductivity_{conc2}$ µS/cm)		
Permeate – 2		
P_{perm2} (psi)		
Q_{perm2} (gpm)		
pH_{perm2}		
$Conductivity_{perm2}$ (µS/cm)		
RO Feed Pump Speed – 2		

3.0 PILOT TEST DESCRIPTION AND SCHEDULE

3.1 Pilot Equipment

As presented in Section 2.2, the pilot plant will be composed of two seawater reverse osmosis trains, the first receiving water pretreated with membrane pretreatment, and the second received conventionally pretreated seawater.

3.1.1 Pretreatment Systems

The MF/UF units will start-up with technical support from each of the manufacturers. Operation throughout the testing will be according to manufacturer's direction and they will each be provided weekly data analysis in order to follow the progress of the units. The description for each MF/UF unit is shown in Table 13.

The pretreatment systems to be tested include:

- PT–1: Zenon Zeeweed 1000 UF unit
- PT–2: Norit UF unit
- PT-3: Hydranautics Hydracap UF unit
- PT-4: Memcor CMF MF unit
- PT-5: Conventional pretreatment consisting of:
  - ♦ Chlorination/dechlorination
  - ♦ Coagulant addition, if appropriate
  - ♦ Dual media filtration

Each of the MF/UF pilot units and conventional pretreatments will be monitored individually in Phase I. Optimum operational parameters for each MF/UF unit will be identified and refined in Phase I. Operation at a low, medium, and high rate for each unit will be evaluated. Membrane integrity challenges will also be conducted in Phase I.

Subsequently, in Phase II, the filtrates from the MF/UF units will be mixed in a transfer tank and fed to the SWRO-1 train. The filtrates must meet a water quality criteria, under normal flux conditions and backwashing, of:

- ♦ SDI < 3
- ♦ Turbidity < 0.5 NTU
- ♦ 4-log removal of particles larger than 2 microns

Simultaneously, pretreated seawater from the conventional pretreatment will be fed to the SWRO-2 train.

Table 13.
Pretreatment Pilot Unit Descriptions

Parameter	**PT-1 Zenon**	**PT-2 Norit**	**PT-3 Hydranautics**	**PT-4 Memcor**	**PT-5 Conven-tional**
Unit	Zeeweed 1000 UF	X-Flow	Hydracap		Media Filtration
Number of modules	Three	Two			
Nominal membrane pore size, microns	0.02 microns	150,000 MWCO	150,000 MWCO		NA
Nominal surface area, ft^2		754			NA
Feed pressure max, psig	NA	NA	73		
Transmembrane pressure range, psig	1-8	2-30	4-22		NA
Raw water feed, min, gpm	9	20			
Raw water feed, max, gpm	26	60			
Filtrate flow min, gpm		20			
Filtrate flow max, gpm		60			
Tank size		NA			
Compressed air supply, psi	100 psi	80 psi, included			NA
Process chemicals	NaOCl	NaOCL, acid	NaOCl + NaOH		NaOCl, $NaHSO_3$, coagulant possibly

3.1.2 SWRO Systems

The combined flow rates for the two SWRO units will be 33,120 gal/day of feedwater producing 11,600 gal/day of permeate. Each unit is designed for 35% recovery as a conservative estimate, but will operate in the 35 – 50% recovery range.

Each SWRO unit is comprised of a raw water pump, a cartridge filtration system, a high pressure, positive displacement pump and two (2) 3-element pressure vessels of 4” diameter. The two units share a common frame, permeate tank (for permeate flushing upon shutdown) and control system. Each unit has analog flow, pressure and conductivity instrumentation reporting to a common PLC with a graphic HMI interface. Each unit of the common system is capable of taking a separate feed water source for evaluation of differing pre-treatment technologies. The major components are as follows:

- Two (2) raw water pumps, model PD2HE-l, as manufactured by Sta-Rite
- Four (4) single element cartridge filter vessels, polypropylene
- Two (2) high-pressure pumps as manufactured by Cat Pumps
- Four (4) fiberglass 3-element pressure vessels, model 40-E-100, as manufactured by Pentair/Codeline
- Twelve (12) 4-inch Toray TM810 seawater elements
- Two (2) chemical (scale inhibitor) feed pumps with common day tank
- One (1) 200 gallon permeate storage tank
- One (1) framework of aluminum or fiberglass
- One (1) control system with GE integrated PLC/HMI with graphic display and downloadable data-logger with modem
- One (1) lot instrumentation including the following:
    - Four (4) pressure transmitters
    - Two (2) dual input flow transmitters with four (4) flow elements
    - Two (2) conductivity transmitters
    - Six (6) pressure indicators, with three-way valving to access all points
    - Four (4) pressure switches

The SWRO testing will encompass 6-9 months of operation in which the short- and long-term operation of the pretreatment units and SWRO units are monitored. The SWRO units will be operated at normal and higher flux rates during the test period in order to accelerate potential RO membrane fouling, and to determine the range of flux rates at which the membrane pretreated SWRO unit can effectively operate. Comparison of cleaning requirements will also be monitored during these flux rate experiments.

3.2 Schedule

The schedule for the complete pilot plant testing period is shown is Figure 2 (still being finalized due to total seawater intake capacities still being evaluated).

4.0 PILOT TEST PERFORMANCE

4.1 Pretreatment Performance

4.1.1 MF/UF Pretreatment

The MF/UF systems will be evaluated in Phase I based on the following criteria, in order of priority, based on operation at three flux rates:

- filtrate water quality
- MF/UF unit performance
- total water cost

The three flux rates will be determined from input from the MF/UF manufacturers and based on operating performance during the initial pilot testing. Optimum flux rates will be determined based on the Phase I results, and used for operating each MF/UF unit during the Phase II testing.

In Phase II, the filtrates must meet the following water quality criteria, under normal flux conditions and backwashing, in order to maintain transfer into the SWRO-1 feed tank.

- SDI < 3
- Turbidity < 0.2 NTU
- 4-log removal of particles larger than 2 microns

Microbial challenge tests will also be conducted in Phase I to evaluate the membrane integrity of the MF/UF systems, in order to gain an understanding of the disinfection capability of this pretreatment option. The challenge tests will utilize *Clostribium* and *Bacillus* microbes injected into the MF/UF feedstreams to simulate removal of the more dangerous microorganisms such as *Giaradia* and *Cryptosporidium*. *Clostribium* and *Bacillus* are acceptable surrogate spores due to their spore size of less than 3 microns.
Cryptosporidium has a spore size of approximately 4-6 microns and *Giaradia* a spore size of approximately 10-12 microns. The goal is to achieve a 5 to 6-log removal of *Clostribium* and *Bacillus* in order to similate a similar removal leval of *Giaradia* and *Cryptosporidium.*

4.1.2 Conventional Pretreatment

The conventional pretreatment system will consist of media filtration and chlorination/dechlorination, with the capability to utilize coagulant addition upstream of the media filtration if necessary. Performance will be monitored using SDI and turbidity readings, as well as chlorine detection, to ensure adequate pretreatment is being achieved. Minimal standards for the conventional pretreatment system include:

- SDI < 5
- Turbidity < 1 NTU

If these standards cannot be met during Phase I testing without coagulant addition, then coagulant addition will be utilized.

4.2 Reverse Osmosis Performance

The criteria by which the RO systems will be evaluated include:

- productivity
- permeate water quality
- cleaning requirements
- total water cost

Productivity will be assessed by the rate of specific flux decline over time of operation. Flux decline is a function of feedwater quality, membrane type and operational conditions. The limiting salt information will be used to define the range of operational conditions (recoveries) that are practical. Subsequent water quality analysis will provide for assessment of the degree of saturation of the sparingly soluble salts in the concentrate streams. The degree of saturation of the salts shall then be compared to the resulting membrane productivity decline. At least two RO flux rates will be evaluated in Phase II for both the SWRO-1 and SWRO-2 systems.

Permeate water quality will be assessed to monitor RO membrane performance, as it can be affected as membrane fouling increases.

Cleaning needs of the RO systems can be determined by monitoring the system performance. The guidelines for determining whether cleaning is required are as follows. If one of these thresholds is met, cleaning should be instigated:

- 10-15% decrease in normalized permeate flow
- 10%-15 increase in feed pressure
- 10% increase in normalized system differential pressure
- 10% decrease in normalized flux

Cleaning of the SWRO systems will be per manufacturer's suggestion. These cleaning events should be documented both in terms of chemicals requirements, duration of cleaning, and overall downtime, as well as the cleaning solution should be analyzed to determine which constituents may have adsorbed or precipitated onto the membrane surface.

The pH of each cleaning solution should be documented during the chemical cleaning procedure. Conductivity and turbidity should also be used to monitor flushing steps. Flow and pressure data should be collected before system shutdown and recollected after chemical cleaning.

At the conclusion of each chemical cleaning event and upon return to membrane operation, the initial condition of transmembrane pressure should be recorded and the specific flux calculated. The efficiency of the chemical cleaning should be evaluated by the recovery of specific flux, compared to recoveries from previous cleanings, if any.

5.0 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control (QA/QC) measures are instrumental to the success of this pilot study, to ensure accurate and consistent data is collected and can be verified should uncertainties arise. The project team has a QA/QC engineer, Dr. Steve Duranceau of Boyle Engineering. His responsibilities include assurance that appropriate QA/QC measures are in place and implemented throughout the study.

5.1 System Calibration and Verification

Calibration of all measuring and monitoring equipment should be conducted on a routine basis, as discussed in Section 2 of this test protocol. A daily walk-through to inspect each piece of equipment and instrumentation should also be conducted, to ensure proper operation. In-line monitoring equipment should be checked to ensure that the read-out and the actual measurement are the same and that the signals being recorded by the data loggers are correct.

Specific QA/QC verifications that should be conducted include the following.

<u>Daily Verifications</u>

- On-line conductivity meters (check and verify components)
- On-line turbidimeter flow rates (verify volumetrically)
- Any chemical feed pump flow rates (verify volumetrically)

<u>Weekly Calibrations and Verifications</u>

- On-line conductivity meters (recalibrate)
- In-line flow meters/rotometers (clean equipment to remove buildup and verify flows volumetrically)

<u>Monthly Calibrations and Verifications</u>

- On-line turbidimeters (clean out reservoirs and recalibrate)
- On-line conductivity meters (recalibrate)
- Differential pressure transmitters (verify gauge readings and electrical signals)
- Tubing and connections (verify in good condition)

6.0 ECONOMIC EVALUATION

This study focuses on evaluating membrane pretreatment versus conventional pretreatment for SWRO. Integral to this evaluation is the cost comparison of these two pretreatment options. Based on data collected during this pilot study, O&M, capital, and total life-cycle costs for a 10 and 25 million gal/day seawater desalting facility will be developed, both for conventional and membrane pretreatment scenarios. The design parameters for these facilities are shown in Table 14.

The O&M costs to be included from scale-up of the pilot data to the large-scale facilities are shown in Table 15, including labor, electricity, chemicals and membrane replacement. Though the pilot plant is too small to employ energy recovery devices, an estimate of these cost savings will be incorporated into the large-scale cost estimation.

Capital costs to be included in the economic evaluation are shown in Table 16, and include site, building, equipment, and financing costs.

Table 14
Design Parameters for Economic Evaluation
(most inputs determined after testing)

Design Parameter	MF/UF Pretreatment	Conventional Pretreatment
Total plant production (mgd)	10 and 25	10 and 25
Recovery (%)	45%	45%
Required membrane train capacity (mgd)		
High/low feed water temperatures (^oC)	22 and 27	22 and 27
Average flux (gsfd/psi)		
Maximum flux (gsfd/psi)		
Cleaning frequency (days)		
High/low feed TDS (mg/L)	25,000 and 35,000	25,000 and 35,000

Table 15
Operations and Maintenance Costs

(most inputs determined after testing)Cost Parameter	MF/UF Pretreatment	Conventional Pretreatment
Labor rate + fringe ($/personnel/hr)		
Labor overhead factor (% of labor)		
Number of O&M personnel hours per week		
Electric rate ($/kWh)		
Power usage rate (kWh/week)		
Membrane replacement frequency (%/yr)		
Chemical dosage (per week)		
Chlorine		
Sodium bisulfite		
Coagulant		
Scale inhibitor		
Caustic		
Cleaning chemicals		

Table 16
Capital Costs
(most inputs determined after testing)

Capital Cost Parameter	MF/UF Pretreatment	Conventional Pretreatment
SWRO membrane equipment area (ft^2/mgd)		
Pretreatment equipment area (ft^2/mgd)		
Building costs ($/$ft^2$)		
Pretreatment equipment ($/mgd)		
Cost of standard 8"x40" membrane element ($)		
SWRO equipment cost ($/mgd)		
Electrical room (ft^2/mgd)		
Chemical room (ft^2/mgd)		
Control room (ft^2/mgd)		
Generator (ft^2)		
Land area requirements (ft^2)		
Land costs, ($/$ft^2$)		
Capital recovery interest rate (%)		
Capital recovery period (years)		
Overhead and profit factor (% of construction)		
Construction contingencies (% of construction)		
Engineering fee factor (% of construction)		
Insurance and bonds (% of construction)		

Appendices

Appendix A – Glossary of Terms

- **Bulk Rejection –** Percent solute concentration retained by the membrane relative to the bulk stream concentration.

- **Bulk Solution –** The solution on the high-pressure side of the membrane that has a water quality between that of the influent and concentrate streams.

- **Concentrate –** One of the membrane output streams that has a more concentrated water quality than the feed stream.

- **Conventional RO Process –** A treatment consisting of acid and/or scale inhibitor addition for scale control, cartridge filtration, RO membrane filtration, aeration, chlorination and corrosion control.

- **Feed –** Input stream to the membrane process after pretreatment.

- **Flux** – Mass (lb/ft^2 –day) or volume (gal/ft^2 – day, gsfd, gfd) rate of transfer through membrane surface.

- **Fouling –** Reduction of productivity measured by a decrease in the temperature normalized water MTC.

- **Influent –** Input stream to the membrane array after the recycle stream has been blended with the feed stream. If there is no concentrate recycle then the feed and influent streams are identical.

- **Mass Transfer Coefficient (MTC) –** Mass or volume unit transfer through membrane based on driving force (gfd/psi).

- **Membrane Element –** A single membrane unit containing a bound group of spiral wound or hollow fiber membranes to provide a nominal surface area for treatment.

- **Membrane System –** An operating water system using membrane elements as the media for process.

- **Permeate –** The membrane output stream that has convected through the membrane.

- **Pressure Vessel** – A single tube or housing that contains several membrane elements in series.

- **Productivity –** The efficiency with which a membrane system produces permeate over time.

- **Raw** – Input Stream to the membrane process prior to any pretreatment.
- **Recovery –** The ratio of permeate flow to feed flow.
- **Rejection (mass) –** The mass of a specific solute entering a membrane system that does not pass through the membrane.
- **Scaling –** The precipitation of solids into the membrane surface due to solute concentrations on the concentrate side of the membrane exceeding solubility and precipitating onto membrane surface.
- **Solute –** The dissolved constituent in a solution or process stream.
- **Solvent –** A substance, usually a liquid such as water, capable of dissolving other substances.
- **Staging –** Parallel configuration of pressure vessels.
- **Total Organic Carbon (TOC) –** A measure of the organic matter in water in terms of the organic content.

Appendix B – Microbial Challenge Testing Protocol

Introduction

Microbial challenge tests are needed for the "Evaluation of Membrane Pretreatment for Seawater Reverse Osmosis Desalination Pilot Study" in order to assist in evaluating the membrane integrity and disinfection capability of the membrane pretreatment options (microfiltration (MF) and ultrafiltration (UF)). The challenge tests will utilize direct injection of surrogate spores of marine bacteria to simulate the retention of these species by the MF and UF membranes. It is desirable to evaluate a 6 to 8 log assessment of the surrogate spores.

Methods and Materials

The challenge experiments will be implemented using primarily one of the MF/UF units, and potentially additional MF/UF units, as well as the conventional pretreatment unit. The limiting factor is the feed flow available for testing, which may be limited to operation of one MF/UF unit at a time.

Dr. Joanna Mott of Texas A&M University, Corpus Christi, will coordinate and supervise the laboratory requirements of the challenge tests, with microbial analysis being conducted at the Dept. of Physical and Life Sciences laboratory (Microbial Laboratory). Samples will require same-day collection, transport, and laboratory delivery.

The challenge experiments are expected to be conducted over a 3-5 day period. It is desirable to evaluate the MF/UF unit under steady state conditions. Continuous spiking is achievable by injection into a batch feed tank in the case of most of the MF/UF units.

Each sampling location will be sampled for the surrogate spores, humic and fulvic acids and turbidity. The Microbial Laboratory will specify the required sample volume, container type and preparation along with sample collection procedures. Turbidity samples will be collected in a beaker or bottle and will be analyzed at the on-site laboratory.

Samples will be obtained at times and locations specified in the attached table. The sampling times are estimates, and will be dependent on NaCl tracer tests performed prior to the challenge tests.

The Microbial Laboratory will provide the concentration estimates of the surrogate species, which will determine the required volume of spiking solution for each challenge event.

Challenge Testing Sampling Locations and Sampling Times

Sample ID	Sample Name	Sample Location	Time
UF-1	UF Feed	UF Feed Tank	After spike and 5 minutes of mixing in UF feed tank
UF-2	UF Feed	UF Feed Tank	Approximately 10 minutes after feed tank spike and restart
UF-3	UF Filtrate	Filtrate sample port	Approximately 10 minutes after feed tank spike and restart
UF-4	UF Feed	UF Feed Tank	Approximately 20 minutes after feed tank spike and restart
UF-5	UF Filtrate	Filtrate sample port	Approximately 20 minutes after feed tank spike and restart
Conv-1	Conv Feed	Conv Feed Tank	After spike and 5 minutes of mixing in conv feed tank
Conv-2	Conv Feed	Conv Feed Tank	After spike and 8 minutes of feed tank spike and restart
Conv-3	Conv Effluent	Conv effluent port	After spike and 8 minutes of feed tank spike and restart
Conv-4	Conv Feed	Conv Feed Tank	After spike and 12 minutes of feed tank spike and restart
Conv-5	Conv Effluent	Conv effluent port	After spike and 12 minutes of feed tank spike and restart

Example Zenon UF Pilot System

The UF unit draws water from a 185 (?) gallon feed tank with raw seawater via a float valve. The unit will shutdown if the level in this tank falls below approximately 3 inches. The unit draws from 9-26 gpm of raw water depending upon operational conditions and enters a 30-second automatic backwash every 15 minutes (?).

It is proposed that spiking of the system be conducted as follows:

1. Prepare data collection sheet and record all data specified.

2. Collect raw and filtrate samples for turbidity and humic and fulvic acids.

3. Shut down the UF unit and close the raw water influent valve.

4. Drain the UF filtrate tank.

5. Direct permeate and concentrate lines to waste container for temporary storage and disinfection.

6. Add the aliquot of the challenge material suspension to the feed tank and allow blower to run approximately 5 minutes for mixing.

7. Obtain feed sample from the feed tank.

8. Restart the UF unit.

9. Collect feed and filtrate samples at the times indicated in the table after the unit has been restarted.

10. After the feed tank is emptied, refill with seawater and continue washing the UF system and backwash to ensure microbes have been flushed from the system.

