APPENDIX B

Experimental Plan

BAY AREA REGIONAL DESALINATION PROJECT

Experimental Plan

for

Contra Costa Water District
East Bay Municipal Utilities District
San Francisco Public Utilities Commission
Santa Clara Valley Water District

Pilot Testing at Mallard Slough

August 2008

MWH

ATTACHMENTS

LIST OF FIGURES

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Abbreviations and Terms for the
Bay Area Regional Desalination Project – Pilot Testing at Mallard Slough
Experimental Plan

ACOE	Army Corps of Engineers
AMS	Applied Marine Sciences
ANSI	American National Standards Institute, Inc.
AU	absorbance unit
AWWA	American Water Works Association
BARDP	Bay Area Regional Desalination Project
BCDC	Bay Conservation and Development Commission
BOD	biological oxygen demand
CCWD	Contra Costa Water District
CalTrans	California Department of Transportation
CDFG	California Department of Fish and Game
CDPH	California Department of Public Health
CDF&G	California Department of Fish & Game
CEQA	California Environmental Quality Act
cfm	cubic feet per minute
cfu	colony forming units
CIP	Clean-In-Place
COD	chemical oxygen demand
Concentrate	RO brine (reject stream)
CTR	California Toxics Rule
DHS	California Department of Health Services
DOC	dissolved organic carbon
DO	dissolved oxygen
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utilities District
EC	electrical conductivity
EDS	energy dispersive spectroscopy
EPA	Environmental Protection Agency
ESA	Environmental Science Associates, Inc.
FEMA	Federal Emergency Management Association
FM	Factory Mutual System
USFWS	US Fish and Wildlife Service
gfd	gallons per square foot per day
gph	gallons per hour
gpm	gallons per minute
HVAC	Heating, ventilating and air conditioning
I&E	Impingement and entrainment
ISO	International Organization for Standardization

K&W	Kearns & West, Inc.
kPa	kiloPascals
kW	Kilowatt
Lph	liters per hour
Lpm	liters per minute
MCL	Maximum Contaminant Level
MF	microfiltration
mg/L	milligram per liter
mgd	million gallons per day
MIT	membrane integrity test
mm	Millimeter
MOA	Memorandum of Agreement
MSPS	Mallard Slough Pump Station
mS/cm	milliSiemens per centimeter
MTC	Mass Transfer Coefficient
mW	megawatt
N	nitrogen
NaOCl	sodium hypochlorite
ND	non-detect
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NEPA	National Environmental Protection Act
NF	nanofiltration
NFPA	National Fire Protection Association
NH_3	Ammonia
nm	nanometer
NMFS	NOAA National Marine Fisheries Service
NTU	nephelometic turbidity unit
O&M	operations and maintenance
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
P	phosphorus
P&ID	process and instrumentation diagram
Pa	Pascal
PDT	Pressure decay test
ppd	Pounds per day
psi	pounds per square inch
PLC	programmable logic controller
PPE	personal protective equipment
PPS	Pilot Plant Study
ppb	parts per billion
ppm	parts per million
QA/QC	quality assurance / quality control

Residuals	Prescreening and pretreatment solids
RO	reverse osmosis
ROP	reverse osmosis permeate
ROW	right-of-way
RWQCB	Regional Water Quality Control Board
SCVWD	Santa Clara Valley Water District
SDI	silt density index
SEM	Scanning electron microscope
SFPUC	San Francisco Public Utilities Commission
STFC	Salt transport temperature correction factor
SWTR	Surface Water Treatment Rule
TCF	Temperature correction factor
TDS	total dissolved solids
TMP	Transmembrane pressure
TOC	total organic carbon
UBC	Uniform Building Code
UF	ultrafiltration
ug/L	microgram per liter
um	Micrometer, micron
UPS	uninterruptible power supply
UV	ultraviolet
UV_{254}	UV absorption at 254 nm wavelength
VOC	volatile organic compound
WWTP	wastewater treatment plant

Standard Terms:

the MWH Team	The combined consultant team organized for the Bay Area Regional Desalination Project
Partner Agencies	The combined group of EBMUD, CCWD, SCVWD, and SFPUC

Section 1 - Introduction

The BARDP will address the regional water reliability needs (emergency, drought, planned outages, and/or long-term water supply needs) of the four regional partner agencies. The project is intended to minimize potential adverse environmental impacts associated with the construction of separate desalination plants in close proximity to one another and would also provide substantial cost savings to the partner agencies because of pooling resources and sharing costs, and thereby to the water users in their respective service areas. The proposed joint ownership, operation, and management of a single desalination facility will serve the needs of four major water providers and is a unique concept without precedent in California.