11. Disinfect filtrate and backwash water using sufficient amounts of sodium hypochlorite.

Appendix 2 –
Data Record

RO Unit 1 – Membrane Pretreatment

Date	days	FPress1 PSI	CPress1 PSI	Pflow1 gpm	Cflow1 gpm	PCond	delta P	P+C flow	Flux gfd	Temp-C	TCF	TC-Flux gfd	TC-Flux Lmh	A	Rejection
04/13/2002	0.0	595	595	2.40	7.45	705		9.85	7.89	23	1.07	8.46	14.31	0.0439	98.397
04/13/2002	0.2	598	582.8	2.25	9.09	706	15.2	11.34	7.40	25	1.00	7.40	12.50	0.0381	98.370
04/13/2002	0.5	598	582.7	2.70	7.45	721	15.3	10.15	8.88	24	1.04	9.19	15.54	0.0502	98.381
04/14/2002	0.7	594	579.2	2.70	7.36	731	14.8	10.06	8.88	24	1.04	9.19	15.54	0.0489	98.324
04/14/2002	1.1	588	572.7	2.63	7.54	721	15.3	10.17	8.63	26	0.97	8.34	14.09	0.0487	98.388
04/19/2002	6.1	588	572.9	2.70	7.91	705	15.1	10.61	8.88	24	1.04	9.19	15.54	0.0512	98.392
04/29/2002	16.1	572	556.3	2.63	7.54	802	15.7	10.17	8.63	28	0.90	7.78	13.15	0.0491	98.197
04/29/2002	16.2	582	566.4	2.63	7.54	716	15.6	10.17	8.63	26	0.97	8.34	14.09	0.0498	98.391
04/30/2002	17.1	579	563.7	2.63	7.54	661	15.3	10.17	8.63	26	0.97	8.34	14.09	0.0509	98.514
05/03/2002	20.1	575	559.7	2.63	7.64	505	15.3	10.26	8.63	26	0.97	8.34	14.09	0.0528	98.865
05/06/2002	23.1	605	589.8	2.33	7.82	278	15.2	10.14	7.64	26	0.97	7.38	12.48	0.0399	99.375
05/07/2002	23.3	594	578.7	2.40	7.91	351	15.3	10.31	7.89	26	0.97	7.62	12.88	0.0436	99.211
05/08/2002	23.7	593	577.2	2.25	7.54	374	15.8	9.79	7.40	26	0.97	7.14	12.07	0.0411	99.159
05/14/2002	29.1	595	579.1	2.33	7.82	619	15.9	10.14	7.64	25	1.00	7.64	12.92	0.0439	98.624
05/15/2002	29.5	592	576.5	2.40	8.18	571	15.5	10.58	7.89	23	1.07	8.46	14.31	0.0525	98.759
05/15/2002	29.8	593	577.4	2.25	8.09	699	15.6	10.34	7.40	25	1.00	7.40	12.50	0.0668	98.648
05/16/2002	30.0	592	576.6	2.25	7.64	706	15.4	9.89	7.40	26	0.97	7.14	12.07	0.0650	98.634
05/16/2002	30.3	591	575.1	2.40	7.45	738	15.9	9.85	7.89	25	1.00	7.89	13.33	0.0735	98.578
05/17/2002	30.6	585	569.1	2.40	7.64	565	15.9	10.04	7.89	27	0.93	7.36	12.44	0.0743	98.911
05/17/2002	31.1	582	566.2	2.33	7.27	770	15.8	9.60	7.64	26	0.97	7.38	12.48	0.0748	98.516
05/18/2002	31.5	575	559.3	2.40	7.82	696	15.7	10.22	7.89	26	0.97	7.62	12.88	0.0702	98.608
05/18/2002	31.8	584	568.3	2.48	7.64	725	15.7	10.11	8.14	25	1.00	8.14	13.75	0.0576	98.474
05/18/2002	32.1	584	568.2	2.48	7.73	741	15.8	10.20	8.14	26	0.97	7.86	13.28	0.0575	98.456
05/19/2002	32.5	587	571.1	2.40	7.54	746	15.9	9.94	7.89	26	0.97	7.62	12.88	0.0584	98.478
05/19/2002	33.1	588	572.7	2.33	7.73	865	15.3	10.05	7.64	26	0.97	7.38	12.48	0.0695	98.333
05/20/2002	33.5	591	575.7	2.40	7.73	764	15.3	10.13	7.89	26	0.97	7.62	12.88	0.0655	98.502
05/21/2002	34.1	588	572.2	2.48	7.73	691	15.8	10.20	8.14	25	1.00	8.14	13.75	0.0771	98.663
05/22/2002	34.5	591	575.6	2.33	7.54	675	15.4	9.87	7.64	26	0.97	7.38	12.48	0.0641	98.676
05/22/2002	35.5	588	572.1	2.40	7.73	665	15.9	10.13	7.89	25	1.00	7.89	13.33	0.0706	98.696
05/22/2002	35.7	589	573.7	2.48	7.27	641	15.3	9.75	8.14	25	1.00	8.14	13.75	0.0667	98.718
05/23/2002	36.3	586	570.1	2.40	7.36	651	15.9	9.76	7.89	26	0.97	7.62	12.88	0.0594	98.671
05/23/2002	36.6	584	568.9	2.40	8.00	656	15.1	10.40	7.89	25	1.00	7.89	13.33	0.0623	98.661
05/23/2002	37.0	580	564.5	2.40	7.54	670	15.5	9.94	7.89	27	0.93	7.36	12.44	0.0600	98.633
05/24/2002	37.3	582	566.7	2.63	7.36	680	15.3	9.99	8.63	26	0.97	8.34	14.09	0.0667	98.612
05/29/2002	42.3	555	539.8	2.63	7.27	682	15.2	9.90	8.63	28	0.90	7.78	13.15	0.0794	98.608
05/29/2002	42.5	565	549.4	2.63	7.64	689	15.6	10.26	8.63	26	0.97	8.34	14.09	0.0773	98.594
05/30/2002	43.0	548	532.7	2.55	7.45	681	15.3	10.00	8.38	27	0.93	7.82	13.22	0.0860	98.610
06/03/2002	43.2	551	535.7	2.55	7.45	998	15.3	10.00	8.38	27	0.93	7.82	13.22	0.0798	97.963
06/04/2002	43.5	555	539.3	2.55	3.09	1061	15.7	5.64	8.38	27	0.93	7.82	13.22	0.0762	97.835
06/05/2002	45.0	559	543.7	2.63	6.91	1375	15.3	9.53	8.63	27	0.93	8.05	13.61	0.0732	97.200
06/05/2002	45.3	547	531.7	2.48	7.27	1358	15.3	9.75	8.14	27	0.93	7.59	12.83	0.0776	97.234
06/06/2002	45.7	548	532.7	2.63	7.64	1311	15.3	10.26	8.63	27	0.93	8.05	13.61	0.0820	97.330
06/06/2002	46.0	549	533.2	2.63	7.64	1341	15.8	10.26	8.63	27	0.93	8.05	13.61	0.0851	97.296
06/06/2002	46.4	564	548.6	2.78	7.27	1313	15.4	10.05	9.12	27	0.93	8.51	14.39	0.0777	97.353
06/07/2002	46.7	563	547.1	2.85	7.18	1289	15.9	10.03	9.37	27	0.93	8.74	14.77	0.0810	97.401
06/07/2002	47.4	559	543.7	2.78	7.09	1409	15.3	9.87	9.12	27	0.93	8.51	14.39	0.0764	97.124
06/08/2002	47.7	580	564.4	2.78	7.18	1400	15.6	9.96	9.12	27	0.93	8.51	14.39	0.0532	96.957
06/08/2002	48.1	560	544.6	2.78	7.18	1317	15.4	9.96	9.12	29	0.87	7.95	13.43	0.0510	97.021
06/08/2002	48.4	558	542.6	2.63	7.36	1399	15.4	9.99	8.63	30	0.84	7.27	12.28	0.0475	96.849
06/09/2002	48.7	580	564.7	2.78	7.45	1399	15.3	10.23	9.12	29	0.87	7.95	13.43	0.0454	96.849
06/09/2002	49.0	562	546.5	2.70	7.54	1339	15.5	10.24	8.88	29	0.87	7.73	13.07	0.0553	97.099
06/09/2002	49.4	555	539.6	2.78	7.45	1419	15.4	10.23	9.12	30	0.84	7.68	12.99	0.0573	96.925
06/10/2002	49.7	563	547.7	2.70	7.64	1419	15.3	10.34	8.88	29	0.87	7.73	13.07	0.0544	96.925
06/10/2002	50.3	557	541.5	2.63	7.54	1489	15.5	10.17	8.63	29	0.87	7.52	12.71	0.0549	96.774
06/12/2002	52.3	550	535.1	2.93	7.54	1480	14.9	10.47	9.62		2.59	24.93	42.13	0.1916	96.793
06/12/2002	52.8	559	544.1	2.85	7.73	1443	14.9	10.58	9.37	29	0.87	8.16	13.80	0.0589	96.873
06/12/2002	53.1	559	544.2	2.78	7.09	1483	14.8	9.87	9.12		2.59	23.65	39.97	0.1699	96.787
07/24/2002	53.2	369	354	4.50	5.64	155	15	10.14	14.79	29	0.87	12.89	21.78	0.3593	99.557
07/29/2002	58.2	356	341.1	4.73	5.64	160	14.9	10.36	15.53	29	0.87	13.53	22.87	0.5887	99.543
07/30/2002	58.5	354	339.2	4.73	5.64	161	14.8	10.36	15.53	29	0.87	13.53	22.87	0.6429	99.540
07/31/2002	59.6	354	339.1	5.70	4.91	167	14.9	10.61	18.74	30	0.84	15.78	26.67	0.7487	99.523
08/01/2002	60.9	409	394.5	5.03	5.54	170	14.5	10.57	16.52	30	0.84	13.91	23.52	0.1823	99.514
08/01/2002	61.2	415	401	4.88	5.36	164	14	10.24	16.03	30	0.84	13.50	22.81	0.1636	99.531
08/03/2002	61.7	397	382.9	5.33	5.27	163	14.1	10.60	17.51	31	0.81	14.26	24.10	0.2213	99.534
08/03/2002	61.9	356	341.6	4.50	5.54	159	14.4	10.04	14.79	31	0.81	12.05	20.36	0.5187	99.546
08/03/2002	62.3	404	390	5.10	5.36	171	14	10.46	16.77	30	0.84	14.12	23.87	0.1973	99.511
08/06/2002	62.4	419	405.1	3.90	6.45	170	13.9	10.35	12.82	30	0.84	10.80	18.25	0.1247	99.514
08/07/2002	62.7	379	365.2	3.38	7.09	169	13.8	10.47	11.10	31	0.81	9.04	15.27	0.1937	99.517
08/27/2002	62.8	462	448.1	2.63	7.36	157	13.9	9.99	8.63	30	0.84	7.27	12.28	0.0562	99.551
02/18/2003	62.8	619	605.2	3.15	7.09	174	13.8	10.24	10.36	18	1.28	13.30	22.48	0.0624	99.594
02/19/2003	63.8	620	606.2	3.23	6.91	166	13.8	10.13	10.60	18	1.28	13.32	22.51	0.0623	99.613
02/19/2003	64.1	623	609.1	3.30	7.00	162	13.9	10.30	10.85	18	1.28	13.40	22.65	0.0618	99.622

02/20/2003	64.4	622	608.3	3.15	6.82	160	13.7	9.97	10.36	18	1.28	13.30	22.48	0.0616	99.627
02/21/2003	65.4	621	607.3	3.15	6.82	162	13.7	9.97	10.36	18	1.28	13.30	22.48	0.0619	99.622
02/23/2003	66.5	620	606.1	3.23	6.73	164	13.9	9.95	10.60	18	1.28	13.62	23.01	0.0637	99.618
02/25/2003	68.0	618	604.3	3.23	6.82	164	13.7	10.04	10.60	18	1.28	13.62	23.01	0.0643	99.618
03/13/2003	85.4	616	602.4	3.15	6.73	175	13.6	9.88	10.36	20	1.19	12.37	20.90	0.0589	99.592
03/13/2003	86.1	610	596.3	3.30	6.82	171	13.7	10.12	10.85	20	1.19	12.96	21.90	0.0635	99.601
03/16/2003	89.1	600	586.3	3.30	7.09	198	13.7	10.39	10.85	20	1.19	12.96	21.90	0.0667	99.538
03/18/2003	91.1	605	591.3	3.23	7.09	194	13.7	10.32	10.60	20	1.19	12.66	21.40	0.0635	99.548
03/19/2003	92.1	607	593.5	3.30	7.09	194	13.5	10.39	10.85	20	1.19	12.96	21.90	0.0643	99.548
03/19/2003	92.3	603	589.3	3.30	7.09	180	13.7	10.39	10.85	20	1.19	12.96	21.90	0.0657	99.580
03/20/2003	93.3	633	619.4	3.38	7.27	162	13.6	10.65	11.10	20	1.19	13.25	22.39	0.0584	99.622
03/24/2003	97.3	601	587.3	3.38	6.82	185	13.7	10.19	11.10	20.7	1.16	12.92	21.84	0.0662	99.569
03/25/2003	98.3	596.19	582.59	3.38	6.67	168.8	13.6	10.05	11.12	21	1.15	12.81	21.65	0.0674	99.607
03/25/2003	98.3	598.79	585.29	3.26	6.79	194	13.5	10.05	10.70	20	1.19	12.78	21.60	0.0662	99.548
03/25/2003	98.3	599.49	586.09	3.35	6.54	200.6	13.4	9.89	11.00	21	1.15	12.67	21.41	0.0653	99.532
03/25/2003	98.3	599.19	585.79	3.31	6.74	201.4	13.4	10.04	10.87	21	1.15	12.53	21.17	0.0647	99.531
03/25/2003	98.3	599.19	585.79	3.23	6.70	200.8	13.4	9.92	10.60	21	1.15	12.21	20.64	0.0630	99.532
03/25/2003	98.4	599.39	585.89	3.27	6.64	200.6	13.5	9.91	10.75	21	1.15	12.39	20.93	0.0639	99.532
03/25/2003	98.4	599.89	586.19	3.26	6.70	199.4	13.7	9.96	10.73	21	1.15	12.36	20.88	0.0636	99.535
03/25/2003	98.4	599.99	586.49	3.37	6.81	198.8	13.5	10.18	11.07	21	1.15	12.75	21.56	0.0656	99.537
03/25/2003	98.4	600.29	586.79	3.35	6.52	198.2	13.5	9.86	11.00	21	1.15	12.67	21.41	0.0651	99.538
03/25/2003	98.4	599.89	586.29	3.32	6.58	198	13.6	9.90	10.92	20	1.19	13.05	22.05	0.0671	99.538
03/25/2003	98.4	599.99	586.49	3.30	7.00	197.6	13.5	10.30	10.85	20	1.19	12.96	21.90	0.0666	99.539
03/25/2003	98.4	600.19	586.69	3.29	7.01	197.4	13.5	10.30	10.82	20	1.19	12.93	21.85	0.0664	99.540
03/25/2003	98.4	600.09	586.59	3.37	6.78	197	13.5	10.15	11.07	20	1.19	13.22	22.34	0.0680	99.541
03/25/2003	98.4	599.89	586.29	3.38	7.34	196.8	13.6	10.72	11.12	20	1.19	13.28	22.44	0.0684	99.541
03/25/2003	98.4	600.19	586.59	3.35	6.81	196.8	13.6	10.16	11.02	20	1.19	13.16	22.25	0.0676	99.541
03/25/2003	98.4	600.29	586.89	3.35	6.99	196.2	13.4	10.34	11.02	20	1.19	13.16	22.25	0.0676	99.543
03/25/2003	98.4	601.19	587.59	3.35	7.34	195.4	13.6	10.70	11.02	20	1.19	13.16	22.25	0.0673	99.545
03/25/2003	98.4	600.59	587.09	3.36	6.42	195.6	13.5	9.78	11.05	20	1.19	13.19	22.30	0.0676	99.544
03/25/2003	98.4	600.89	587.39	3.42	6.71	195.4	13.5	10.13	11.24	20	1.19	13.43	22.69	0.0688	99.545
03/25/2003	98.4	600.69	587.19	3.25	6.98	195.4	13.5	10.23	10.68	20	1.19	12.75	21.55	0.0653	99.545
03/25/2003	98.4	600.49	586.99	3.31	6.27	195.6	13.5	9.58	10.87	20	1.19	12.99	21.95	0.0666	99.544
03/25/2003	98.4	600.99	587.59	3.38	6.90	194.8	13.4	10.27	11.10	20	1.19	13.25	22.39	0.0678	99.546
03/25/2003	98.4	600.79	587.39	3.26	6.69	195	13.4	9.95	10.70	20	1.19	12.78	21.60	0.0655	99.545
03/25/2003	98.4	600.69	587.29	3.40	6.94	194.8	13.4	10.33	11.17	20	1.19	13.34	22.54	0.0684	99.546
03/25/2003	98.4	600.59	587.29	3.34	6.86	195	13.3	10.20	10.97	20	1.19	13.10	22.15	0.0672	99.545
03/25/2003	98.4	600.29	586.89	3.36	7.04	194.8	13.4	10.40	11.05	20	1.19	13.19	22.30	0.0677	99.546
03/25/2003	98.4	600.29	586.99	3.35	6.70	194.8	13.3	10.04	11.00	20	1.19	13.13	22.20	0.0674	99.546
03/25/2003	98.4	600.19	586.79	3.38	6.60	194.8	13.4	9.97	11.10	20	1.19	13.25	22.39	0.0681	99.546
03/25/2003	98.4	600.59	587.09	3.36	6.44	194.6	13.5	9.80	11.05	20	1.19	13.19	22.30	0.0677	99.546
03/25/2003	98.4	600.39	586.89	3.46	6.67	194.8	13.5	10.13	11.37	20	1.19	13.58	22.94	0.0697	99.546
03/25/2003	98.4	600.09	586.59	3.30	7.13	194.2	13.5	10.43	10.85	20	1.19	12.96	21.90	0.0666	99.547
03/25/2003	98.4	599.89	586.59	3.36	6.66	194.2	13.3	10.02	11.05	20	1.19	13.19	22.30	0.0679	99.547
03/25/2003	98.4	600.19	586.79	3.44	7.32	194.4	13.4	10.75	11.29	20	1.19	13.49	22.79	0.0693	99.547
03/25/2003	98.4	599.89	586.49	3.42	6.64	194	13.4	10.06	11.24	20	1.19	13.43	22.69	0.0691	99.548
03/25/2003	98.5	600.29	586.69	3.39	6.63	193.6	13.6	10.02	11.15	20	1.19	13.31	22.49	0.0684	99.549
03/25/2003	98.5	600.29	586.99	3.35	6.56	193.4	13.3	9.91	11.00	20	1.19	13.13	22.20	0.0674	99.549
03/25/2003	98.5	599.89	586.49	3.42	6.69	193.6	13.4	10.11	11.24	20	1.19	13.43	22.69	0.0691	99.549
03/25/2003	98.5	599.59	586.29	3.23	6.50	193.6	13.3	9.73	10.63	20	1.19	12.69	21.45	0.0654	99.549
03/25/2003	98.5	600.49	586.99	3.44	6.53	192.6	13.5	9.97	11.32	20	1.19	13.52	22.84	0.0694	99.551
03/25/2003	98.5	600.09	586.59	3.43	6.74	193.2	13.5	10.17	11.27	20	1.19	13.46	22.74	0.0692	99.550
03/25/2003	98.5	600.39	586.89	3.44	6.80	192.6	13.5	10.24	11.32	20	1.19	13.52	22.84	0.0694	99.551
03/25/2003	98.5	600.09	586.69	3.33	6.96	192.8	13.4	10.29	10.95	20	1.19	13.07	22.10	0.0672	99.551
03/25/2003	98.5	600.09	586.69	3.32	6.79	192.8	13.4	10.11	10.90	20	1.19	13.02	22.00	0.0669	99.551
03/25/2003	98.5	599.69	586.39	3.29	6.84	192.6	13.3	10.14	10.82	20	1.19	12.93	21.85	0.0666	99.551
03/25/2003	98.5	599.99	586.59	3.41	6.58	192.2	13.4	9.99	11.19	20	1.19	13.37	22.59	0.0688	99.552
03/25/2003	98.5	600.49	587.09	3.32	6.44	191.4	13.4	9.77	10.92	20	1.19	13.05	22.05	0.0669	99.554
03/25/2003	98.5	600.09	586.59	3.36	7.18	192	13.5	10.54	11.05	20	1.19	13.19	22.30	0.0678	99.552
03/26/2003	98.7	598.29	584.59	3.41	6.30	173.6	13.7	9.70	11.19	20	1.19	13.37	22.59	0.0695	99.595
03/26/2003	98.7	598.89	585.19	3.37	6.99	192.6	13.7	10.36	11.07	20	1.19	13.22	22.34	0.0684	99.551
03/26/2003	98.7	599.09	585.39	3.38	7.15	196.6	13.7	10.53	11.10	20	1.19	13.25	22.39	0.0685	99.542
03/26/2003	98.7	599.49	585.79	3.35	6.76	196	13.7	10.12	11.02	20	1.19	13.16	22.25	0.0679	99.543
03/26/2003	98.7	599.19	585.59	3.36	6.73	196	13.6	10.09	11.05	20	1.19	13.19	22.30	0.0682	99.543
03/26/2003	98.7	599.59	585.89	3.39	7.11	195.4	13.7	10.50	11.15	20	1.19	13.31	22.49	0.0686	99.545
03/26/2003	98.7	600.09	586.39	3.32	6.35	195.4	13.7	9.67	10.90	20	1.19	13.02	22.00	0.0669	99.545
03/26/2003	98.7	600.69	586.99	3.32	7.03	195.8	13.7	10.35	10.92	20	1.19	13.05	22.05	0.0669	99.544
03/26/2003	98.7	601.09	587.49	3.29	6.45	196	13.6	9.75	10.82	20	1.19	12.93	21.85	0.0661	99.543
03/26/2003	98.7	601.59	587.89	3.26	6.53	196	13.7	9.78	10.70	20	1.19	12.78	21.60	0.0652	99.543
03/26/2003	98.7	601.59	587.99	3.20	6.97	195.8	13.6	10.17	10.53	20	1.19	12.57	21.25	0.0642	99.544
03/26/2003	98.7	601.89	588.39	3.27	6.61	196.6	13.5	9.88	10.75	20	1.19	12.84	21.70	0.0654	99.542
03/26/2003	98.7	603.39	589.79	3.29	6.65	196.8	13.6	9.94	10.80	20	1.19	12.90	21.80	0.0652	99.541

03/26/2003	98.8	602.49	588.89	3.41	6.85	196.4	13.6	10.26	11.19	20	1.19	13.37	22.59	0.0679	99.542
03/26/2003	98.8	602.89	589.29	3.33	6.77	196.6	13.6	10.10	10.95	20	1.19	13.07	22.10	0.0663	99.542
03/26/2003	98.8	603.19	589.59	3.29	6.91	196.8	13.6	10.20	10.82	20	1.19	12.93	21.85	0.0654	99.541
03/26/2003	98.8	603.19	589.49	3.26	6.85	196.6	13.7	10.11	10.70	20	1.19	12.78	21.60	0.0647	99.542
03/26/2003	98.8	603.29	589.59	3.32	6.79	196.8	13.7	10.11	10.92	20	1.19	13.05	22.05	0.0660	99.541
03/26/2003	98.8	603.49	589.69	3.29	6.65	196.6	13.8	9.95	10.82	20	1.19	12.93	21.85	0.0654	99.542
03/26/2003	98.8	603.49	589.99	3.39	6.33	195.8	13.5	9.72	11.15	20	1.19	13.31	22.49	0.0673	99.544
03/26/2003	98.8	603.49	589.79	3.31	6.94	196	13.7	10.24	10.87	20	1.19	12.99	21.95	0.0656	99.543
03/26/2003	98.8	603.49	589.79	3.38	6.81	196	13.7	10.18	11.10	20	1.19	13.25	22.39	0.0670	99.543
03/26/2003	98.8	602.89	589.29	3.38	6.34	195.8	13.6	9.73	11.12	20	1.19	13.28	22.44	0.0673	99.544
03/26/2003	98.8	603.09	589.39	3.29	6.71	195.4	13.7	10.00	10.82	20	1.19	12.93	21.85	0.0655	99.545
03/26/2003	98.8	602.59	589.29	3.39	6.56	195	13.3	9.95	11.15	20	1.19	13.31	22.49	0.0675	99.545
03/26/2003	98.8	602.29	588.89	3.29	6.74	195	13.4	10.03	10.80	20	1.19	12.90	21.80	0.0656	99.545
03/27/2003	99.7	606.29	592.79	3.41	7.26	181.6	13.5	10.67	11.19	20	1.19	13.37	22.59	0.0667	99.577
03/27/2003	99.7	606.09	592.49	3.35	7.44	182.4	13.6	10.79	11.02	20	1.19	13.16	22.25	0.0670	99.579
03/27/2003	99.8	605.79	592.19	3.39	6.90	184	13.6	10.29	11.15	20	1.19	13.31	22.49	0.0678	99.575
03/27/2003	99.8	605.79	592.19	3.39	6.90	184	13.6	10.29	11.15	20	1.19	13.31	22.49	0.0678	99.575
03/27/2003	99.8	605.29	591.79	3.38	6.70	185	13.5	10.08	11.12	20	1.19	13.28	22.44	0.0678	99.573
03/27/2003	99.9	605.09	591.49	3.42	6.78	185.6	13.6	10.20	11.24	20	1.19	13.43	22.69	0.0686	99.571
03/27/2003	99.9	605.29	591.59	3.36	6.42	186.4	13.7	9.78	11.05	20	1.19	13.19	22.30	0.0674	99.570
03/28/2003	100.0	602.99	589.59	3.41	6.74	198.8	13.4	10.15	11.19	21	1.15	12.90	21.80	0.0666	99.541
03/28/2003	100.0	602.59	589.19	3.31	6.75	194.6	13.4	10.06	10.87	21	1.15	12.53	21.17	0.0648	99.551
03/28/2003	100.0	602.89	589.29	3.41	6.63	193.4	13.6	10.04	11.22	21	1.15	12.92	21.84	0.0668	99.553
03/28/2003	100.1	603.99	590.49	3.29	6.72	191.2	13.5	10.00	10.80	21	1.15	12.44	21.03	0.0639	99.558
03/28/2003	100.1	600.29	586.69	3.27	6.59	185.6	13.6	9.86	10.75	21	1.15	12.39	20.93	0.0649	99.571
03/28/2003	100.2	598.39	584.69	3.38	7.14	181.4	13.7	10.52	11.12	21	1.15	12.81	21.65	0.0679	99.581
03/28/2003	100.2	599.09	585.59	3.46	6.25	181.6	13.5	9.71	11.37	21	1.15	13.10	22.13	0.0691	99.581
03/28/2003	100.3	598.09	584.59	3.34	6.84	179.4	13.5	10.18	10.97	21	1.15	12.64	21.36	0.0670	99.586
03/28/2003	100.3	598.69	585.19	3.35	6.84	179.4	13.5	10.18	11.00	21	1.15	12.67	21.41	0.0670	99.586
03/28/2003	100.3	601.69	588.19	3.29	6.75	180.2	13.5	10.04	10.80	21	1.15	12.44	21.03	0.0647	99.584
03/28/2003	100.4	605.49	591.99	3.35	6.71	182.8	13.5	10.05	11.00	21	1.15	12.67	21.41	0.0646	99.578
03/28/2003	100.4	606.79	592.99	3.25	6.64	183.4	13.8	9.89	10.68	21	1.15	12.30	20.79	0.0624	99.576
03/28/2003	100.5	607.69	593.89	3.22	6.76	181.6	13.8	9.98	10.58	21	1.15	12.19	20.59	0.0615	99.581
03/29/2003	100.5	609.09	595.29	3.30	6.96	183.4	13.8	10.26	10.85	19	1.24	13.43	22.70	0.0674	99.576
03/29/2003	100.5	611.29	597.59	3.25	6.76	183.6	13.7	10.01	10.68	19	1.24	13.22	22.34	0.0655	99.576
03/29/2003	100.6	611.59	597.69	3.26	6.61	184	13.9	9.87	10.73	19	1.24	13.28	22.45	0.0658	99.575
03/29/2003	100.6	612.89	599.19	3.10	6.47	182	13.7	9.57	10.18	19	1.24	12.61	21.31	0.0620	99.580
03/29/2003	100.7	614.39	600.69	3.25	6.78	182	13.7	10.03	10.68	19	1.24	13.22	22.34	0.0646	99.580
03/29/2003	100.7	615.49	601.59	3.34	6.71	182.4	13.9	10.05	10.97	19	1.24	13.59	22.96	0.0660	99.579
03/29/2003	100.8	616.59	602.59	3.30	6.55	181.4	14	9.85	10.85	19	1.24	13.43	22.70	0.0650	99.581
03/29/2003	100.8	617.19	603.19	3.26	6.94	180.6	14	10.20	10.70	19	1.24	13.25	22.40	0.0639	99.583
03/29/2003	100.8	618.59	604.69	3.15	7.07	181.4	13.9	10.22	10.36	19	1.24	12.82	21.67	0.0614	99.581
03/29/2003	100.9	620.19	606.09	3.27	6.93	179.2	14.1	10.20	10.75	19	1.24	13.31	22.50	0.0633	99.586
03/29/2003	100.9	621.19	607.09	3.24	6.79	180.6	14.1	10.03	10.65	19	1.24	13.19	22.29	0.0624	99.583
03/29/2003	101.0	621.09	607.29	3.37	6.92	180.6	13.8	10.28	11.07	19	1.24	13.71	23.17	0.0648	99.583
03/29/2003	101.0	621.79	607.89	3.21	6.72	181.4	13.9	9.93	10.55	19	1.24	13.07	22.09	0.0616	99.581
03/29/2003	101.0	625.39	611.39	3.29	6.84	187.6	14	10.14	10.82	19	1.24	13.40	22.65	0.0621	99.567
03/29/2003	101.1	626.49	612.59	3.23	6.93	192	13.9	10.15	10.60	19	1.24	13.13	22.19	0.0605	99.557
03/29/2003	101.1	626.99	613.19	3.24	7.42	193.2	13.8	10.66	10.65	19	1.24	13.19	22.29	0.0606	99.554
03/29/2003	101.2	625.39	611.39	3.20	6.99	191.8	14	10.19	10.50	19	1.24	13.01	21.98	0.0603	99.557
03/29/2003	101.2	622.19	608.39	3.18	7.06	187.8	13.8	10.24	10.45	19	1.24	12.95	21.88	0.0609	99.566
03/29/2003	101.3	624.59	610.59	3.18	7.04	188.8	14	10.22	10.45	19	1.24	12.95	21.88	0.0602	99.564
03/29/2003	101.3	626.19	612.19	3.16	6.84	191.8	14	10.00	10.38	19	1.24	12.85	21.72	0.0594	99.557
03/29/2003	101.3	628.59	614.59	3.08	6.71	192.6	14	9.79	10.13	19	1.24	12.55	21.21	0.0573	99.555
03/29/2003	101.4	628.99	614.99	3.23	6.85	191.2	14	10.09	10.63	19	1.24	13.16	22.24	0.0600	99.558
03/29/2003	101.4	629.89	615.79	3.14	7.12	191	14.1	10.26	10.33	19	1.24	12.79	21.62	0.0581	99.559
03/29/2003	101.5	630.79	616.69	3.08	6.60	190.4	14.1	9.68	10.13	19	1.24	12.55	21.21	0.0568	99.560
03/30/2003	101.5	631.39	617.19	3.17	7.04	189.8	14.2	10.22	10.43	17	1.33	13.90	23.49	0.0627	99.562
03/30/2003	101.5	632.29	618.09	3.11	6.79	188	14.2	9.90	10.23	17	1.33	13.63	23.04	0.0613	99.566
03/30/2003	101.6	632.29	618.19	3.15	6.58	187.4	14.1	9.73	10.36	17	1.33	13.80	23.32	0.0620	99.567
03/30/2003	101.6	633.29	619.19	3.21	6.90	187.6	14.1	10.11	10.55	17	1.33	14.06	23.76	0.0629	99.567
03/30/2003	101.7	634.89	620.49	3.26	7.08	186.4	14.4	10.34	10.73	17	1.33	14.29	24.15	0.0635	99.570
03/30/2003	101.7	634.69	620.19	3.08	6.74	185.2	14.5	9.83	10.13	17	1.33	13.50	22.82	0.0601	99.572
03/30/2003	101.8	633.69	619.39	3.19	6.63	182.4	14.3	9.81	10.48	17	1.33	13.96	23.60	0.0624	99.579
03/30/2003	101.8	633.19	618.89	3.16	7.13	182	14.3	10.28	10.38	17	1.33	13.83	23.37	0.0619	99.580
03/30/2003	101.8	638.39	623.69	3.13	7.49	176.4	14.7	10.62	10.28	17	1.33	13.70	23.15	0.0600	99.593
03/30/2003	101.9	638.99	624.69	3.13	6.91	170.8	14.3	10.04	10.28	17	1.33	13.70	23.15	0.0598	99.606
03/30/2003	101.9	640.09	625.59	3.15	6.69	171.6	14.5	9.84	10.36	17	1.33	13.80	23.32	0.0600	99.604
03/30/2003	102.0	642.09	627.49	3.13	6.70	169.6	14.6	9.83	10.28	17	1.33	13.70	23.15	0.0591	99.608
03/30/2003	102.0	646.69	632.09	3.00	6.97	159	14.6	9.97	9.86	17	1.33	13.14	22.21	0.0556	99.633
03/30/2003	102.0	643.29	629.09	3.08	6.88	162	14.2	9.96	10.11	17	1.33	13.47	22.76	0.0578	99.626
03/30/2003	102.1	641.39	627.29	3.16	6.92	163.8	14.1	10.07	10.38	17	1.33	13.83	23.37	0.0598	99.622
03/30/2003	102.1	641.99	627.99	3.08	6.92	162.6	14	10.00	10.13	17	1.33	13.50	22.82	0.0582	99.624
03/30/2003	102.2	640.19	626.19	3.17	6.82	164	14	9.98	10.41	17	1.33	13.86	23.43	0.0602	99.621
03/30/2003	102.2	639.39	625.19	3.17	7.03	164.6	14.2	10.20	10.43	17	1.33	13.90	23.49	0.0606	99.620

03/31/2003	102.7	640.29	625.89	3.17	6.88	151.4	14.4	10.05	10.43	18	1.28	13.40	22.64	0.0583	99.650
03/31/2003	102.7	637.99	623.79	3.12	6.96	152	14.2	10.08	10.26	18	1.28	13.17	22.26	0.0578	99.649
03/31/2003	102.8	637.99	623.59	3.17	6.82	154.2	14.4	9.99	10.43	18	1.28	13.40	22.64	0.0588	99.644
03/31/2003	102.8	638.69	624.39	3.09	7.12	148	14.3	10.21	10.16	18	1.28	13.05	22.05	0.0571	99.658
03/31/2003	102.8	634.19	619.69	3.17	6.78	146.8	14.5	9.95	10.41	18	1.28	13.36	22.59	0.0597	99.661
03/31/2003	102.9	630.49	616.39	3.18	6.81	148.8	14.1	9.99	10.45	18	1.28	13.43	22.69	0.0610	99.656
03/31/2003	103.1	610.39	596.59	3.24	6.80	180.2	13.8	10.04	10.65	18	1.28	13.68	23.12	0.0682	99.584
03/31/2003	103.2	610.79	596.89	3.26	7.11	178.2	13.9	10.36	10.70	18	1.28	13.74	23.23	0.0684	99.588
03/31/2003	103.2	610.09	596.49	3.28	6.80	177.4	13.6	10.08	10.78	18	1.28	13.84	23.39	0.0690	99.590
03/31/2003	103.3	610.59	597.09	3.32	7.09	178.2	13.5	10.41	10.90	18	1.28	14.00	23.66	0.0696	99.588
03/31/2003	103.3	611.19	597.59	3.30	6.92	179	13.6	10.22	10.85	18	1.28	13.93	23.55	0.0691	99.587
03/31/2003	103.3	612.19	598.49	3.25	6.44	179	13.7	9.68	10.68	18	1.28	13.71	23.17	0.0677	99.587
03/31/2003	103.4	612.39	598.49	3.30	6.52	179.4	13.9	9.82	10.85	18	1.28	13.93	23.55	0.0688	99.586
03/31/2003	103.4	612.89	599.09	3.41	6.60	178.2	13.8	10.01	11.22	18	1.28	14.41	24.35	0.0709	99.588
04/01/2003	103.5	614.09	600.09	3.29	6.79	177.4	14	10.08	10.82	19	1.24	13.40	22.65	0.0656	99.590
04/01/2003	103.5	614.69	600.89	3.30	6.27	177	13.8	9.57	10.85	19	1.24	13.43	22.70	0.0655	99.591
04/01/2003	103.5	615.79	601.89	3.35	6.91	176.8	13.9	10.26	11.02	19	1.24	13.65	23.07	0.0662	99.592
04/01/2003	103.6	615.69	601.89	3.30	7.04	176.6	13.8	10.34	10.85	19	1.24	13.43	22.70	0.0652	99.592
04/01/2003	103.6	615.69	601.69	3.29	6.41	175.6	14	9.70	10.82	19	1.24	13.40	22.65	0.0651	99.594
04/01/2003	103.7	614.89	600.89	3.32	7.11	175.4	14	10.42	10.90	19	1.24	13.50	22.81	0.0658	99.595
04/01/2003	103.7	613.49	599.39	3.34	6.47	172.6	14.1	9.81	10.97	19	1.24	13.59	22.96	0.0667	99.601
04/01/2003	103.8	613.29	599.29	3.30	6.59	172	14	9.89	10.85	19	1.24	13.43	22.70	0.0660	99.603
04/01/2003	103.8	612.39	598.29	3.29	6.59	172	14.1	9.88	10.80	19	1.24	13.37	22.60	0.0661	99.603
04/01/2003	103.8	612.09	598.19	3.28	6.72	172	13.9	10.00	10.78	19	1.24	13.34	22.55	0.0660	99.603
04/01/2003	103.9	611.39	597.59	3.27	6.95	172.6	13.8	10.22	10.75	19	1.24	13.31	22.50	0.0660	99.601
04/01/2003	103.9	610.69	596.89	3.27	6.70	172.8	13.8	9.97	10.75	19	1.24	13.31	22.50	0.0663	99.601
04/01/2003	104.0	610.09	596.29	3.36	6.78	173.2	13.8	10.14	11.05	19	1.24	13.68	23.12	0.0683	99.600
04/01/2003	104.0	609.49	595.59	3.35	6.82	174	13.9	10.16	11.00	19	1.24	13.62	23.01	0.0682	99.598
04/01/2003	104.0	609.09	595.59	3.24	6.49	175.2	13.5	9.73	10.65	19	1.24	13.19	22.29	0.0661	99.595
04/02/2003	105.2	595.49	582.09	3.35	6.99	213.2	13.4	10.34	11.00	19	1.24	13.62	23.01	0.0730	99.508
04/02/2003	105.2	598.39	584.89	3.27	6.77	206.4	13.5	10.04	10.75	19	1.24	13.31	22.50	0.0704	99.523
04/02/2003	105.3	598.79	585.19	3.36	6.62	203.8	13.6	9.98	11.05	19	1.24	13.68	23.12	0.0722	99.529
04/02/2003	105.3	598.59	584.89	3.33	6.83	203.6	13.7	10.16	10.95	19	1.24	13.56	22.91	0.0716	99.530
04/02/2003	105.3	599.59	585.89	3.37	6.67	202.2	13.7	10.04	11.07	19	1.24	13.71	23.17	0.0721	99.533
04/02/2003	105.4	600.59	587.09	3.39	6.51	201	13.5	9.90	11.15	19	1.24	13.80	23.32	0.0721	99.536
04/02/2003	105.4	599.39	585.99	3.47	6.74	201.4	13.4	10.22	11.42	19	1.24	14.14	23.89	0.0743	99.535
04/03/2003	105.5	600.89	587.39	3.37	6.82	200.2	13.5	10.19	11.07	20	1.19	13.22	22.34	0.0690	99.538
04/03/2003	105.5	600.79	586.99	3.32	7.04	200.2	13.8	10.36	10.92	20	1.19	13.05	22.05	0.0682	99.538
04/03/2003	105.5	600.49	587.09	3.33	6.54	199.8	13.4	9.87	10.95	20	1.19	13.07	22.10	0.0684	99.539
04/03/2003	105.6	601.29	587.69	3.35	6.88	198.8	13.6	10.23	11.02	20	1.19	13.16	22.25	0.0686	99.541
04/03/2003	105.6	601.69	587.79	3.38	6.94	198	13.9	10.31	11.10	20	1.19	13.25	22.39	0.0689	99.543
04/03/2003	105.7	601.39	587.59	3.38	6.97	198.4	13.8	10.35	11.12	20	1.19	13.28	22.44	0.0692	99.542
04/03/2003	105.7	601.59	587.99	3.44	7.02	198.2	13.6	10.45	11.29	20	1.19	13.49	22.79	0.0701	99.542
04/03/2003	105.8	602.59	588.69	3.30	6.88	197.6	13.9	10.18	10.85	20	1.19	12.96	21.90	0.0671	99.544
04/03/2003	105.8	601.89	587.99	3.32	6.87	198.4	13.9	10.19	10.90	20	1.19	13.02	22.00	0.0676	99.542
04/03/2003	105.8	601.69	587.99	3.38	6.46	198.2	13.7	9.84	11.10	20	1.19	13.25	22.39	0.0689	99.542
04/03/2003	105.9	601.59	588.09	3.32	6.68	198.6	13.5	10.00	10.92	20	1.19	13.05	22.05	0.0678	99.541
04/03/2003	105.9	600.69	586.99	3.40	6.72	199	13.7	10.12	11.17	20	1.19	13.34	22.54	0.0697	99.540
04/03/2003	106.0	601.09	587.59	3.30	6.49	199	13.5	9.79	10.85	20	1.19	12.96	21.90	0.0675	99.540
04/03/2003	106.0	601.19	587.79	3.40	6.67	199	13.4	10.07	11.17	20	1.19	13.34	22.54	0.0695	99.540
04/03/2003	106.0	600.09	586.69	3.39	6.80	200	13.4	10.19	11.15	20	1.19	13.31	22.49	0.0697	99.538
04/03/2003	106.1	600.09	586.49	3.43	6.46	200.8	13.6	9.89	11.27	20	1.19	13.46	22.74	0.0705	99.536
04/03/2003	106.1	599.59	586.09	3.38	7.06	201.8	13.5	10.45	11.12	20	1.19	13.28	22.44	0.0698	99.534
04/03/2003	106.2	599.39	585.89	3.32	6.35	202.4	13.5	9.68	10.92	20	1.19	13.05	22.05	0.0686	99.533
04/03/2003	106.2	599.59	586.09	3.35	7.08	202.6	13.5	10.43	11.00	20	1.19	13.13	22.20	0.0690	99.532
04/03/2003	106.3	599.89	586.49	3.44	6.62	202.4	13.4	10.05	11.29	20	1.19	13.49	22.79	0.0707	99.533
04/03/2003	106.3	599.49	585.99	3.37	6.53	202.4	13.5	9.89	11.07	20	1.19	13.22	22.34	0.0695	99.533
04/03/2003	106.3	599.89	586.39	3.44	6.49	201.8	13.5	9.93	11.29	20	1.19	13.49	22.79	0.0707	99.534
04/03/2003	106.4	600.19	586.49	3.44	6.74	201.6	13.7	10.19	11.32	20	1.19	13.52	22.84	0.0708	99.534
04/03/2003	106.4	599.09	585.79	3.35	6.62	201	13.3	9.97	11.02	20	1.19	13.16	22.25	0.0693	99.536
04/04/2003	106.5	600.09	586.59	3.45	6.72	200.4	13.5	10.17	11.34	20	1.19	13.55	22.89	0.0710	99.537
04/04/2003	106.5	600.49	586.89	3.32	6.79	200.4	13.6	10.11	10.90	20	1.19	13.02	22.00	0.0681	99.537
04/04/2003	106.5	601.19	587.49	3.40	6.37	200.2	13.7	9.77	11.17	20	1.19	13.34	22.54	0.0695	99.538
04/04/2003	106.6	600.79	587.19	3.38	6.29	200.6	13.6	9.67	11.12	20	1.19	13.28	22.44	0.0694	99.537
04/04/2003	106.6	600.49	586.89	3.35	6.76	201	13.6	10.11	11.00	20	1.19	13.13	22.20	0.0687	99.536
04/04/2003	106.7	594.29	580.79	3.40	6.74	224.4	13.5	10.14	11.17	20	1.19	13.34	22.54	0.0720	99.482
04/04/2003	106.7	595.09	581.59	3.44	6.23	220.8	13.5	9.66	11.29	20	1.19	13.49	22.79	0.0725	99.490
04/04/2003	106.8	588.99	575.99	3.32	6.37	234	13	9.69	10.92	20	1.19	13.05	22.05	0.0723	99.460
04/04/2003	106.8	592.09	578.79	3.37	6.74	226.6	13.3	10.10	11.07	20	1.19	13.22	22.34	0.0721	99.477
04/04/2003	106.8	594.29	580.89	3.50	6.52	222.4	13.4	10.01	11.49	20	1.19	13.72	23.19	0.0740	99.486
04/04/2003	106.9	593.69	580.39	3.33	6.69	222.4	13.3	10.02	10.95	20	1.19	13.07	22.10	0.0707	99.486
04/04/2003	106.9	592.59	579.39	3.36	6.74	223	13.2	10.10	11.05	20	1.19	13.19	22.30	0.0718	99.485
04/04/2003	107.0	594.29	580.99	3.43	6.70	222.6	13.3	10.13	11.27	20	1.19	13.46	22.74	0.0726	99.486
04/04/2003	107.0	593.69	580.29	3.35	6.53	221.6	13.4	9.87	11.00	20	1.19	13.13	22.20	0.0711	99.488
04/04/2003	107.0	594.29	580.89	3.29	6.66	220.4	13.4	9.96	10.82	20	1.19	12.93	21.85	0.0697	99.491

04/05/2003	107.3	595.69	582.19	3.41	6.61	217.4	13.5	10.01	11.19	20	1.19	13.37	22.59	0.0716	99.498
04/05/2003	107.3	595.99	582.39	3.35	6.93	216.8	13.6	10.28	11.02	20	1.19	13.16	22.25	0.0704	99.499
04/05/2003	107.4	595.49	581.99	3.34	6.80	216.8	13.5	10.14	10.97	20	1.19	13.10	22.15	0.0703	99.499
04/05/2003	107.4	595.79	582.19	3.43	6.71	216.6	13.6	10.14	11.27	20	1.19	13.46	22.74	0.0721	99.500
04/05/2003	107.5	595.29	581.99	3.43	6.74	216.2	13.3	10.16	11.27	20	1.19	13.46	22.74	0.0722	99.501
04/05/2003	107.5	595.89	582.49	3.41	6.43	217	13.4	9.84	11.22	20	1.19	13.40	22.64	0.0717	99.499
04/05/2003	107.5	595.09	581.79	3.50	6.37	217.6	13.3	9.87	11.52	20	1.19	13.75	23.24	0.0739	99.497
04/05/2003	107.6	594.49	580.99	3.31	6.61	217.6	13.5	9.92	10.87	20	1.19	12.99	21.95	0.0700	99.497
04/05/2003	107.6	594.49	580.89	3.31	6.74	217.4	13.6	10.04	10.87	20	1.19	12.99	21.95	0.0700	99.498
04/05/2003	107.7	592.99	579.59	3.31	7.17	218.2	13.4	10.48	10.87	20	1.19	12.99	21.95	0.0706	99.496
04/05/2003	107.7	592.69	579.29	3.49	6.48	218.8	13.4	9.97	11.47	20	1.19	13.69	23.14	0.0745	99.495
04/05/2003	107.8	592.69	579.09	3.33	6.74	219.8	13.6	10.07	10.95	20	1.19	13.07	22.10	0.0712	99.492
04/05/2003	107.8	592.99	579.89	3.37	6.87	219.6	13.1	10.24	11.07	20	1.19	13.22	22.34	0.0718	99.493
04/05/2003	107.8	593.79	580.49	3.43	6.74	219	13.3	10.16	11.27	20	1.19	13.46	22.74	0.0728	99.494
04/05/2003	107.9	593.79	580.49	3.35	6.54	219.4	13.3	9.88	11.00	20	1.19	13.13	22.20	0.0710	99.493
04/05/2003	107.9	593.79	580.39	3.40	6.39	219.6	13.4	9.79	11.17	20	1.19	13.34	22.54	0.0722	99.493
04/05/2003	108.0	593.29	579.89	3.45	6.34	220.2	13.4	9.79	11.34	20	1.19	13.55	22.89	0.0735	99.491
04/06/2003	108.0	593.59	580.29	3.40	6.67	220.2	13.3	10.07	11.17	21	1.15	12.87	21.75	0.0697	99.491
04/06/2003	108.0	594.29	580.79	3.39	6.59	220.2	13.5	9.98	11.15	21	1.15	12.84	21.70	0.0693	99.491
04/06/2003	108.1	594.29	580.89	3.42	6.81	220.2	13.4	10.23	11.24	21	1.15	12.95	21.89	0.0699	99.491
04/06/2003	108.1	594.49	581.19	3.52	6.74	220.8	13.3	10.26	11.56	21	1.15	13.32	22.52	0.0718	99.490
04/06/2003	108.2	594.59	581.19	3.44	6.71	221.4	13.4	10.15	11.32	21	1.15	13.04	22.04	0.0702	99.489
04/06/2003	108.2	594.99	581.59	3.40	6.87	221.6	13.4	10.27	11.17	21	1.15	12.87	21.75	0.0692	99.488
04/06/2003	108.3	595.19	581.69	3.46	6.81	221.2	13.5	10.27	11.37	21	1.15	13.10	22.13	0.0703	99.489
04/06/2003	108.3	594.89	581.59	3.41	6.66	221	13.3	10.07	11.19	21	1.15	12.90	21.80	0.0693	99.490
04/06/2003	108.3	594.29	580.99	3.31	6.62	220.4	13.3	9.93	10.87	21	1.15	12.53	21.17	0.0676	99.491
04/06/2003	108.4	593.99	580.59	3.38	6.47	220.2	13.4	9.85	11.10	21	1.15	12.78	21.60	0.0691	99.491
04/06/2003	108.4	594.09	580.89	3.50	6.60	221	13.2	10.09	11.49	21	1.15	13.24	22.37	0.0715	99.490
04/06/2003	108.5	593.89	580.59	3.29	6.57	221.6	13.3	9.86	10.82	21	1.15	12.47	21.08	0.0674	99.488
04/06/2003	108.5	593.39	580.09	3.43	6.72	222	13.3	10.15	11.27	21	1.15	12.98	21.94	0.0704	99.487
04/06/2003	108.5	592.99	579.89	3.37	6.93	223	13.1	10.29	11.07	21	1.15	12.75	21.56	0.0692	99.485
04/06/2003	108.6	593.89	580.59	3.29	6.77	223.2	13.3	10.06	10.82	21	1.15	12.47	21.08	0.0674	99.485
04/06/2003	108.6	593.49	580.29	3.48	6.76	223.8	13.2	10.24	11.44	21	1.15	13.18	22.28	0.0714	99.483
04/06/2003	108.7	593.69	580.49	3.41	6.88	224.4	13.2	10.29	11.22	21	1.15	12.92	21.84	0.0699	99.482
04/06/2003	108.7	593.79	580.59	3.34	6.74	224.6	13.2	10.07	10.97	21	1.15	12.64	21.36	0.0683	99.481
04/06/2003	108.8	594.29	581.09	3.45	7.09	224.8	13.2	10.54	11.34	21	1.15	13.07	22.08	0.0704	99.481
04/06/2003	108.8	593.39	580.09	3.38	6.77	225.8	13.3	10.15	11.12	21	1.15	12.81	21.65	0.0694	99.479
04/06/2003	108.8	594.39	581.19	3.34	6.59	226.2	13.2	9.93	10.97	21	1.15	12.64	21.36	0.0681	99.478
04/06/2003	108.9	595.29	581.99	3.38	6.27	225.8	13.3	9.65	11.12	21	1.15	12.81	21.65	0.0687	99.479
04/06/2003	108.9	594.19	581.19	3.38	6.39	225.8	13	9.77	11.10	21	1.15	12.78	21.60	0.0689	99.479
04/06/2003	109.0	595.09	581.89	3.36	6.72	225.6	13.2	10.08	11.05	21	1.15	12.73	21.51	0.0683	99.479
04/07/2003	109.0	595.09	581.89	3.35	7.03	225.8	13.2	10.37	11.00	20	1.19	13.13	22.20	0.0705	99.479
04/07/2003	109.0	595.99	582.69	3.36	6.40	224.8	13.3	9.76	11.05	20	1.19	13.19	22.30	0.0705	99.481
04/07/2003	109.1	595.89	582.49	3.40	6.89	226.2	13.4	10.29	11.17	20	1.19	13.34	22.54	0.0713	99.478
04/07/2003	109.1	596.49	583.19	3.32	6.41	227	13.3	9.73	10.92	20	1.19	13.05	22.05	0.0695	99.476
04/07/2003	109.2	597.19	583.99	3.26	6.53	227	13.2	9.79	10.73	20	1.19	12.81	21.65	0.0680	99.476
04/07/2003	109.2	597.59	584.29	3.38	6.85	227	13.3	10.24	11.12	20	1.19	13.28	22.44	0.0703	99.476
04/07/2003	109.3	597.29	583.99	3.41	6.72	227	13.3	10.12	11.19	20	1.19	13.37	22.59	0.0709	99.476
04/08/2003	109.3	592.99	579.49	3.38	7.04	265.6	13.5	10.42	11.12	21	1.15	12.81	21.65	0.0694	99.387
04/08/2003	109.3	594.59	581.09	3.33	6.73	260.6	13.5	10.06	10.95	21	1.15	12.61	21.32	0.0678	99.398
04/08/2003	109.4	596.29	582.89	3.27	6.61	257.4	13.4	9.88	10.75	21	1.15	12.39	20.93	0.0659	99.406
04/08/2003	109.4	599.29	585.79	3.35	7.12	256.6	13.5	10.47	11.02	21	1.15	12.70	21.46	0.0666	99.407
04/08/2003	109.5	599.49	585.79	3.31	7.03	256.2	13.7	10.33	10.87	21	1.15	12.53	21.17	0.0656	99.408
04/08/2003	109.5	601.19	587.79	3.36	7.04	259.6	13.4	10.40	11.05	21	1.15	12.73	21.51	0.0660	99.400
04/08/2003	109.5	596.29	582.89	3.27	6.61	257.4	13.4	9.88	10.75	21	1.15	12.39	20.93	0.0659	99.406
04/08/2003	109.6	599.29	585.79	3.35	7.12	256.6	13.5	10.47	11.02	21	1.15	12.70	21.46	0.0666	99.407
04/08/2003	109.6	599.49	585.79	3.31	7.03	256.2	13.7	10.33	10.87	21	1.15	12.53	21.17	0.0656	99.408
04/08/2003	109.7	601.19	587.79	3.36	7.04	259.6	13.4	10.40	11.05	21	1.15	12.73	21.51	0.0660	99.400
04/08/2003	109.7	602.99	589.39	3.37	7.20	274.6	13.6	10.57	11.07	21	1.15	12.75	21.56	0.0655	99.366
04/08/2003	109.8	604.19	590.69	3.37	6.40	273	13.5	9.77	11.07	21	1.15	12.75	21.56	0.0651	99.370
04/08/2003	109.8	605.99	592.59	3.33	6.40	273.8	13.4	9.73	10.95	21	1.15	12.61	21.32	0.0638	99.368
04/08/2003	109.8	607.59	594.09	3.21	7.14	273.2	13.5	10.35	10.55	21	1.15	12.16	20.55	0.0610	99.369
04/08/2003	109.9	609.49	596.09	3.32	7.14	272.2	13.4	10.46	10.92	21	1.15	12.58	21.27	0.0625	99.371
04/08/2003	109.9	610.19	596.99	3.32	6.55	272	13.2	9.88	10.92	21	1.15	12.58	21.27	0.0623	99.372
04/08/2003	110.0	611.79	598.39	3.35	6.69	267.8	13.4	10.04	11.00	21	1.15	12.67	21.41	0.0623	99.382
04/09/2003	110.0	611.69	598.09	3.33	6.62	266	13.6	9.95	10.95	19	1.24	13.56	22.91	0.0667	99.386
04/09/2003	110.0	611.29	597.69	3.21	6.55	261.8	13.6	9.76	10.55	19	1.24	13.07	22.09	0.0750	99.435
04/09/2003	110.1	611.19	597.49	3.40	6.79	259	13.7	10.19	11.17	19	1.24	13.83	23.38	0.0795	99.441
04/09/2003	110.1	610.59	596.89	3.27	6.62	255.8	13.7	9.89	10.75	19	1.24	13.31	22.50	0.0768	99.448
04/09/2003	110.2	610.69	596.89	3.26	6.81	254.4	13.8	10.06	10.70	19	1.24	13.25	22.40	0.0764	99.451
04/09/2003	110.2	611.39	597.59	3.19	7.10	253.8	13.8	10.29	10.48	19	1.24	12.98	21.93	0.0745	99.453
04/09/2003	110.3	613.39	599.69	3.26	7.00	251.4	13.7	10.25	10.70	19	1.24	13.25	22.40	0.0752	99.458
04/09/2003	110.3	612.69	598.99	3.24	6.49	251.4	13.7	9.73	10.65	19	1.24	13.19	22.29	0.0752	99.458
04/09/2003	110.3	613.69	599.59	3.23	6.99	250.2	14.1	10.22	10.63	19	1.24	13.16	22.24	0.0747	99.460
04/09/2003	110.4	614.59	600.59	3.35	6.74	248	14	10.09	11.02	19	1.24	13.65	23.07	0.0770	99.465

04/09/2003	110.6	608.49	594.99	3.32	6.68	258.4	13.5	10.00	10.90	19	1.24	13.50	22.81	0.0787	99.443
04/09/2003	110.7	609.19	595.49	3.23	6.78	263.2	13.7	10.01	10.63	19	1.24	13.16	22.24	0.0765	99.432
04/09/2003	110.7	608.99	595.59	3.27	7.20	264.6	13.4	10.47	10.75	19	1.24	13.31	22.50	0.0774	99.429
04/09/2003	110.8	608.99	595.59	3.31	6.69	264.4	13.4	10.00	10.87	19	1.24	13.47	22.76	0.0783	99.430
04/09/2003	110.8	609.89	596.59	3.32	6.61	263.8	13.3	9.93	10.92	19	1.24	13.53	22.86	0.0782	99.431
04/09/2003	110.8	610.89	597.59	3.31	6.96	261.4	13.3	10.27	10.87	19	1.24	13.47	22.76	0.0774	99.436
04/09/2003	110.9	611.39	597.99	3.43	6.89	260.4	13.4	10.32	11.27	19	1.24	13.95	23.58	0.0800	99.438
04/09/2003	110.9	612.29	598.89	3.38	6.85	259.2	13.4	10.24	11.12	19	1.24	13.77	23.27	0.0786	99.441
04/10/2003	111.0	611.79	598.39	3.29	6.78	258.4	13.4	10.07	10.82	20	1.19	12.93	21.85	0.0740	99.443
04/10/2003	111.0	611.89	598.29	3.30	7.28	256.8	13.6	10.58	10.85	20	1.19	12.96	21.90	0.0741	99.446
04/10/2003	111.0	611.59	598.09	3.33	6.85	256.4	13.5	10.18	10.95	20	1.19	13.07	22.10	0.0749	99.447
04/10/2003	111.1	612.19	598.59	3.31	7.20	254.4	13.6	10.51	10.87	20	1.19	12.99	21.95	0.0742	99.451
04/10/2003	111.1	612.29	598.49	3.20	6.39	253	13.8	9.59	10.53	20	1.19	12.57	21.25	0.0718	99.454
04/10/2003	111.2	613.29	599.59	3.26	6.74	251.8	13.7	10.00	10.73	20	1.19	12.81	21.65	0.0728	99.457
04/10/2003	111.2	610.89	597.09	3.17	6.18	246.4	13.8	9.35	10.43	20	1.19	12.46	21.05	0.0718	99.469
04/10/2003	111.3	605.49	591.59	3.32	6.72	237.2	13.9	10.03	10.90	20	1.19	13.02	22.00	0.0775	99.488
04/10/2003	111.6	550.59	536.69	2.62	6.50	165	13.9	9.12	8.61	20	1.19	10.28	17.37	0.0917	99.644
04/10/2003	111.6	593.79	580.29	2.53	6.80	213.4	13.5	9.33	8.31	20	1.19	9.92	16.77	0.0635	99.540
04/10/2003	111.7	593.89	580.59	2.54	6.85	213	13.3	9.40	8.36	20	1.19	9.98	16.87	0.0638	99.541
04/10/2003	111.7	593.89	580.49	2.51	6.59	213.8	13.4	9.10	8.24	20	1.19	9.84	16.62	0.0629	99.539
04/10/2003	111.8	594.19	580.69	2.59	6.77	213	13.5	9.36	8.51	20	1.19	10.16	17.17	0.0649	99.541
04/10/2003	111.8	595.59	582.09	2.57	6.51	213.2	13.5	9.07	8.43	20	1.19	10.07	17.02	0.0638	99.540
04/10/2003	111.8	595.69	582.49	2.61	6.71	212.2	13.2	9.32	8.58	20	1.19	10.25	17.32	0.0648	99.542
04/10/2003	111.9	595.99	582.69	2.58	6.44	212	13.3	9.02	8.48	20	1.19	10.13	17.12	0.0639	99.543
04/10/2003	111.9	596.19	582.79	2.53	6.81	211.2	13.4	9.34	8.31	20	1.19	9.92	16.77	0.0626	99.544
04/11/2003	112.0	596.69	583.19	2.59	6.67	211	13.5	9.26	8.51	20	1.19	10.16	17.17	0.0639	99.545
04/11/2003	112.0	597.19	583.99	2.60	6.77	210.4	13.2	9.37	8.53	20	1.19	10.19	17.22	0.0638	99.546
04/11/2003	112.0	597.09	583.89	2.53	6.38	209	13.2	8.91	8.31	20	1.19	9.92	16.77	0.0622	99.549
04/11/2003	112.1	596.79	583.59	2.53	6.44	207.8	13.2	8.96	8.31	20	1.19	9.92	16.77	0.0623	99.552
04/11/2003	112.1	598.79	585.39	2.54	6.74	208.4	13.4	9.28	8.36	20	1.19	9.98	16.87	0.0619	99.550
04/11/2003	112.2	599.29	585.79	2.51	6.71	207	13.5	9.21	8.24	20	1.19	9.84	16.62	0.0609	99.553
04/11/2003	112.2	598.59	585.19	2.60	6.61	205.6	13.4	9.21	8.56	20	1.19	10.22	17.27	0.0635	99.557
04/11/2003	112.3	599.69	586.29	2.50	6.48	205	13.4	8.98	8.21	20	1.19	9.81	16.57	0.0605	99.558
04/11/2003	112.3	600.69	587.09	2.54	6.84	205.8	13.6	9.38	8.33	20	1.19	9.95	16.82	0.0611	99.556
04/11/2003	112.3	601.09	587.59	2.54	6.54	209.6	13.5	9.08	8.36	20	1.19	9.98	16.87	0.0611	99.548
04/11/2003	112.4	599.99	586.59	2.40	6.29	202.2	13.4	8.69	7.89	20	1.19	9.42	15.93	0.0581	99.564
04/11/2003	112.4	598.69	585.09	2.58	6.64	206.2	13.6	9.22	8.48	20	1.19	10.13	17.12	0.0630	99.555
04/11/2003	112.5	598.49	585.19	3.23	6.24	241.4	13.3	9.47	10.63	20	1.19	12.69	21.45	0.0787	99.479
04/11/2003	112.5	598.19	584.99	3.48	6.84	239.8	13.2	10.32	11.44	20	1.19	13.66	23.09	0.0848	99.483
04/11/2003	112.5	597.89	584.59	3.41	6.43	239	13.3	9.83	11.19	20	1.19	13.37	22.59	0.0832	99.484
04/11/2003	112.6	597.99	584.79	3.52	6.52	239.8	13.2	10.04	11.56	20	1.19	13.81	23.34	0.0859	99.483
04/11/2003	112.6	597.09	584.09	3.41	6.78	240.8	13	10.19	11.19	20	1.19	13.37	22.59	0.0835	99.481
04/11/2003	112.7	596.99	583.69	3.46	6.56	241.8	13.3	10.02	11.37	20	1.19	13.58	22.94	0.0849	99.478
04/11/2003	112.7	596.89	583.79	3.44	6.65	241.6	13.1	10.10	11.32	20	1.19	13.52	22.84	0.0846	99.479
04/11/2003	112.8	596.39	583.19	3.48	6.76	241.6	13.2	10.24	11.44	20	1.19	13.66	23.09	0.0858	99.479
04/11/2003	112.8	596.99	583.79	3.47	6.11	240.8	13.2	9.57	11.39	20	1.19	13.60	22.99	0.0851	99.481
04/11/2003	112.8	597.69	583.99	3.41	6.69	239.6	13.7	10.10	11.22	20	1.19	13.40	22.64	0.0836	99.483
04/11/2003	112.9	596.89	583.59	3.43	6.46	240.2	13.3	9.89	11.27	20	1.19	13.46	22.74	0.0843	99.482
04/11/2003	112.9	597.99	584.59	3.36	6.97	239.6	13.4	10.33	11.05	20	1.19	13.19	22.30	0.0821	99.483
04/12/2003	113.0	598.59	585.29	3.49	6.64	238.6	13.3	10.13	11.47	20	1.19	13.69	23.14	0.0848	99.485
04/12/2003	113.0	599.19	585.99	3.38	6.50	239.2	13.2	9.87	11.10	19	1.24	13.74	23.22	0.0848	99.484
04/12/2003	113.0	599.59	586.29	3.40	6.62	239.4	13.3	10.02	11.17	19	1.24	13.83	23.38	0.0852	99.484
04/12/2003	113.1	600.29	586.99	3.46	6.55	237.4	13.3	10.01	11.37	19	1.24	14.08	23.79	0.0863	99.488
04/12/2003	113.1	599.99	586.49	3.36	6.50	236.6	13.5	9.86	11.05	19	1.24	13.68	23.12	0.0841	99.490
04/12/2003	113.2	600.29	586.59	3.59	6.77	235.8	13.7	10.36	11.79	19	1.24	14.60	24.67	0.0896	99.491
04/12/2003	113.2	599.89	586.59	3.34	6.47	235.2	13.3	9.81	10.97	19	1.24	13.59	22.96	0.0835	99.493
04/12/2003	113.3	600.39	586.89	3.39	6.92	234.4	13.5	10.31	11.15	19	1.24	13.80	23.32	0.0847	99.494
04/12/2003	113.3	600.09	586.59	3.41	6.73	234.4	13.5	10.14	11.22	19	1.24	13.89	23.48	0.0854	99.494
04/12/2003	113.3	599.39	585.89	3.31	6.88	234.4	13.5	10.19	10.87	19	1.24	13.47	22.76	0.0831	99.494
04/12/2003	113.4	599.49	586.19	3.39	6.59	235	13.3	9.98	11.15	19	1.24	13.80	23.32	0.0851	99.493
04/12/2003	113.4	598.99	585.69	3.35	6.57	236	13.3	9.92	11.02	19	1.24	13.65	23.07	0.0844	99.491
04/12/2003	113.5	598.29	584.99	3.38	6.76	236.6	13.3	10.14	11.10	19	1.24	13.74	23.22	0.0853	99.490
04/12/2003	113.5	598.09	584.79	3.41	6.85	237.4	13.3	10.26	11.19	19	1.24	13.86	23.43	0.0862	99.488
04/12/2003	113.5	596.59	583.49	3.40	6.66	240.2	13.1	10.06	11.17	19	1.24	13.83	23.38	0.0867	99.482
04/12/2003	113.6	596.09	582.89	3.44	6.48	241.6	13.2	9.92	11.32	19	1.24	14.02	23.69	0.0882	99.479
04/12/2003	113.6	595.99	582.79	3.47	6.64	243	13.2	10.11	11.42	19	1.24	14.14	23.89	0.0890	99.476
04/12/2003	113.7	595.09	581.89	3.47	6.58	245.4	13.2	10.05	11.39	19	1.24	14.11	23.84	0.0893	99.471
04/12/2003	113.7	594.69	581.49	3.33	6.64	246.4	13.2	9.97	10.95	19	1.24	13.56	22.91	0.0860	99.469
04/12/2003	113.8	594.79	581.69	3.53	6.84	246.2	13.1	10.37	11.59	19	1.24	14.35	24.25	0.0910	99.469
04/12/2003	113.8	594.99	581.89	3.56	6.45	246.2	13.1	10.01	11.69	19	1.24	14.47	24.46	0.0916	99.469
04/12/2003	113.8	595.89	582.49	3.43	7.03	245.2	13.4	10.45	11.27	19	1.24	13.95	23.58	0.0879	99.471
04/12/2003	113.9	595.59	582.29	3.46	6.57	245.4	13.3	10.03	11.37	19	1.24	14.08	23.79	0.0888	99.471
04/12/2003	113.9	596.39	583.19	3.40	6.50	244.4	13.2	9.90	11.17	19	1.24	13.83	23.38	0.0868	99.473
04/13/2003	114.0	596.79	583.59	3.47	6.81	243.4	13.2	10.27	11.39	20	1.19	13.60	22.99	0.0852	99.475
04/13/2003	114.0	596.69	583.49	3.38	6.68	242.4	13.2	10.06	11.12	20	1.19	13.28	22.44	0.0832	99.477

04/13/2003	114.1	597.09	583.69	3.38	6.34	241.4	13.4	9.73	11.12	20	1.19	13.28	22.44	0.0831	99.479
04/15/2003	114.1	588.29	575.19	3.53	6.14	291.8	13.1	9.66	11.59	21	1.15	13.35	22.56	0.0879	99.371
04/15/2003	114.2	588.59	575.49	3.56	6.81	287.6	13.1	10.37	11.71	21	1.15	13.49	22.80	0.0887	99.380
04/15/2003	114.2	589.79	576.59	3.45	6.51	285.6	13.2	9.96	11.34	21	1.15	13.07	22.08	0.0853	99.384
04/15/2003	114.3	589.59	576.69	3.44	6.68	284.4	12.9	10.12	11.29	21	1.15	13.01	21.99	0.0849	99.387
04/17/2003	116.3	586.19	573.19	3.51	6.51	312.8	13	10.02	11.54	21	1.15	13.29	22.47	0.0886	99.325
04/17/2003	116.3	585.89	572.79	3.38	6.11	310.6	13.1	9.49	11.12	21	1.15	12.81	21.65	0.0856	99.330
04/17/2003	116.3	586.19	573.09	3.47	6.47	309.2	13.1	9.94	11.42	21	1.15	13.15	22.23	0.0877	99.333
04/17/2003	116.4	586.59	573.49	3.54	6.60	307	13.1	10.14	11.64	21	1.15	13.41	22.66	0.0892	99.338
04/17/2003	116.4	587.29	574.29	3.46	6.94	305	13	10.40	11.37	21	1.15	13.10	22.13	0.0867	99.342
04/17/2003	116.5	587.19	574.29	3.39	6.54	304.4	12.9	9.93	11.15	21	1.15	12.84	21.70	0.0850	99.343
04/17/2003	116.5	588.19	575.19	3.42	6.40	302.4	13	9.82	11.24	21	1.15	12.95	21.89	0.0852	99.348
04/17/2003	116.5	587.79	574.59	3.47	6.30	302.4	13.2	9.76	11.39	21	1.15	13.12	22.18	0.0866	99.348
04/17/2003	116.6	588.09	575.09	3.42	6.58	301.4	13	10.00	11.24	21	1.15	12.95	21.89	0.0853	99.350
04/18/2003	116.6	588.79	575.69	3.53	6.44	299.6	13.1	9.97	11.59	21	1.15	13.35	22.56	0.0876	99.354
04/18/2003	116.7	588.79	575.69	3.40	6.44	297.8	13.1	9.84	11.17	21	1.15	12.87	21.75	0.0844	99.358
04/18/2003	116.7	589.19	576.19	3.47	6.42	296.6	13	9.89	11.42	21	1.15	13.15	22.23	0.0860	99.360
04/25/2003	116.8	579.39	566.89	3.47	6.48	358.4	12.5	9.95	11.42	21	1.15	13.15	22.23	0.0912	99.227
04/25/2003	116.8	582.69	570.29	3.48	6.49	345.4	12.4	9.97	11.44	21	1.15	13.18	22.28	0.0895	99.255
04/25/2003	116.8	582.69	570.29	3.47	6.67	344.8	12.4	10.14	11.42	21	1.15	13.15	22.23	0.0893	99.256
04/25/2003	116.9	582.49	570.29	3.47	6.93	344.2	12.2	10.40	11.42	21	1.15	13.15	22.23	0.0893	99.258
04/25/2003	116.9	582.69	570.39	3.50	6.69	344.4	12.3	10.19	11.52	21	1.15	13.27	22.42	0.0900	99.257
04/25/2003	117.0	582.29	569.99	3.55	6.63	342.4	12.3	10.17	11.66	21	1.15	13.44	22.71	0.0914	99.261
04/25/2003	117.0	584.09	571.49	3.47	6.37	336.6	12.6	9.84	11.42	21	1.15	13.15	22.23	0.0886	99.274
04/25/2003	117.0	584.59	571.79	3.46	6.60	333.2	12.8	10.06	11.37	21	1.15	13.10	22.13	0.0880	99.281
04/25/2003	117.1	584.99	572.39	3.48	6.66	331.2	12.6	10.14	11.44	21	1.15	13.18	22.28	0.0883	99.286
04/26/2003	117.1	585.89	573.19	3.50	6.16	327.6	12.7	9.67	11.52	21	1.15	13.27	22.42	0.0884	99.293
04/26/2003	117.2	586.39	573.69	3.47	6.57	323.8	12.7	10.04	11.39	21	1.15	13.12	22.18	0.0871	99.302
04/26/2003	117.2	586.39	573.69	3.44	6.44	322	12.7	9.88	11.29	21	1.15	13.01	21.99	0.0864	99.305
04/26/2003	117.3	586.89	574.29	3.47	6.83	320.2	12.6	10.29	11.39	21	1.15	13.12	22.18	0.0869	99.309
04/26/2003	117.3	587.29	574.69	3.48	7.03	318.8	12.6	10.51	11.44	21	1.15	13.18	22.28	0.0870	99.312
04/26/2003	117.3	588.19	575.49	3.41	6.95	317.2	12.7	10.37	11.22	21	1.15	12.92	21.84	0.0849	99.316
04/26/2003	117.4	589.99	577.09	3.47	6.78	315.6	12.9	10.25	11.39	21	1.15	13.12	22.18	0.0852	99.319
04/26/2003	117.4	589.39	576.69	3.40	7.11	315.8	12.7	10.51	11.17	21	1.15	12.87	21.75	0.0838	99.319
04/26/2003	117.5	589.39	576.39	3.48	6.75	315.4	13	10.23	11.44	21	1.15	13.18	22.28	0.0860	99.320
04/26/2003	117.5	588.99	576.29	3.53	6.47	315.6	12.7	10.00	11.59	21	1.15	13.35	22.56	0.0872	99.319
04/26/2003	117.5	589.29	576.59	3.41	6.48	316.6	12.7	9.89	11.19	21	1.15	12.90	21.80	0.0841	99.317
04/26/2003	117.6	588.79	576.19	3.48	6.66	318	12.6	10.14	11.44	21	1.15	13.18	22.28	0.0862	99.314
04/26/2003	117.6	589.09	576.39	3.47	6.49	318.4	12.7	9.96	11.42	21	1.15	13.15	22.23	0.0858	99.313
04/26/2003	117.7	588.99	576.39	3.46	6.67	321.8	12.6	10.13	11.37	21	1.15	13.10	22.13	0.0855	99.306
04/26/2003	117.7	588.19	575.69	3.39	6.56	322.6	12.5	9.95	11.15	21	1.15	12.84	21.70	0.0842	99.304
04/26/2003	117.8	588.29	575.69	3.53	6.80	323.6	12.6	10.32	11.59	21	1.15	13.35	22.56	0.0875	99.302
04/26/2003	117.8	587.69	575.19	3.52	6.79	326	12.5	10.31	11.56	21	1.15	13.32	22.52	0.0876	99.297
04/26/2003	117.8	588.09	575.59	3.37	6.41	328.4	12.5	9.78	11.07	21	1.15	12.75	21.56	0.0837	99.292
04/26/2003	117.9	587.69	575.29	3.35	6.64	330	12.4	10.00	11.02	21	1.15	12.70	21.46	0.0835	99.288
04/26/2003	117.9	587.79	575.29	3.38	6.47	330	12.5	9.85	11.12	21	1.15	12.81	21.65	0.0842	99.288
04/26/2003	118.0	588.39	575.89	3.41	6.56	329	12.5	9.97	11.19	21	1.15	12.90	21.80	0.0844	99.290
04/26/2003	118.0	589.19	576.49	3.56	6.36	327.4	12.7	9.93	11.71	21	1.15	13.49	22.80	0.0879	99.294
04/26/2003	118.0	589.49	576.79	3.54	6.84	326.2	12.7	10.38	11.64	21	1.15	13.41	22.66	0.0872	99.296
04/26/2003	118.1	589.29	576.59	3.47	6.90	324.8	12.7	10.36	11.39	21	1.15	13.12	22.18	0.0855	99.299
04/27/2003	118.1	590.59	577.99	3.35	6.52	322.4	12.6	9.86	11.00	21	1.15	12.67	21.41	0.0818	99.305
04/27/2003	118.2	590.09	577.39	3.50	6.64	322.4	12.7	10.15	11.52	21	1.15	13.27	22.42	0.0860	99.305
04/27/2003	118.2	590.59	577.79	3.46	6.50	320.6	12.8	9.96	11.37	21	1.15	13.10	22.13	0.0846	99.308
04/27/2003	118.3	591.79	578.89	3.47	6.49	318.6	12.9	9.96	11.42	21	1.15	13.15	22.23	0.0844	99.313
04/27/2003	118.3	590.99	578.09	3.51	6.39	319.2	12.9	9.90	11.54	21	1.15	13.29	22.47	0.0858	99.311
04/27/2003	118.3	591.69	578.69	3.37	6.47	316.8	13	9.84	11.07	21	1.15	12.75	21.56	0.0819	99.317
04/27/2003	118.4	592.09	579.19	3.47	6.84	315	12.9	10.32	11.42	21	1.15	13.15	22.23	0.0843	99.321
04/27/2003	118.4	591.29	578.49	3.38	6.68	315.8	12.8	10.06	11.10	21	1.15	12.78	21.60	0.0823	99.319
04/27/2003	118.5	591.39	578.39	3.51	6.44	314.6	13	9.95	11.54	21	1.15	13.29	22.47	0.0856	99.321
04/27/2003	118.5	591.59	578.79	3.49	6.90	314.6	12.8	10.39	11.47	22	1.11	12.75	21.54	0.0819	99.321
04/27/2003	118.5	589.99	577.39	3.44	6.51	316.8	12.6	9.94	11.29	22	1.11	12.55	21.22	0.0814	99.317
04/27/2003	118.6	589.89	577.19	3.44	6.77	318	12.7	10.21	11.29	22	1.11	12.55	21.22	0.0815	99.314
04/27/2003	118.6	589.59	577.09	3.50	6.76	319	12.5	10.27	11.52	23	1.07	12.35	20.88	0.0803	99.312
04/27/2003	118.7	589.29	576.69	3.50	6.54	321.2	12.6	10.04	11.52	23	1.07	12.35	20.88	0.0805	99.307
04/27/2003	118.7	589.29	576.49	3.46	6.65	322.6	12.8	10.11	11.37	24	1.04	11.77	19.90	0.0767	99.304
04/28/2003	119.7	589.39	576.93	3.47	6.64	320.4	12.46	10.10	11.39	24	1.04	11.80	19.94	0.0787	99.315
04/29/2003	120.7	590.29	577.37	3.49	6.55	320.6	12.92	10.04	11.47	24	1.04	11.87	20.07	0.0788	99.314
04/30/2003	121.7	590.49	578.39	3.49	6.54	322.8	12.1	10.03	11.47	24	1.04	11.87	20.07	0.0785	99.310
05/02/2003	124.7	590.39	577.91	3.41	6.83	322	12.48	10.24	11.22	25	1.00	11.22	18.96	0.0731	99.308
05/03/2003	125.7	590.79	577.39	3.46	6.69	323.4	13.4	10.15	11.37	25	1.00	11.37	19.21	0.0741	99.305
05/04/2003	126.7	590.99	577.19	3.47	6.61	323.6	13.8	10.08	11.42	25	1.00	11.42	19.29	0.0745	99.304
05/05/2003	127.7	591.19	577.98	3.49	6.70	323.6	13.21	10.19	11.47	25	1.00	11.47	19.38	0.0745	99.304
05/06/2003	128.7	591.39	577.72	3.51	6.80	324.2	13.67	10.31	11.54	25	1.00	11.54	19.50	0.0750	99.303
05/08/2003	130.7	591.69	578.42	3.50	6.72	323.8	13.27	10.22	11.52	25	1.00	11.52	19.46	0.0746	99.304
05/10/2003	132.7	592.09	578.13	3.44	6.71	325.6	13.96	10.15	11.32	26	0.97	10.93	18.47	0.0708	99.300

RO Unit 2 – Media Pretreatment

Date	Days	FPress2 PSI	CPress2 PSI	PFlow2 gpm	CFlow2 gpm	PCond2	delta P	P+C Flow	Flux gfd	Temp C	TCF	TC Flux gfd	TC Flux Lmh	A	Rejection
02/27/2003	0.00	650.00	635.50	3.37	7.86	160.0	14.5	11.23	11.08	19	1.24	13.72	23.19	0.0564	99.62704
03/13/2003	14.00	647.00	633.00	3.37	7.06	161.0	14.0	10.43	11.08	20	1.19	13.23	22.36	0.0550	99.62471
03/13/2003	14.08	640.00	626.00	3.37	7.42	156.0	14.0	10.79	11.08	20	1.19	13.23	22.36	0.0566	99.63636
03/13/2003	14.38	641.00	627.00	3.45	7.59	147.0	14.0	11.04	11.33	20	1.19	13.53	22.87	0.0577	99.65734
03/18/2003	19.38	631.00	617.00	3.60	7.42	180.0	14.0	11.02	11.84	20	1.19	14.14	23.89	0.0628	99.58042
03/19/2003	20.38	634.00	621.00	3.60	7.33	160.0	13.0	10.93	11.84	20	1.19	14.14	23.89	0.0619	99.62704
03/19/2003	20.54	632.00	618.00	3.52	7.24	164.0	14.0	10.76	11.58	20	1.19	13.83	23.38	0.0613	99.61772
03/20/2003	21.54	632.00	618.00	3.60	7.24	162.0	14.0	10.84	11.84	20	1.19	14.14	23.89	0.0626	99.62238
03/24/2003	25.54	631.00	617.00	3.45	7.06	172.0	14.0	10.51	11.33	20	1.19	13.53	22.87	0.0602	99.59907
03/24/2003	25.71	629.00	616.00	3.45	7.15	172.0	13.0	10.60	11.33	20	1.19	13.53	22.87	0.0606	99.59907
03/25/2003	26.71	627.49	613.39	3.57	7.37	174.8	14.1	10.94	11.74	21	1.15	13.52	22.85	0.0611	99.59254
03/25/2003	26.71	627.19	612.99	3.55	7.20	174.8	14.2	10.74	11.66	21	1.15	13.43	22.70	0.0608	99.59254
03/25/2003	26.71	628.19	614.09	3.51	7.47	174.8	14.1	10.98	11.53	21	1.15	13.29	22.46	0.0598	99.59254
03/25/2003	26.72	628.69	614.59	3.56	7.31	174.8	14.1	10.87	11.71	21	1.15	13.49	22.80	0.0606	99.59254
03/25/2003	26.73	628.59	614.49	3.39	7.35	172.9	14.1	10.74	11.16	20	1.19	13.32	22.52	0.0599	99.59697
03/25/2003	26.74	628.19	613.89	3.55	7.26	172.9	14.3	10.80	11.66	20	1.19	13.92	23.53	0.0627	99.59697
03/25/2003	26.76	627.89	613.99	3.43	7.30	172.9	13.9	10.73	11.28	20	1.19	13.47	22.77	0.0607	99.59697
03/25/2003	26.78	628.09	613.99	3.53	7.21	172.9	14.1	10.75	11.61	20	1.19	13.86	23.43	0.0625	99.59697
03/25/2003	26.81	628.29	614.29	3.55	7.24	172.9	14.0	10.79	11.69	20	1.19	13.96	23.58	0.0628	99.59697
03/25/2003	26.83	628.49	614.39	3.64	7.17	172.9	14.1	10.81	11.96	20	1.19	14.29	24.14	0.0643	99.59697
03/25/2003	26.87	628.69	614.59	3.46	7.21	172.9	14.1	10.67	11.38	20	1.19	13.59	22.97	0.0611	99.59697
03/25/2003	26.90	628.19	614.09	3.41	7.15	172.9	14.1	10.56	11.21	20	1.19	13.38	22.62	0.0603	99.59697
03/25/2003	26.94	628.19	614.19	3.45	7.19	172.9	14.0	10.64	11.36	20	1.19	13.56	22.92	0.0611	99.59697
03/25/2003	26.98	628.39	614.39	3.53	7.14	172.9	14.0	10.67	11.61	20	1.19	13.86	23.43	0.0624	99.59697
03/25/2003	27.03	628.19	614.29	3.49	7.25	172.9	13.9	10.73	11.46	20	1.19	13.68	23.13	0.0616	99.59697
03/25/2003	27.07	627.99	613.99	3.61	7.39	172.9	14.0	11.00	11.86	20	1.19	14.17	23.94	0.0638	99.59697
03/25/2003	27.13	628.29	614.09	3.68	7.31	172.9	14.2	11.00	12.11	20	1.19	14.47	24.45	0.0651	99.59697
03/25/2003	27.18	628.39	614.29	3.49	7.24	172.9	14.1	10.73	11.46	20	1.19	13.68	23.13	0.0616	99.59697
03/25/2003	27.24	628.69	614.39	3.42	7.13	171.0	14.3	10.56	11.26	20	1.19	13.44	22.72	0.0604	99.6014
03/25/2003	27.30	627.99	613.89	3.59	7.24	171.0	14.1	10.83	11.81	20	1.19	14.11	23.84	0.0636	99.6014
03/25/2003	27.37	628.19	614.19	3.33	7.23	171.0	14.0	10.56	10.95	20	1.19	13.08	22.11	0.0589	99.6014
03/25/2003	27.44	628.09	613.99	3.38	7.17	171.0	14.1	10.55	11.11	20	1.19	13.26	22.41	0.0598	99.6014
03/25/2003	27.51	627.79	613.79	3.69	7.23	171.0	14.0	10.92	12.14	20	1.19	14.50	24.50	0.0654	99.6014
03/25/2003	27.59	628.29	614.19	3.49	7.36	171.0	14.1	10.85	11.48	20	1.19	13.71	23.18	0.0617	99.6014
03/25/2003	27.67	628.19	613.99	3.60	7.18	171.0	14.2	10.78	11.84	20	1.19	14.14	23.89	0.0637	99.6014
03/25/2003	27.75	628.09	613.99	3.61	7.09	171.0	14.1	10.70	11.86	20	1.19	14.17	23.94	0.0638	99.6014
03/25/2003	27.84	627.89	613.89	3.38	7.51	171.0	14.0	10.89	11.11	20	1.19	13.26	22.41	0.0598	99.6014
03/25/2003	27.93	627.59	613.39	3.44	7.04	171.0	14.2	10.48	11.31	20	1.19	13.50	22.82	0.0610	99.6014
03/25/2003	28.02	627.49	613.39	3.46	7.13	171.0	14.1	10.60	11.38	20	1.19	13.59	22.97	0.0614	99.6014
03/25/2003	28.12	627.29	613.29	3.45	7.28	171.0	14.0	10.74	11.36	20	1.19	13.56	22.92	0.0613	99.6014
03/25/2003	28.22	627.69	613.59	3.49	7.09	171.0	14.1	10.58	11.48	20	1.19	13.71	23.18	0.0619	99.6014
03/25/2003	28.32	627.59	613.39	3.56	7.24	171.0	14.2	10.80	11.71	20	1.19	13.99	23.63	0.0632	99.6014
03/25/2003	28.43	627.29	613.29	3.47	7.04	171.0	14.0	10.51	11.41	20	1.19	13.62	23.02	0.0616	99.6014
03/25/2003	28.54	627.09	612.89	3.39	7.02	171.0	14.2	10.41	11.16	20	1.19	13.32	22.52	0.0603	99.6014
03/25/2003	28.66	627.29	613.29	3.49	6.91	171.0	14.0	10.40	11.48	20	1.19	13.71	23.18	0.0620	99.6014
03/25/2003	28.78	627.19	612.99	3.45	6.85	171.0	14.2	10.30	11.33	20	1.19	13.53	22.87	0.0613	99.6014
03/25/2003	28.90	627.19	613.09	3.54	7.16	171.0	14.1	10.70	11.63	20	1.19	13.89	23.48	0.0629	99.6014
03/25/2003	29.02	627.39	613.29	3.46	7.09	171.0	14.1	10.55	11.38	20	1.19	13.59	22.97	0.0615	99.6014
03/25/2003	29.15	626.79	612.79	3.32	7.34	171.0	14.0	10.65	10.90	20	1.19	13.02	22.01	0.0590	99.6014
03/25/2003	29.28	626.39	612.39	3.51	7.37	171.0	14.0	10.88	11.53	20	1.19	13.77	23.28	0.0625	99.6014
03/25/2003	29.42	627.09	613.29	3.44	7.08	171.0	13.8	10.52	11.31	20	1.19	13.50	22.82	0.0611	99.6014
03/25/2003	29.56	626.69	612.79	3.45	7.25	171.0	13.9	10.70	11.33	20	1.19	13.53	22.87	0.0614	99.6014
03/25/2003	29.70	627.09	612.89	3.56	7.32	171.0	14.2	10.88	11.71	20	1.19	13.99	23.63	0.0633	99.6014
03/25/2003	29.84	626.79	612.89	3.48	7.39	171.0	13.9	10.87	11.43	20	1.19	13.65	23.08	0.0619	99.6014
03/25/2003	29.99	626.79	612.99	3.52	7.13	169.1	13.8	10.65	11.58	20	1.19	13.83	23.38	0.0627	99.60583
03/25/2003	30.15	626.59	612.59	3.46	7.34	169.1	14.0	10.80	11.38	20	1.19	13.59	22.97	0.0617	99.60583
03/25/2003	30.30	626.79	612.69	3.58	6.97	171.0	14.1	10.55	11.79	20	1.19	14.08	23.79	0.0638	99.6014
03/25/2003	30.46	627.39	613.39	3.55	7.27	169.1	14.0	10.81	11.66	20	1.19	13.92	23.53	0.0629	99.60583
03/26/2003	30.63	626.89	612.79	3.55	7.31	169.1	14.1	10.86	11.66	20	1.19	13.92	23.53	0.0631	99.60583
03/26/2003	30.79	630.09	615.69	3.47	7.25	161.5	14.4	10.72	11.41	20	1.19	13.62	23.02	0.0609	99.62354
03/26/2003	30.79	630.09	615.49	3.53	7.42	172.9	14.6	10.95	11.61	20	1.19	13.86	23.43	0.0620	99.59697
03/26/2003	30.80	629.99	615.69	3.49	7.28	176.7	14.3	10.78	11.48	20	1.19	13.71	23.18	0.0613	99.58811
03/26/2003	30.80	630.49	616.09	3.45	7.30	176.7	14.4	10.75	11.33	20	1.19	13.53	22.87	0.0604	99.58811
03/26/2003	30.80	630.29	615.89	3.52	6.94	176.7	14.4	10.46	11.56	20	1.19	13.80	23.33	0.0616	99.58811
03/26/2003	30.81	630.79	616.49	3.39	7.30	176.7	14.3	10.70	11.16	20	1.19	13.32	22.52	0.0593	99.58811
03/26/2003	30.81	631.19	616.79	3.57	7.02	176.7	14.4	10.59	11.74	20	1.19	14.02	23.69	0.0623	99.58811
03/26/2003	30.81	631.49	616.99	3.58	7.17	176.7	14.5	10.75	11.76	20	1.19	14.05	23.74	0.0624	99.58811
03/26/2003	30.82	631.59	617.29	3.43	7.26	176.7	14.3	10.69	11.28	20	1.19	13.47	22.77	0.0598	99.58811
03/26/2003	30.82	631.59	617.69	3.52	7.40	174.8	13.9	10.92	11.58	20	1.19	13.83	23.38	0.0613	99.59254
03/26/2003	30.82	631.59	617.29	3.57	7.20	176.7	14.3	10.77	11.74	20	1.19	14.02	23.69	0.0622	99.58811
03/26/2003	30.83	631.69	617.39	3.42	7.15	176.7	14.3	10.58	11.26	20	1.19	13.44	22.72	0.0596	99.58811
03/26/2003	30.83	632.89	618.49	3.49	7.24	174.8	14.4	10.73	11.48	20	1.19	13.71	23.18	0.0605	99.59254
03/26/2003	30.83	631.79	617.49	3.65	7.12	176.7	14.3	10.77	12.01	20	1.19	14.35	24.24	0.0636	99.58811

03/26/2003	30.84	631.99	617.89	3.58	7.27	176.7	14.1	10.85	11.79	20	1.19	14.08	23.79	0.0623	99.58811
03/26/2003	30.84	632.39	618.09	3.32	7.22	176.7	14.3	10.55	10.93	20	1.19	13.05	22.06	0.0577	99.58811
03/26/2003	30.84	632.29	617.89	3.54	7.13	174.8	14.4	10.67	11.63	20	1.19	13.89	23.48	0.0615	99.59254
03/26/2003	30.85	632.39	618.09	3.32	7.31	174.8	14.3	10.64	10.93	20	1.19	13.05	22.06	0.0577	99.59254
03/26/2003	30.85	632.29	617.89	3.54	6.87	174.8	14.4	10.41	11.63	20	1.19	13.89	23.48	0.0615	99.59254
03/26/2003	30.85	632.29	618.09	3.57	7.43	174.8	14.2	11.00	11.74	20	1.19	14.02	23.69	0.0620	99.59254
03/26/2003	30.86	632.09	617.89	3.45	7.14	174.8	14.2	10.59	11.33	20	1.19	13.53	22.87	0.0599	99.59254
03/26/2003	30.86	632.09	617.69	3.58	7.09	174.8	14.4	10.67	11.76	20	1.19	14.05	23.74	0.0622	99.59254
03/26/2003	30.86	631.49	617.29	3.53	7.18	174.8	14.2	10.71	11.61	20	1.19	13.86	23.43	0.0615	99.59254
03/26/2003	30.87	631.59	617.29	3.46	7.11	174.8	14.3	10.57	11.38	20	1.19	13.59	22.97	0.0603	99.59254
03/26/2003	30.87	630.99	616.79	3.46	6.95	174.8	14.2	10.41	11.38	20	1.19	13.59	22.97	0.0605	99.59254
03/27/2003	30.88	630.69	616.39	3.42	7.28	172.9	14.3	10.69	11.23	20	1.19	13.41	22.67	0.0598	99.59697
03/27/2003	31.79	633.59	619.29	3.44	7.09	161.5	14.3	10.53	11.31	20	1.19	13.50	22.82	0.0594	99.62354
03/27/2003	31.83	633.39	618.99	3.45	7.12	163.4	14.4	10.57	11.36	20	1.19	13.56	22.92	0.0598	99.61911
03/27/2003	31.88	632.99	618.49	3.56	7.15	163.4	14.5	10.71	11.71	20	1.19	13.99	23.63	0.0617	99.61911
03/27/2003	31.92	632.39	618.19	3.42	7.13	165.3	14.2	10.55	11.26	20	1.19	13.44	22.72	0.0595	99.61469
03/27/2003	31.96	632.19	617.79	3.52	7.16	165.3	14.4	10.68	11.58	20	1.19	13.83	23.38	0.0613	99.61469
03/27/2003	32.00	632.49	618.29	3.37	7.02	165.3	14.2	10.39	11.08	20	1.19	13.23	22.36	0.0585	99.61469
03/27/2003	32.04	631.39	617.19	3.59	7.26	165.3	14.2	10.85	11.81	20	1.19	14.11	23.84	0.0627	99.61469
03/27/2003	32.08	632.39	618.09	3.44	6.91	163.4	14.3	10.35	11.31	20	1.19	13.50	22.82	0.0598	99.61911
03/27/2003	32.13	632.79	618.49	3.43	7.16	163.4	14.3	10.59	11.28	20	1.19	13.47	22.77	0.0595	99.61911
03/27/2003	32.17	633.09	618.69	3.40	7.01	163.4	14.4	10.41	11.18	20	1.19	13.35	22.57	0.0599	99.62263
03/28/2003	32.21	633.79	619.39	3.36	7.37	163.4	14.4	10.73	11.03	21	1.15	12.71	21.48	0.0568	99.62263
03/28/2003	32.25	634.49	619.99	3.46	7.25	161.5	14.5	10.71	11.38	21	1.15	13.11	22.16	0.0585	99.62702
03/28/2003	32.29	633.69	619.39	3.34	7.17	161.5	14.3	10.51	10.98	21	1.15	12.65	21.38	0.0566	99.62702
03/28/2003	32.33	633.79	619.59	3.40	6.99	161.5	14.2	10.39	11.18	21	1.15	12.88	21.77	0.0576	99.62702
03/28/2003	32.38	633.49	619.19	3.50	7.13	161.5	14.3	10.64	11.51	21	1.15	13.26	22.41	0.0594	99.62702
03/28/2003	32.42	632.99	618.49	3.35	7.04	161.5	14.5	10.38	11.01	21	1.15	12.68	21.43	0.0569	99.62702
03/28/2003	32.46	633.29	618.89	3.47	7.12	161.5	14.4	10.59	11.41	21	1.15	13.14	22.21	0.0589	99.62702
03/28/2003	32.50	632.69	618.29	3.32	7.16	159.6	14.4	10.49	10.93	21	1.15	12.59	21.28	0.0566	99.63141
03/28/2003	32.54	632.99	618.49	3.49	6.98	159.6	14.5	10.48	11.48	21	1.15	13.23	22.36	0.0594	99.63141
03/28/2003	32.58	633.59	619.19	3.58	7.21	159.6	14.4	10.78	11.76	21	1.15	13.55	22.90	0.0607	99.63141
03/28/2003	32.63	632.99	618.79	3.46	7.10	159.6	14.2	10.56	11.38	21	1.15	13.11	22.16	0.0588	99.63141
03/28/2003	32.67	632.79	618.69	3.45	7.25	161.5	14.1	10.70	11.36	21	1.15	13.08	22.11	0.0587	99.62702
03/28/2003	32.71	632.19	617.59	3.45	6.97	159.6	14.6	10.41	11.33	21	1.15	13.06	22.06	0.0588	99.63141
03/28/2003	32.75	634.79	620.19	3.42	7.15	157.7	14.6	10.58	11.26	21	1.15	12.97	21.92	0.0578	99.6358
03/28/2003	32.79	627.19	612.79	3.52	7.10	150.1	14.4	10.62	11.56	21	1.15	13.32	22.51	0.0614	99.65335
03/28/2003	32.83	631.39	616.49	3.34	7.35	153.9	14.9	10.69	10.98	21	1.15	12.65	21.38	0.0573	99.64457
03/28/2003	32.88	628.69	614.19	3.55	7.23	152.0	14.5	10.79	11.69	21	1.15	13.46	22.75	0.0617	99.64896
03/28/2003	32.92	628.29	613.69	3.25	7.20	150.1	14.6	10.44	10.68	21	1.15	12.30	20.79	0.0565	99.65335
03/28/2003	32.96	628.89	614.49	3.44	7.20	150.1	14.4	10.64	11.31	21	1.15	13.03	22.01	0.0596	99.65335
03/28/2003	33.00	632.49	618.09	3.49	7.00	152.0	14.4	10.50	11.48	21	1.15	13.23	22.36	0.0595	99.64896
03/28/2003	33.04	636.99	622.39	3.58	7.24	155.8	14.6	10.82	11.76	21	1.15	13.55	22.90	0.0598	99.64018
03/28/2003	33.08	636.59	621.89	3.44	7.27	153.9	14.7	10.71	11.31	21	1.15	13.03	22.01	0.0576	99.64457
03/29/2003	33.13	637.59	622.79	3.37	7.39	153.9	14.8	10.76	11.08	19	1.24	13.72	23.19	0.0604	99.64457
03/29/2003	33.17	639.69	624.99	3.51	7.14	155.8	14.7	10.65	11.53	19	1.24	14.28	24.14	0.0623	99.64018
03/29/2003	33.21	641.69	626.89	3.39	7.24	155.8	14.8	10.63	11.16	19	1.24	13.82	23.35	0.0597	99.64018
03/29/2003	33.25	642.09	627.29	3.29	7.11	153.9	14.8	10.40	10.83	19	1.24	13.41	22.66	0.0579	99.64457
03/29/2003	33.29	642.79	627.99	3.37	6.99	153.9	14.8	10.36	11.08	19	1.24	13.72	23.19	0.0591	99.64457
03/29/2003	33.33	645.19	630.19	3.39	7.34	153.9	15.0	10.72	11.13	19	1.24	13.78	23.29	0.0588	99.64457
03/29/2003	33.38	645.69	630.79	3.49	7.61	153.9	14.9	11.10	11.48	19	1.24	14.22	24.03	0.0605	99.64457
03/29/2003	33.42	646.39	631.49	3.45	7.34	153.9	14.9	10.79	11.36	19	1.24	14.06	23.77	0.0596	99.64457
03/29/2003	33.46	647.69	632.59	3.27	7.36	153.9	15.1	10.63	10.75	19	1.24	13.32	22.50	0.0562	99.64457
03/29/2003	33.50	648.69	633.69	3.44	7.24	153.9	15.0	10.68	11.31	19	1.24	14.00	23.66	0.0588	99.64457
03/29/2003	33.54	650.39	635.29	3.36	7.05	153.9	15.1	10.41	11.06	19	1.24	13.69	23.14	0.0571	99.64457
03/29/2003	33.58	651.99	636.69	3.31	7.39	153.9	15.3	10.70	10.88	19	1.24	13.47	22.77	0.0558	99.64457
03/29/2003	33.63	651.59	636.29	3.36	7.18	153.9	15.3	10.54	11.06	19	1.24	13.69	23.14	0.0568	99.64457
03/29/2003	33.67	653.59	638.39	3.39	7.30	155.8	15.2	10.69	11.13	19	1.24	13.78	23.29	0.0567	99.64018
03/29/2003	33.71	657.39	642.29	3.27	7.06	161.5	15.1	10.33	10.75	19	1.24	13.32	22.50	0.0539	99.62702
03/29/2003	33.75	657.49	642.49	3.36	7.21	163.4	15.0	10.57	11.03	19	1.24	13.66	23.08	0.0553	99.62263
03/29/2003	33.79	657.49	642.59	3.39	7.13	165.3	14.9	10.53	11.16	19	1.24	13.82	23.35	0.0559	99.61824
03/29/2003	33.83	654.39	639.39	3.33	7.19	161.5	15.0	10.52	10.95	19	1.24	13.57	22.93	0.0556	99.62702
03/29/2003	33.88	651.99	636.99	3.45	7.10	159.6	15.0	10.55	11.36	19	1.24	14.06	23.77	0.0582	99.63141
03/29/2003	33.92	656.39	641.39	3.37	7.35	161.5	15.0	10.72	11.08	19	1.24	13.72	23.19	0.0558	99.62702
03/29/2003	33.96	657.49	642.59	3.31	7.35	163.4	14.9	10.66	10.88	19	1.24	13.47	22.77	0.0545	99.62263
03/29/2003	34.00	658.89	643.69	3.24	7.49	163.4	15.2	10.73	10.65	19	1.24	13.19	22.29	0.0531	99.62263
03/29/2003	34.04	658.69	643.59	3.49	7.30	163.4	15.1	10.80	11.48	19	1.24	14.22	24.03	0.0573	99.62263
03/29/2003	34.08	659.09	644.09	3.34	7.58	163.4	15.0	10.92	10.98	19	1.24	13.60	22.98	0.0547	99.62263
03/30/2003	34.13	660.09	644.79	3.28	7.52	161.5	15.3	10.80	10.78	17	1.33	14.36	24.27	0.0576	99.62702
03/30/2003	34.17	660.49	645.19	3.34	7.10	159.6	15.3	10.44	10.98	17	1.33	14.63	24.72	0.0586	99.63141
03/30/2003	34.21	661.19	645.79	3.40	7.28	159.6	15.4	10.69	11.18	17	1.33	14.90	25.18	0.0595	99.63141
03/30/2003	34.25	661.69	646.49	3.31	7.48	159.6	15.2	10.79	10.88	17	1.33	14.50	24.50	0.0577	99.63141
03/30/2003	34.29	662.89	647.69	3.28	7.51	159.6	15.2	10.78	10.78	17	1.33	14.36	24.27	0.0569	99.63141
03/30/2003	34.33	664.19	648.79	3.24	7.34	157.7	15.4	10.58	10.65	17	1.33	14.19	23.99	0.0560	99.6358
03/30/2003	34.38	663.19	647.79	3.29	7.53	155.8	15.4	10.82	10.80	17	1.33	14.39	24.33	0.0570	99.64018

03/30/2003	34.42	662.49	647.19	3.33	7.32	153.9	15.3	10.65	10.95	17	1.33	14.60	24.67	0.0580	99.64457
03/30/2003	34.46	662.99	647.59	3.31	7.36	153.9	15.4	10.67	10.88	17	1.33	14.50	24.50	0.0575	99.64457
03/30/2003	34.50	664.09	648.69	3.35	7.24	153.9	15.4	10.59	11.01	17	1.33	14.66	24.78	0.0579	99.64457
03/30/2003	34.54	662.89	647.49	3.15	7.21	155.8	15.4	10.35	10.35	17	1.33	13.79	23.31	0.0547	99.64018
03/30/2003	34.58	663.79	648.39	3.29	7.52	157.7	15.4	10.81	10.80	17	1.33	14.39	24.33	0.0569	99.6358
03/30/2003	34.63	662.69	647.29	3.32	7.34	159.6	15.4	10.65	10.90	17	1.33	14.53	24.55	0.0577	99.63141
03/30/2003	34.67	661.49	646.29	3.26	7.31	159.6	15.2	10.57	10.73	17	1.33	14.29	24.16	0.0570	99.63141
03/30/2003	34.71	660.69	645.59	3.32	7.25	161.5	15.1	10.57	10.93	17	1.33	14.56	24.61	0.0582	99.62702
03/30/2003	34.75	659.79	644.79	3.21	7.39	163.4	15.0	10.60	10.55	17	1.33	14.06	23.76	0.0564	99.62263
03/30/2003	34.79	659.39	644.29	3.25	7.28	163.4	15.1	10.52	10.68	17	1.33	14.23	24.04	0.0572	99.62263
03/30/2003	34.83	658.59	643.59	3.26	7.30	163.4	15.0	10.56	10.70	17	1.33	14.26	24.10	0.0575	99.62263
03/30/2003	34.88	658.29	643.29	3.29	7.36	163.4	15.0	10.66	10.83	17	1.33	14.43	24.38	0.0582	99.62263
03/30/2003	34.92	656.89	641.89	3.36	7.33	163.4	15.0	10.68	11.03	17	1.33	14.70	24.84	0.0596	99.62263
03/30/2003	34.96	656.39	641.29	3.24	7.40	163.4	15.1	10.64	10.65	17	1.33	14.19	23.99	0.0577	99.62263
03/30/2003	35.00	657.09	641.79	3.34	7.11	163.4	15.3	10.45	10.98	17	1.33	14.63	24.72	0.0594	99.62263
03/30/2003	35.04	656.59	641.59	3.34	7.20	163.4	15.0	10.54	10.98	17	1.33	14.63	24.72	0.0594	99.62263
03/31/2003	35.08	656.59	641.59	3.32	7.32	161.5	15.0	10.64	10.93	18	1.28	14.04	23.72	0.0570	99.62702
03/31/2003	35.13	658.29	643.19	3.27	7.34	161.5	15.1	10.61	10.75	18	1.28	13.81	23.34	0.0557	99.62702
03/31/2003	35.17	657.79	642.39	3.30	7.24	161.5	15.4	10.54	10.85	18	1.28	13.94	23.56	0.0564	99.62702
03/31/2003	35.21	657.79	642.59	3.29	7.36	157.7	15.2	10.64	10.80	18	1.28	13.88	23.45	0.0561	99.6358
03/31/2003	35.25	657.29	641.99	3.30	7.42	157.7	15.3	10.72	10.85	18	1.28	13.94	23.56	0.0565	99.6358
03/31/2003	35.29	658.19	642.89	3.22	7.30	155.8	15.3	10.53	10.60	18	1.28	13.62	23.01	0.0550	99.64018
03/31/2003	35.33	657.89	642.59	3.49	7.41	153.9	15.3	10.90	11.48	18	1.28	14.75	24.93	0.0597	99.64457
03/31/2003	35.38	657.89	642.29	3.34	7.28	153.9	15.6	10.62	10.98	18	1.28	14.10	23.83	0.0571	99.64457
03/31/2003	35.42	652.79	637.29	3.38	7.63	159.6	15.5	11.01	11.11	18	1.28	14.26	24.11	0.0589	99.63141
03/31/2003	35.46	650.29	634.89	3.44	7.27	163.4	15.4	10.71	11.31	18	1.28	14.52	24.54	0.0606	99.62263
03/31/2003	35.50	650.19	634.89	3.39	7.28	161.5	15.3	10.66	11.13	18	1.28	14.30	24.16	0.0597	99.62702
03/31/2003	35.67	646.39	631.09	3.33	7.14	148.2	15.3	10.48	10.95	18	1.28	14.07	23.78	0.0597	99.65774
03/31/2003	35.71	646.49	631.49	3.35	7.10	167.2	15.0	10.45	11.01	18	1.28	14.13	23.89	0.0599	99.61386
03/31/2003	35.75	645.79	630.79	3.38	7.36	165.3	15.0	10.73	11.11	18	1.28	14.26	24.11	0.0606	99.61824
03/31/2003	35.79	646.19	631.19	3.39	7.28	165.3	15.0	10.67	11.16	18	1.28	14.33	24.21	0.0608	99.61824
03/31/2003	35.83	646.69	631.49	3.42	7.48	165.3	15.2	10.90	11.26	18	1.28	14.46	24.43	0.0612	99.61824
03/31/2003	35.88	647.69	632.59	3.39	7.25	163.4	15.1	10.64	11.13	18	1.28	14.30	24.16	0.0603	99.62263
03/31/2003	35.92	648.19	632.89	3.43	7.36	163.4	15.3	10.80	11.28	18	1.28	14.49	24.49	0.0610	99.62263
04/01/2003	35.96	648.69	633.49	3.43	7.01	161.5	15.2	10.44	11.28	19	1.24	13.97	23.61	0.0587	99.62702
04/01/2003	36.00	649.99	634.79	3.32	7.24	161.5	15.2	10.57	10.93	19	1.24	13.53	22.87	0.0565	99.62702
04/01/2003	36.04	650.79	635.69	3.32	7.29	159.6	15.1	10.62	10.93	19	1.24	13.53	22.87	0.0563	99.63141
04/01/2003	36.08	652.29	636.89	3.26	7.35	159.6	15.4	10.60	10.70	19	1.24	13.25	22.40	0.0549	99.63141
04/01/2003	36.13	652.19	636.99	3.33	7.44	159.6	15.2	10.78	10.95	19	1.24	13.57	22.93	0.0562	99.63141
04/01/2003	36.17	652.09	636.79	3.36	7.35	157.7	15.3	10.71	11.06	19	1.24	13.69	23.14	0.0567	99.6358
04/01/2003	36.21	650.79	635.59	3.43	7.34	157.7	15.2	10.77	11.28	19	1.24	13.97	23.61	0.0582	99.6358
04/01/2003	36.25	649.69	634.49	3.40	7.22	155.8	15.2	10.62	11.18	19	1.24	13.85	23.40	0.0579	99.64018
04/01/2003	36.29	649.99	634.69	3.39	7.28	153.9	15.3	10.67	11.13	19	1.24	13.78	23.29	0.0576	99.64457
04/01/2003	36.33	648.89	633.69	3.39	7.07	153.9	15.2	10.47	11.16	19	1.24	13.82	23.35	0.0580	99.64457
04/01/2003	36.38	648.79	633.49	3.45	7.13	153.9	15.3	10.58	11.33	19	1.24	14.03	23.72	0.0590	99.64457
04/01/2003	36.42	648.19	633.09	3.42	7.14	153.9	15.1	10.56	11.23	19	1.24	13.91	23.51	0.0586	99.64457
04/01/2003	36.46	647.99	632.89	3.42	7.39	153.9	15.1	10.81	11.23	19	1.24	13.91	23.51	0.0586	99.64457
04/01/2003	36.50	647.29	632.19	3.38	7.51	155.8	15.1	10.88	11.11	19	1.24	13.75	23.24	0.0581	99.64018
04/01/2003	36.54	646.99	631.89	3.33	7.31	155.8	15.1	10.64	10.95	19	1.24	13.57	22.93	0.0574	99.64018
04/02/2003	36.58	646.79	631.69	3.47	7.22	155.8	15.1	10.69	11.41	19	1.24	14.13	23.87	0.0598	99.64018
04/02/2003	36.71	639.89	624.99	3.29	7.13	174.8	14.9	10.42	10.80	19	1.24	13.38	22.61	0.0583	99.5963
04/02/2003	36.75	641.69	626.89	3.48	7.27	171.0	14.8	10.74	11.43	19	1.24	14.16	23.93	0.0612	99.60508
04/02/2003	36.79	641.89	626.99	3.49	6.83	169.1	14.9	10.32	11.48	19	1.24	14.22	24.03	0.0614	99.60947
04/02/2003	36.83	641.29	626.29	3.44	7.27	169.1	15.0	10.71	11.31	19	1.24	14.00	23.66	0.0606	99.60947
04/02/2003	36.88	641.99	627.19	3.39	7.43	167.2	14.8	10.82	11.16	19	1.24	13.82	23.35	0.0596	99.61386
04/02/2003	36.92	643.09	628.29	3.46	7.44	165.3	14.8	10.91	11.38	19	1.24	14.10	23.82	0.0606	99.61824
04/03/2003	36.96	641.69	626.79	3.28	7.13	165.3	14.9	10.40	10.78	20	1.19	12.87	21.75	0.0557	99.61824
04/03/2003	37.00	643.39	628.59	3.42	7.08	165.3	14.8	10.51	11.26	20	1.19	13.44	22.72	0.0577	99.61824
04/03/2003	37.04	642.89	627.99	3.27	7.38	163.4	14.9	10.65	10.75	20	1.19	12.84	21.70	0.0552	99.62263
04/03/2003	37.08	643.39	628.39	3.34	7.36	163.4	15.0	10.70	10.98	20	1.19	13.11	22.16	0.0563	99.62263
04/03/2003	37.13	643.99	628.79	3.31	7.43	163.4	15.2	10.74	10.88	20	1.19	12.99	21.96	0.0557	99.62263
04/03/2003	37.17	643.89	628.99	3.44	7.50	163.4	14.9	10.94	11.31	20	1.19	13.50	22.82	0.0578	99.62263
04/03/2003	37.21	643.89	628.79	3.51	7.02	163.4	15.1	10.53	11.53	20	1.19	13.77	23.28	0.0590	99.62263
04/03/2003	37.25	643.79	629.09	3.48	7.11	161.5	14.7	10.59	11.43	20	1.19	13.65	23.08	0.0585	99.62702
04/03/2003	37.29	644.89	629.99	3.32	7.18	161.5	14.9	10.50	10.90	20	1.19	13.02	22.01	0.0555	99.62702
04/03/2003	37.33	644.09	629.09	3.28	7.54	161.5	15.0	10.82	10.78	20	1.19	12.87	21.75	0.0551	99.62702
04/03/2003	37.38	644.09	629.19	3.45	7.26	161.5	14.9	10.71	11.36	20	1.19	13.56	22.92	0.0581	99.62702
04/03/2003	37.42	644.09	629.19	3.42	7.11	161.5	14.9	10.52	11.23	20	1.19	13.41	22.67	0.0574	99.62702
04/03/2003	37.46	642.89	628.19	3.36	7.07	163.4	14.7	10.43	11.03	20	1.19	13.17	22.26	0.0566	99.62263
04/03/2003	37.50	643.69	629.19	3.34	7.33	163.4	14.5	10.67	10.98	20	1.19	13.11	22.16	0.0562	99.62263
04/03/2003	37.54	643.79	629.19	3.33	7.08	163.4	14.6	10.41	10.95	20	1.19	13.08	22.11	0.0560	99.62263
04/03/2003	37.58	642.79	627.89	3.32	7.36	163.4	14.9	10.68	10.90	20	1.19	13.02	22.01	0.0560	99.62263
04/03/2003	37.63	642.29	627.59	3.32	7.29	163.4	14.7	10.62	10.93	20	1.19	13.05	22.06	0.0563	99.62263
04/03/2003	37.67	641.79	626.99	3.45	7.25	165.3	14.8	10.70	11.33	20	1.19	13.53	22.87	0.0585	99.61824
04/03/2003	37.71	641.29	626.59	3.29	7.03	165.3	14.7	10.32	10.83	20	1.19	12.93	21.86	0.0560	99.61824

04/03/2003	37.75	641.59	626.79	3.44	7.31	165.3	14.8	10.75	11.31	20	1.19	13.50	22.82	0.0584	99.61824
04/03/2003	37.79	641.59	627.09	3.42	7.31	165.3	14.5	10.73	11.23	20	1.19	13.41	22.67	0.0580	99.61824
04/03/2003	37.83	641.09	626.49	3.26	7.54	165.3	14.6	10.80	10.73	20	1.19	12.81	21.65	0.0555	99.61824
04/03/2003	37.88	641.19	626.59	3.36	7.51	165.3	14.6	10.87	11.03	20	1.19	13.17	22.26	0.0570	99.61824
04/03/2003	37.92	641.69	626.69	3.51	7.24	163.4	15.0	10.75	11.53	20	1.19	13.77	23.28	0.0596	99.62263
04/04/2003	37.96	640.59	626.09	3.33	7.08	163.4	14.5	10.41	10.95	20	1.19	13.08	22.11	0.0568	99.62263
04/04/2003	38.00	641.79	627.09	3.41	7.25	163.4	14.7	10.66	11.21	20	1.19	13.38	22.62	0.0578	99.62263
04/04/2003	38.04	642.19	627.49	3.32	7.50	163.4	14.7	10.82	10.93	20	1.19	13.05	22.06	0.0563	99.62263
04/04/2003	38.08	643.29	628.39	3.42	7.27	163.4	14.9	10.69	11.26	20	1.19	13.44	22.72	0.0577	99.62263
04/04/2003	38.13	642.79	628.09	3.28	7.11	163.4	14.7	10.39	10.78	20	1.19	12.87	21.75	0.0554	99.62263
04/04/2003	38.17	642.69	627.69	3.49	7.28	163.4	15.0	10.78	11.48	20	1.19	13.71	23.18	0.0591	99.62263
04/04/2003	38.21	642.19	627.29	3.36	7.30	163.4	14.9	10.67	11.06	20	1.19	13.20	22.31	0.0570	99.62263
04/04/2003	38.25	641.69	626.79	3.47	7.24	163.4	14.9	10.71	11.41	20	1.19	13.62	23.02	0.0589	99.62263
04/04/2003	38.29	642.79	627.89	3.44	7.12	161.5	14.9	10.56	11.31	20	1.19	13.50	22.82	0.0581	99.62702
04/04/2003	38.33	641.99	627.09	3.33	7.28	163.4	14.9	10.62	10.95	20	1.19	13.08	22.11	0.0565	99.62263
04/04/2003	38.38	642.29	627.29	3.38	7.32	163.4	15.0	10.70	11.11	20	1.19	13.26	22.41	0.0572	99.62263
04/04/2003	38.42	641.79	626.89	3.36	7.31	163.4	14.9	10.67	11.03	20	1.19	13.17	22.26	0.0569	99.62263
04/04/2003	38.46	642.09	627.09	3.39	7.18	163.4	15.0	10.57	11.16	20	1.19	13.32	22.52	0.0575	99.62263
04/04/2003	38.50	641.29	626.49	3.53	7.49	165.3	14.8	11.02	11.61	20	1.19	13.86	23.43	0.0600	99.61824
04/04/2003	38.67	635.19	620.59	3.50	7.27	180.5	14.6	10.77	11.51	20	1.19	13.74	23.23	0.0610	99.58314
04/04/2003	38.71	638.79	624.19	3.31	7.33	174.8	14.6	10.64	10.88	20	1.19	12.99	21.96	0.0568	99.5963
04/04/2003	38.75	639.99	625.29	3.33	7.21	172.9	14.7	10.55	10.95	20	1.19	13.08	22.11	0.0569	99.60069
04/04/2003	38.79	638.89	624.29	3.29	7.30	172.9	14.6	10.59	10.80	20	1.19	12.90	21.81	0.0564	99.60069
04/04/2003	38.83	637.59	622.99	3.29	7.19	174.8	14.6	10.47	10.80	20	1.19	12.90	21.81	0.0567	99.5963
04/04/2003	38.88	638.29	623.89	3.53	7.07	172.9	14.4	10.60	11.61	20	1.19	13.86	23.43	0.0607	99.60069
04/04/2003	38.92	637.69	623.19	3.55	7.28	172.9	14.5	10.84	11.69	20	1.19	13.96	23.58	0.0613	99.60069
04/05/2003	38.96	638.39	623.69	3.43	7.19	172.9	14.7	10.62	11.28	20	1.19	13.47	22.77	0.0590	99.60069
04/05/2003	39.00	638.69	623.89	3.35	7.05	171.0	14.8	10.39	11.01	20	1.19	13.14	22.21	0.0575	99.60508
04/05/2003	39.04	639.39	624.69	3.34	7.22	171.0	14.7	10.56	10.98	20	1.19	13.11	22.16	0.0572	99.60508
04/05/2003	39.08	639.49	624.89	3.45	7.26	171.0	14.6	10.71	11.36	20	1.19	13.56	22.92	0.0592	99.60508
04/05/2003	39.13	638.79	623.99	3.44	7.27	171.0	14.8	10.71	11.31	20	1.19	13.50	22.82	0.0591	99.60508
04/05/2003	39.17	639.29	624.49	3.46	7.21	169.1	14.8	10.67	11.38	20	1.19	13.59	22.97	0.0594	99.60947
04/05/2003	39.21	639.39	624.59	3.42	7.36	169.1	14.8	10.78	11.26	20	1.19	13.44	22.72	0.0587	99.60947
04/05/2003	39.25	640.29	625.29	3.42	7.13	169.1	15.0	10.55	11.23	20	1.19	13.41	22.67	0.0583	99.60947
04/05/2003	39.29	640.79	625.99	3.34	7.36	169.1	14.8	10.70	10.98	20	1.19	13.11	22.16	0.0569	99.60947
04/05/2003	39.33	639.99	625.19	3.42	7.06	169.1	14.8	10.48	11.23	20	1.19	13.41	22.67	0.0584	99.60947
04/05/2003	39.38	640.29	625.49	3.33	7.21	169.1	14.8	10.54	10.95	20	1.19	13.08	22.11	0.0569	99.60947
04/05/2003	39.42	639.49	624.79	3.29	6.92	169.1	14.7	10.22	10.83	20	1.19	12.93	21.86	0.0564	99.60947
04/05/2003	39.46	639.59	624.99	3.36	7.24	169.1	14.6	10.60	11.03	20	1.19	13.17	22.26	0.0574	99.60947
04/08/2003	39.50	639.49	624.89	3.37	7.21	171.0	14.6	10.58	11.08	21	1.15	12.77	21.57	0.0557	99.60508
04/08/2003	39.54	657.99	642.99	3.31	7.44	174.8	15.0	10.75	10.88	21	1.15	12.53	21.18	0.0506	99.5963
04/08/2003	39.58	658.19	643.09	3.26	7.27	172.9	15.1	10.52	10.70	21	1.15	12.33	20.84	0.0498	99.60069
04/08/2003	39.63	659.79	644.49	3.41	7.36	174.8	15.3	10.76	11.21	21	1.15	12.91	21.82	0.0518	99.5963
04/08/2003	39.67	658.69	643.29	3.31	7.58	174.8	15.4	10.89	10.88	21	1.15	12.53	21.18	0.0505	99.5963
04/08/2003	39.71	658.39	642.99	3.32	7.75	174.8	15.4	11.07	10.90	21	1.15	12.56	21.23	0.0507	99.5963
04/08/2003	39.75	661.69	646.49	3.38	7.49	176.7	15.2	10.87	11.11	21	1.15	12.79	21.62	0.0509	99.59192
04/08/2003	39.79	662.69	647.39	3.25	7.49	178.6	15.3	10.74	10.68	21	1.15	12.30	20.79	0.0488	99.58753
04/08/2003	39.83	664.09	648.89	3.34	7.34	180.5	15.2	10.68	10.98	21	1.15	12.65	21.38	0.0499	99.58314
04/08/2003	39.88	664.59	649.49	3.34	7.57	180.5	15.1	10.91	10.98	21	1.15	12.65	21.38	0.0497	99.58314
04/08/2003	39.92	666.39	651.29	3.23	7.55	180.5	15.1	10.78	10.63	21	1.15	12.24	20.69	0.0478	99.58314
04/08/2003	39.96	667.09	651.89	3.20	7.49	180.5	15.2	10.69	10.53	21	1.15	12.13	20.49	0.0472	99.58314
04/09/2003	40.00	668.59	653.39	3.24	7.43	178.6	15.2	10.68	10.65	19	1.24	13.19	22.29	0.0511	99.58753
04/09/2003	40.04	667.69	652.49	3.26	7.62	176.7	15.2	10.88	10.70	19	1.24	13.25	22.40	0.0515	99.59192
04/09/2003	40.08	668.19	652.99	3.18	7.54	174.8	15.2	10.72	10.45	19	1.24	12.94	21.87	0.0502	99.5963
04/09/2003	40.13	667.79	652.49	3.34	7.56	172.9	15.3	10.90	10.98	19	1.24	13.60	22.98	0.0528	99.60069
04/09/2003	40.17	667.29	651.99	3.29	7.32	171.0	15.3	10.61	10.80	19	1.24	13.38	22.61	0.0521	99.60508
04/09/2003	40.21	667.59	652.19	3.39	7.81	171.0	15.4	11.21	11.16	19	1.24	13.82	23.35	0.0538	99.60508
04/09/2003	40.25	668.49	653.09	3.24	7.36	171.0	15.4	10.60	10.65	19	1.24	13.19	22.29	0.0511	99.60508
04/09/2003	40.29	670.99	655.19	3.28	7.57	169.1	15.8	10.85	10.78	19	1.24	13.35	22.56	0.0513	99.60947
04/09/2003	40.33	669.79	654.19	3.31	7.21	169.1	15.6	10.51	10.88	19	1.24	13.47	22.77	0.0520	99.60947
04/09/2003	40.38	670.69	655.09	3.25	7.34	169.1	15.6	10.59	10.68	19	1.24	13.22	22.35	0.0509	99.60947
04/09/2003	40.42	672.19	656.69	3.21	7.89	165.3	15.5	11.10	10.55	19	1.24	13.07	22.08	0.0500	99.61824
04/09/2003	40.46	670.39	654.59	3.27	7.39	163.4	15.8	10.66	10.75	19	1.24	13.32	22.50	0.0513	99.62263
04/09/2003	40.50	670.99	655.29	3.25	7.66	163.4	15.7	10.90	10.68	19	1.24	13.22	22.35	0.0508	99.62263
04/09/2003	40.54	667.19	651.59	3.28	7.27	161.5	15.6	10.55	10.78	19	1.24	13.35	22.56	0.0521	99.62702
04/09/2003	40.58	664.59	649.19	3.30	7.84	161.5	15.4	11.14	10.85	19	1.24	13.44	22.72	0.0529	99.62702
04/09/2003	40.63	665.29	649.79	3.28	7.43	165.3	15.5	10.71	10.78	19	1.24	13.35	22.56	0.0524	99.61824
04/09/2003	40.67	664.79	649.49	3.15	7.32	167.2	15.3	10.47	10.35	19	1.24	12.82	21.66	0.0504	99.61386
04/09/2003	40.71	664.99	649.49	3.29	7.39	171.0	15.5	10.68	10.83	19	1.24	13.41	22.66	0.0527	99.60508
04/09/2003	40.75	664.69	649.59	3.36	7.13	172.9	15.1	10.49	11.06	19	1.24	13.69	23.14	0.0538	99.60069
04/09/2003	40.79	664.09	649.09	3.51	7.45	174.8	15.0	10.96	11.53	19	1.24	14.28	24.14	0.0563	99.5963
04/09/2003	40.83	664.09	648.89	3.17	7.62	174.8	15.2	10.79	10.43	19	1.24	12.91	21.82	0.0509	99.5963
04/09/2003	40.88	664.69	649.49	3.34	7.41	174.8	15.2	10.75	10.98	19	1.24	13.60	22.98	0.0535	99.5963
04/09/2003	40.92	665.79	650.59	3.20	7.31	174.8	15.2	10.51	10.53	19	1.24	13.04	22.03	0.0510	99.5963
04/09/2003	40.96	665.99	650.89	3.31	7.58	174.8	15.1	10.89	10.88	19	1.24	13.47	22.77	0.0527	99.5963

04/09/2003	41.00	666.69	651.59	3.43	7.42	174.8	15.1	10.85	11.28	19	1.24	13.97	23.61	0.0545	99.5963
04/15/2003	41.04	675.49	661.99	3.45	6.37	186.2	13.5	9.82	11.36	21	1.15	13.08	22.11	0.0551	99.59836
04/15/2003	41.08	674.59	661.09	3.40	6.96	180.5	13.5	10.36	11.18	21	1.15	12.88	21.77	0.0545	99.61066
04/15/2003	41.13	675.29	661.59	3.37	6.81	178.6	13.7	10.18	11.08	21	1.15	12.77	21.57	0.0538	99.61475
04/15/2003	41.17	674.09	660.59	3.41	7.06	178.6	13.5	10.47	11.21	21	1.15	12.91	21.82	0.0547	99.61475
04/15/2003	41.21	672.19	658.59	3.49	6.90	178.6	13.6	10.38	11.46	21	1.15	13.20	22.31	0.0564	99.61475
04/15/2003	41.25	672.29	658.79	3.39	6.87	176.7	13.5	10.26	11.13	21	1.15	12.82	21.67	0.0548	99.61885
04/15/2003	41.29	673.29	659.39	3.50	6.91	176.7	13.9	10.41	11.51	21	1.15	13.26	22.41	0.0564	99.61885
04/15/2003	41.33	672.39	658.99	3.49	6.80	174.8	13.4	10.29	11.48	21	1.15	13.23	22.36	0.0565	99.62295
04/16/2003	41.38	672.89	659.29	3.44	6.58	174.8	13.6	10.02	11.31	21	1.15	13.03	22.01	0.0555	99.62295
04/16/2003	41.42	673.49	660.09	3.34	7.05	174.8	13.4	10.39	10.98	21	1.15	12.65	21.38	0.0537	99.62295
04/16/2003	41.46	673.19	659.49	3.42	6.85	172.9	13.7	10.27	11.23	21	1.15	12.94	21.87	0.0551	99.62705
04/16/2003	41.50	674.09	660.49	3.32	6.83	172.9	13.6	10.15	10.93	21	1.15	12.59	21.28	0.0534	99.62705
04/16/2003	41.54	673.89	660.29	3.37	6.73	172.9	13.6	10.10	11.08	21	1.15	12.77	21.57	0.0542	99.62705
04/16/2003	41.58	674.39	660.89	3.29	6.75	172.9	13.5	10.04	10.83	21	1.15	12.48	21.08	0.0528	99.62705
04/16/2003	41.63	673.59	659.99	3.32	6.73	172.9	13.6	10.05	10.90	21	1.15	12.56	21.23	0.0534	99.62705
04/16/2003	41.67	674.39	660.89	3.36	6.88	172.9	13.5	10.24	11.06	21	1.15	12.74	21.52	0.0539	99.62705
04/16/2003	41.71	674.39	660.89	3.36	6.56	172.9	13.5	9.92	11.06	21	1.15	12.74	21.52	0.0539	99.62705
04/16/2003	41.75	674.69	660.99	3.40	6.39	172.9	13.7	9.79	11.18	21	1.15	12.88	21.77	0.0545	99.62705
04/16/2003	41.79	673.89	660.29	3.32	6.76	172.9	13.6	10.09	10.93	21	1.15	12.59	21.28	0.0534	99.62705
04/16/2003	41.83	673.39	659.69	3.36	6.76	174.8	13.7	10.13	11.06	21	1.15	12.74	21.52	0.0542	99.62295
04/16/2003	41.88	672.79	659.19	3.51	6.93	174.8	13.6	10.44	11.53	21	1.15	13.29	22.46	0.0566	99.62295
04/16/2003	41.92	673.09	659.29	3.37	6.75	174.8	13.8	10.13	11.08	21	1.15	12.77	21.57	0.0544	99.62295
04/16/2003	41.96	673.19	659.69	3.35	6.59	174.8	13.5	9.93	11.01	21	1.15	12.68	21.43	0.0539	99.62295
04/16/2003	42.00	673.19	659.49	3.53	6.75	172.9	13.7	10.29	11.61	21	1.15	13.37	22.60	0.0569	99.62705
04/16/2003	42.04	672.99	659.49	3.40	6.94	174.8	13.5	10.34	11.18	21	1.15	12.88	21.77	0.0548	99.62295
04/16/2003	42.08	672.29	658.79	3.43	6.87	174.8	13.5	10.30	11.28	21	1.15	13.00	21.97	0.0555	99.62295
04/16/2003	42.13	670.79	657.39	3.32	6.92	176.7	13.4	10.24	10.90	21	1.15	12.56	21.23	0.0540	99.61885
04/16/2003	42.17	671.29	657.69	3.44	6.97	176.7	13.6	10.41	11.31	21	1.15	13.03	22.01	0.0559	99.61885
04/16/2003	42.21	670.69	657.09	3.43	6.70	176.7	13.6	10.13	11.28	21	1.15	13.00	21.97	0.0559	99.61885
04/16/2003	42.25	671.19	657.79	3.44	6.99	174.8	13.4	10.43	11.31	21	1.15	13.03	22.01	0.0559	99.62295
04/16/2003	42.29	671.89	658.19	3.37	6.73	174.8	13.7	10.10	11.08	21	1.15	12.77	21.57	0.0546	99.62295
04/16/2003	42.33	671.69	658.19	3.40	6.65	172.9	13.5	10.05	11.18	21	1.15	12.88	21.77	0.0552	99.62705
04/17/2003	42.38	673.29	659.69	3.39	7.03	172.9	13.6	10.41	11.13	21	1.15	12.82	21.67	0.0545	99.62705
04/17/2003	42.42	672.79	659.19	3.37	6.66	172.9	13.6	10.03	11.08	21	1.15	12.77	21.57	0.0544	99.62705
04/17/2003	42.46	672.29	658.79	3.38	6.98	172.9	13.5	10.35	11.11	21	1.15	12.79	21.62	0.0546	99.62705
04/17/2003	42.50	673.19	659.49	3.43	6.93	172.9	13.7	10.36	11.28	21	1.15	13.00	21.97	0.0553	99.62705
04/17/2003	42.54	672.59	658.89	3.39	6.83	172.9	13.7	10.23	11.16	21	1.15	12.85	21.72	0.0548	99.62705
04/17/2003	42.58	672.39	658.89	3.50	6.72	172.9	13.5	10.22	11.51	21	1.15	13.26	22.41	0.0566	99.62705
04/17/2003	42.63	672.09	658.69	3.40	6.86	172.9	13.4	10.26	11.18	21	1.15	12.88	21.77	0.0551	99.62705
04/17/2003	42.67	672.49	658.89	3.33	6.46	172.9	13.6	9.80	10.95	21	1.15	12.62	21.33	0.0539	99.62705
04/17/2003	42.71	672.49	658.89	3.40	6.56	172.9	13.6	9.96	11.18	21	1.15	12.88	21.77	0.0550	99.62705
04/17/2003	42.75	672.39	658.79	3.33	6.62	172.9	13.6	9.95	10.95	21	1.15	12.62	21.33	0.0539	99.62705
04/17/2003	42.79	672.19	658.79	3.32	6.98	172.9	13.4	10.29	10.90	21	1.15	12.56	21.23	0.0537	99.62705
04/17/2003	42.83	671.99	658.59	3.35	6.66	172.9	13.4	10.01	11.01	21	1.15	12.68	21.43	0.0542	99.62705
04/17/2003	42.88	672.09	658.79	3.52	6.72	172.9	13.3	10.24	11.58	21	1.15	13.35	22.55	0.0570	99.62705
04/17/2003	42.92	671.89	658.39	3.30	6.64	172.9	13.5	9.94	10.85	21	1.15	12.50	21.13	0.0535	99.62705
04/17/2003	42.96	670.29	657.09	3.39	6.91	174.8	13.2	10.31	11.16	21	1.15	12.85	21.72	0.0553	99.62295
04/17/2003	43.00	673.19	659.49	3.43	6.93	172.9	13.7	10.36	11.28	21	1.15	13.00	21.97	0.0553	99.62705
04/17/2003	43.04	672.59	658.89	3.39	6.83	172.9	13.7	10.23	11.16	21	1.15	12.85	21.72	0.0548	99.62705
04/17/2003	43.08	672.39	658.89	3.50	6.72	172.9	13.5	10.22	11.51	21	1.15	13.26	22.41	0.0566	99.62705
04/17/2003	43.13	672.09	658.69	3.40	6.86	172.9	13.4	10.26	11.18	21	1.15	12.88	21.77	0.0551	99.62705
04/17/2003	43.17	672.49	658.89	3.33	6.46	172.9	13.6	9.80	10.95	21	1.15	12.62	21.33	0.0539	99.62705
04/17/2003	43.21	672.49	658.89	3.40	6.56	172.9	13.6	9.96	11.18	21	1.15	12.88	21.77	0.0550	99.62705
04/17/2003	43.25	672.39	658.79	3.33	6.62	172.9	13.6	9.95	10.95	21	1.15	12.62	21.33	0.0539	99.62705
04/17/2003	43.29	672.19	658.79	3.32	6.98	172.9	13.4	10.29	10.90	21	1.15	12.56	21.23	0.0537	99.62705
04/17/2003	43.33	671.99	658.59	3.35	6.66	172.9	13.4	10.01	11.01	21	1.15	12.68	21.43	0.0542	99.62705
04/17/2003	43.38	672.09	658.79	3.52	6.72	172.9	13.3	10.24	11.58	21	1.15	13.35	22.55	0.0570	99.62705
04/17/2003	43.42	671.89	658.39	3.30	6.64	172.9	13.5	9.94	10.85	21	1.15	12.50	21.13	0.0535	99.62705
04/17/2003	43.46	670.29	657.09	3.39	6.91	174.8	13.2	10.31	11.16	21	1.15	12.85	21.72	0.0553	99.62295
04/17/2003	43.50	670.09	656.79	3.34	6.45	176.7	13.3	9.79	10.98	21	1.15	12.65	21.38	0.0545	99.61885
04/17/2003	43.54	668.69	655.69	3.39	6.75	178.6	13.0	10.14	11.13	21	1.15	12.82	21.67	0.0555	99.61475
04/17/2003	43.58	667.69	654.39	3.29	6.48	180.5	13.3	9.77	10.80	21	1.15	12.45	21.03	0.0542	99.61066
04/17/2003	43.63	667.29	654.39	3.46	6.79	182.4	12.9	10.25	11.38	21	1.15	13.11	22.16	0.0571	99.60656
04/17/2003	43.67	667.59	654.49	3.34	6.48	180.5	13.1	9.82	10.98	21	1.15	12.65	21.38	0.0551	99.61066
04/17/2003	43.71	667.09	653.89	3.43	6.77	180.5	13.2	10.20	11.28	21	1.15	13.00	21.97	0.0567	99.61066
04/17/2003	43.75	666.49	653.29	3.39	6.68	182.4	13.2	10.08	11.16	21	1.15	12.85	21.72	0.0562	99.60656
04/17/2003	43.79	667.29	654.19	3.38	6.48	182.4	13.1	9.86	11.11	21	1.15	12.79	21.62	0.0558	99.60656
04/17/2003	43.83	666.59	653.39	3.37	6.55	182.4	13.2	9.92	11.08	21	1.15	12.77	21.57	0.0558	99.60656
04/18/2003	43.88	666.99	653.69	3.36	6.57	182.4	13.3	9.93	11.06	21	1.15	12.74	21.52	0.0556	99.60656
04/18/2003	43.92	667.59	654.39	3.36	6.92	180.5	13.2	10.28	11.03	21	1.15	12.71	21.48	0.0553	99.61066
04/18/2003	43.96	667.79	654.39	3.51	6.85	180.5	13.4	10.36	11.53	21	1.15	13.29	22.46	0.0578	99.61066
04/25/2003	44.00	668.29	655.09	3.38	6.98	180.5	13.2	10.36	11.11	21	1.15	12.79	21.62	0.0555	99.61066

04/25/2003	44.04	657.39	644.19	3.55	6.37	235.6	13.2	9.91	11.66	21	1.15	13.43	22.70	0.0610	99.4918
04/25/2003	44.08	660.39	647.19	3.56	6.65	226.1	13.2	10.21	11.71	21	1.15	13.49	22.80	0.0605	99.5123
04/25/2003	44.13	661.09	647.89	3.45	6.71	224.2	13.2	10.17	11.36	21	1.15	13.08	22.11	0.0585	99.51639
04/25/2003	44.17	659.69	646.49	3.48	6.51	224.2	13.2	9.99	11.43	21	1.15	13.17	22.26	0.0592	99.51639
04/25/2003	44.21	659.19	646.09	3.55	6.78	222.3	13.1	10.34	11.69	21	1.15	13.46	22.75	0.0607	99.52049
04/25/2003	44.25	659.19	646.19	3.43	6.96	222.3	13.0	10.39	11.28	21	1.15	13.00	21.97	0.0586	99.52049
04/25/2003	44.29	658.99	645.99	3.44	6.66	220.4	13.0	10.10	11.31	21	1.15	13.03	22.01	0.0588	99.52459
04/25/2003	44.33	660.59	647.59	3.41	6.75	216.6	13.0	10.15	11.21	21	1.15	12.91	21.82	0.0578	99.53279
04/25/2003	44.38	660.99	647.89	3.46	6.63	214.7	13.1	10.09	11.38	21	1.15	13.11	22.16	0.0587	99.53689
04/26/2003	44.42	661.79	648.59	3.43	6.70	212.8	13.2	10.13	11.28	21	1.15	13.00	21.97	0.0579	99.54098
04/26/2003	44.46	662.89	649.59	3.59	6.68	210.9	13.3	10.28	11.81	21	1.15	13.61	23.00	0.0604	99.54508
04/26/2003	44.50	663.39	649.99	3.42	6.72	209.0	13.4	10.14	11.23	21	1.15	12.94	21.87	0.0573	99.54918
04/26/2003	44.54	663.79	650.39	3.47	6.58	207.1	13.4	10.05	11.41	21	1.15	13.14	22.21	0.0581	99.55328
04/26/2003	44.58	664.09	650.79	3.46	6.60	207.1	13.3	10.06	11.38	21	1.15	13.11	22.16	0.0579	99.55328
04/26/2003	44.63	664.59	651.19	3.57	6.68	205.2	13.4	10.25	11.74	21	1.15	13.52	22.85	0.0596	99.55738
04/26/2003	44.67	664.79	651.29	3.47	6.69	203.3	13.5	10.16	11.41	21	1.15	13.14	22.21	0.0579	99.56148
04/26/2003	44.71	666.59	653.19	3.47	6.74	203.3	13.4	10.21	11.41	21	1.15	13.14	22.21	0.0574	99.56148
04/26/2003	44.75	665.69	652.19	3.44	6.54	205.2	13.5	9.98	11.31	21	1.15	13.03	22.01	0.0571	99.55738
04/26/2003	44.79	665.79	652.19	3.50	6.65	203.3	13.6	10.15	11.51	21	1.15	13.26	22.41	0.0582	99.56148
04/26/2003	44.83	665.59	651.99	3.44	6.70	203.3	13.6	10.14	11.31	21	1.15	13.03	22.01	0.0572	99.56148
04/26/2003	44.88	665.79	652.29	3.36	6.70	205.2	13.5	10.06	11.06	21	1.15	12.74	21.52	0.0558	99.55738
04/26/2003	44.92	665.39	651.89	3.46	6.53	205.2	13.5	10.00	11.38	21	1.15	13.11	22.16	0.0576	99.55738
04/26/2003	44.96	665.79	652.39	3.55	6.67	205.2	13.4	10.21	11.66	21	1.15	13.43	22.70	0.0589	99.55738
04/26/2003	45.00	665.49	652.29	3.47	6.60	207.1	13.2	10.07	11.41	21	1.15	13.14	22.21	0.0577	99.55328
04/26/2003	45.04	664.19	651.09	3.53	6.66	207.1	13.1	10.19	11.61	21	1.15	13.37	22.60	0.0590	99.55328
04/26/2003	45.08	664.39	651.19	3.36	6.96	209.0	13.2	10.31	11.03	21	1.15	12.71	21.48	0.0560	99.54918
04/26/2003	45.13	663.49	650.39	3.48	6.76	210.0	13.1	10.24	11.43	21	1.15	13.17	22.26	0.0583	99.54702
04/26/2003	45.17	663.79	650.79	3.49	6.83	210.9	13.0	10.32	11.46	21	1.15	13.20	22.31	0.0583	99.54508
04/26/2003	45.21	663.29	650.29	3.48	6.69	210.9	13.0	10.17	11.43	21	1.15	13.17	22.26	0.0583	99.54508
04/26/2003	45.25	663.39	650.49	3.49	6.87	210.9	12.9	10.36	11.48	21	1.15	13.23	22.36	0.0585	99.54508
04/26/2003	45.29	664.09	650.79	3.55	6.85	210.9	13.3	10.41	11.69	21	1.15	13.46	22.75	0.0594	99.54508
04/26/2003	45.33	664.59	651.49	3.43	6.74	210.9	13.1	10.17	11.28	21	1.15	13.00	21.97	0.0572	99.54508
04/26/2003	45.38	665.09	651.59	3.41	6.41	209.0	13.5	9.82	11.21	21	1.15	12.91	21.82	0.0568	99.54918
04/27/2003	45.42	664.79	651.49	3.45	6.76	209.0	13.3	10.22	11.36	21	1.15	13.08	22.11	0.0576	99.54918
04/27/2003	45.46	666.89	653.69	3.52	6.84	207.1	13.2	10.36	11.56	21	1.15	13.32	22.51	0.0581	99.55328
04/27/2003	45.50	665.89	652.49	3.52	6.61	207.1	13.4	10.13	11.56	21	1.15	13.32	22.51	0.0583	99.55328
04/27/2003	45.54	666.49	652.99	3.40	6.59	205.2	13.5	9.99	11.18	21	1.15	12.88	21.77	0.0563	99.55738
04/27/2003	45.58	667.49	654.19	3.50	6.60	205.2	13.3	10.11	11.51	21	1.15	13.26	22.41	0.0577	99.55738
04/27/2003	45.63	666.49	653.19	3.39	6.84	205.2	13.3	10.23	11.13	21	1.15	12.82	21.67	0.0560	99.55738
04/27/2003	45.67	667.39	653.79	3.37	6.75	203.3	13.6	10.12	11.08	21	1.15	12.77	21.57	0.0556	99.56148
04/27/2003	45.71	668.49	654.89	3.52	6.55	203.3	13.6	10.07	11.56	21	1.15	13.32	22.51	0.0577	99.56148
04/27/2003	45.75	667.69	654.19	3.48	6.75	203.3	13.5	10.22	11.43	21	1.15	13.17	22.26	0.0573	99.56148
04/27/2003	45.79	667.29	653.99	3.40	6.74	203.3	13.3	10.14	11.18	21	1.15	12.88	21.77	0.0561	99.56148
04/27/2003	45.83	667.89	654.29	3.52	6.80	203.3	13.6	10.32	11.56	21	1.15	13.32	22.51	0.0579	99.56148
04/27/2003	45.88	665.89	652.39	3.47	6.70	205.2	13.5	10.17	11.41	21	1.15	13.14	22.21	0.0576	99.55738
04/27/2003	45.92	665.79	652.39	3.38	6.62	205.2	13.4	10.00	11.11	21	1.15	12.79	21.62	0.0561	99.55738
04/27/2003	45.96	665.59	652.19	3.39	6.66	205.2	13.4	10.05	11.16	21	1.15	12.85	21.72	0.0564	99.55738
04/27/2003	46.00	665.29	651.79	3.45	6.65	205.2	13.5	10.10	11.36	21	1.15	13.08	22.11	0.0575	99.55738
04/27/2003	46.04	664.79	651.79	3.42	6.69	207.1	13.0	10.11	11.23	21	1.15	12.94	21.87	0.0569	99.55328
04/27/2003	46.08	663.69	650.49	3.47	6.77	207.1	13.2	10.24	11.41	21	1.15	13.14	22.21	0.0581	99.55328
04/27/2003	46.13	662.59	649.49	3.39	6.75	209.0	13.1	10.14	11.13	21	1.15	12.82	21.67	0.0570	99.54918
04/27/2003	46.17	662.39	649.29	3.52	6.53	209.0	13.1	10.05	11.56	21	1.15	13.32	22.51	0.0592	99.54918
04/27/2003	46.21	661.79	648.69	3.35	6.68	209.0	13.1	10.03	11.01	21	1.15	12.68	21.43	0.0565	99.54918
04/27/2003	46.25	661.39	648.19	3.46	6.45	209.0	13.2	9.91	11.38	21	1.15	13.11	22.16	0.0586	99.54918
04/27/2003	46.29	661.39	648.19	3.48	6.66	209.0	13.2	10.14	11.43	21	1.15	13.17	22.26	0.0588	99.54918
04/27/2003	46.33	662.09	648.69	3.46	6.74	209.0	13.4	10.20	11.38	21	1.15	13.11	22.16	0.0584	99.54918
04/27/2003	46.38	663.69	650.39	3.50	6.77	209.0	13.3	10.27	11.51	21	1.15	13.26	22.41	0.0586	99.54918
04/28/2003	46.42	662.69	649.39	3.56	6.78	209.0	13.3	10.34	11.71	21	1.15	13.49	22.80	0.0599	99.54918
04/28/2003	46.46	663.69	650.49	3.52	6.67	207.1	13.2	10.19	11.58	21	1.15	13.35	22.55	0.0590	99.55328
04/28/2003	46.50	663.79	650.39	3.47	6.44	207.1	13.4	9.91	11.41	21	1.15	13.14	22.21	0.0581	99.55328
04/28/2003	46.54	664.39	651.09	3.35	6.51	205.2	13.3	9.86	11.01	21	1.15	12.68	21.43	0.0559	99.55738
04/28/2003	46.58	664.39	650.99	3.55	6.33	203.3	13.4	9.88	11.66	21	1.15	13.43	22.70	0.0593	99.56148
04/28/2003	46.63	663.39	650.19	3.47	6.50	203.3	13.2	9.97	11.41	21	1.15	13.14	22.21	0.0582	99.56148
04/28/2003	46.67	664.39	651.19	3.42	6.61	203.3	13.2	10.03	11.23	21	1.15	12.94	21.87	0.0571	99.56148
04/28/2003	46.71	666.59	652.99	3.44	6.47	203.3	13.6	9.91	11.31	21	1.15	13.03	22.01	0.0569	99.56148
04/28/2003	46.75	664.89	651.39	3.42	6.57	203.3	13.5	9.99	11.23	21	1.15	12.94	21.87	0.0570	99.56148
04/28/2003	46.79	664.99	651.49	3.43	6.48	203.3	13.5	9.91	11.28	21	1.15	13.00	21.97	0.0572	99.56148
04/28/2003	46.83	665.49	651.79	3.39	6.81	203.3	13.7	10.20	11.16	21	1.15	12.85	21.72	0.0565	99.56148

04/28/2003	46.88	664.79	651.19	3.45	6.98	203.3	13.6	10.44	11.36	21	1.15	13.08	22.11	0.0576	99.56148
04/28/2003	46.92	663.79	650.49	3.55	6.66	203.3	13.3	10.20	11.66	21	1.15	13.43	22.70	0.0594	99.56148
04/28/2003	46.96	663.99	650.59	3.47	6.66	205.2	13.4	10.13	11.41	21	1.15	13.14	22.21	0.0581	99.55738
04/28/2003	47.00	664.39	651.19	3.35	6.61	205.2	13.2	9.96	11.01	21	1.15	12.68	21.43	0.0559	99.55738
04/28/2003	47.04	663.29	649.79	3.49	6.29	205.2	13.5	9.78	11.48	21	1.15	13.23	22.36	0.0587	99.55738
04/28/2003	47.08	663.29	649.69	3.26	6.74	205.2	13.6	9.99	10.70	21	1.15	12.33	20.84	0.0547	99.55738
04/28/2003	47.13	663.19	649.99	3.41	6.81	207.1	13.2	10.22	11.21	21	1.15	12.91	21.82	0.0572	99.55328
04/28/2003	47.17	663.99	650.49	3.58	6.72	207.1	13.5	10.30	11.76	21	1.15	13.55	22.90	0.0599	99.55328
04/28/2003	47.21	663.49	650.09	3.51	6.51	207.1	13.4	10.02	11.53	21	1.15	13.29	22.46	0.0588	99.55328
04/28/2003	47.25	663.79	650.49	3.53	6.73	205.2	13.3	10.26	11.61	21	1.15	13.37	22.60	0.0591	99.55738
04/28/2003	47.29	663.29	649.89	3.37	6.29	205.2	13.4	9.66	11.08	21	1.15	12.77	21.57	0.0566	99.55738
04/28/2003	47.33	663.29	649.89	3.41	6.89	205.2	13.4	10.30	11.21	21	1.15	12.91	21.82	0.0572	99.55738
04/28/2003	47.38	663.29	649.79	3.55	6.61	205.2	13.5	10.17	11.69	21	1.15	13.46	22.75	0.0597	99.55738
04/29/2003	47.42	663.49	650.09	3.36	6.57	205.2	13.4	9.92	11.03	21	1.15	12.71	21.48	0.0563	99.55738
04/29/2003	47.46	664.59	651.29	3.67	6.94	205.2	13.3	10.61	12.06	21	1.15	13.90	23.49	0.0612	99.55738
04/29/2003	47.50	664.89	651.39	3.52	6.38	203.3	13.5	9.89	11.56	21	1.15	13.32	22.51	0.0586	99.56148
04/29/2003	47.54	664.79	651.29	3.44	6.52	203.3	13.5	9.96	11.31	21	1.15	13.03	22.01	0.0574	99.56148
04/29/2003	47.58	665.09	651.59	3.52	6.58	203.3	13.5	10.10	11.58	21	1.15	13.35	22.55	0.0587	99.56148
04/29/2003	47.63	664.89	651.39	3.42	6.85	203.3	13.5	10.27	11.23	21	1.15	12.94	21.87	0.0570	99.56148
04/29/2003	47.67	665.19	651.39	3.46	6.50	203.3	13.8	9.96	11.38	21	1.15	13.11	22.16	0.0577	99.56148
04/29/2003	47.71	665.19	651.69	3.42	6.88	203.3	13.5	10.30	11.26	21	1.15	12.97	21.92	0.0570	99.56148
04/29/2003	47.75	665.29	651.59	3.44	6.60	203.3	13.7	10.04	11.31	21	1.15	13.03	22.01	0.0573	99.56148
04/29/2003	47.79	665.29	651.49	3.39	6.47	203.3	13.8	9.86	11.13	21	1.15	12.82	21.67	0.0564	99.56148
04/29/2003	47.83	665.59	651.89	3.44	6.53	203.3	13.7	9.96	11.31	21	1.15	13.03	22.01	0.0572	99.56148