The proposed pilot plant will be located at CCWD's Mallard Slough Pumping Plant site near Pittsburg, California adjacent to the Estuary at Suisun Bay. All work shall be conducted without adversely impacting CCWD's existing operations. The pilot project will obtain additional data and help determine the optimal operations for a full-scale plant to be located in the San Francisco Bay Area. Data obtained from the PPS will also benefit others considering desalination in an estuarine environment.

Water diverted from the slough will undergo treatment first by a screening and membrane pretreatment system followed by either RO or NF. It is the intent of the project to discharge permeate into an existing CCWD raw water pipeline, and to discharge combined brine/reject streams into a nearby sanitary sewer. Residuals and waste generated from the pilot plant that cannot be similarly discharged will be sent offsite for disposal.

As a general set of project goals, the PPS will be conducted to:

- Minimize adverse environmental effects to aquatic organisms from the intake of source water.
- Confirm requirements for pre-screening upstream of the pretreatment systems.
- Make recommendations for a preferred pretreatment method.
- Test pretreatment residuals to evaluate disposal options.
- Test technologies and methods to maximize the efficiency of the plant (pretreatment and RO/NF configuration).
- Identify and test brine toxicity levels.
- Identify potential impacts of brine discharges.
- Test product water quality.

This Plan will guide experimental and analytical work throughout the project, and contains:

- goals and objectives;
- proposed pilot schedule,
- equipment and strategies;
- procedures for testing and quality assurance;
- anticipated water quality;
- biological sampling and analysis requirements;
- brine testing requirements; and
- procedures for finished water studies.

Specific PPS objective are described in Section 2 herein.

Section 2 - Pilot Program Objectives

Specific piloting objectives have been developed to evaluate effectiveness and cost benefit of potential membrane filtration and RO processes to be applied to the proposed BARDP source waters. The overall intent of the partner agencies is to use pilot study results as a basis for estimating full scale desalination plant design parameters and costs.

2.1 Objectives

With the limited duration of the BARDP pilot study, it is important to establish clear and achievable objectives. Based on workshops held with the agencies during 2007, five objectives have been identified.

2.1.1 Assess Pretreatment System Performance

Two membrane pretreatment systems will be tested to evaluate the effectiveness and cost benefits of membrane filtration pretreatment on RO productivity. One system will be an outside-in air-liquid backwash process, and the second will be an inside-out liquid-only backwash process. Each system will be operated for the full pilot period, utilizing coagulant as appropriate and recommended by the system manufacturer, and utilizing various flux and recovery rates to determine:

- water productivity,
- water quality,
- capital and operating costs, and
- cleaning efficiency and frequency.

The highest sustainable flux and rate of membrane fouling will be identified through at least one trial.

2.1.2 Assess RO and NF Performance

Using the combined filtrate from the pretreatment systems, three parallel systems will be used to test NF and RO elements under varied conditions. RO trains will consist of one two stage RO and one single stage RO. The NF train will consist of one single stage NF. All three trains will operate in parallel. Transmembrane pressures and flux rates will be measured to enable comparisons between energy requirements and flux. A range of flux and recovery will be evaluated to identify:

- salt rejection,
- operating pressures,
- water productivity,

- water quality,
- chemical requirements,
- capital and operating costs, and
- cleaning efficiency and frequency.

The highest sustainable flux and rate of membrane fouling will be evaluated through one trial, if possible due to time constraints.

2.1.3 Assess Source Water Biological Impacts

Investigate impingement and entrainment associated with the proposed pilot plant intake by obtaining entrainment and source water samples during two seasons over a period of one year (four sampling events). Numbers of each species entrained into the intake system during operation of the pilot plant and full scale plant entrainment predictions will be developed.

2.1.4 Assess Finished Water Compatibility

Using a series of bench scale tests with permeate produced by the pilot plant RO Train No. 1, the compatibility of finished water with existing supplies in the EBMUD Mokolumne Aqueduct and the CCWD Multipurpose Pipeline will be identified. Post-treatment chemical requirements for pH and alkalinity adjustment will also be identified and recommendations developed for the full scale desalination plant.

2.1.5 Assess Brine Toxicity

One of the major potential issues associated with potential full-scale desalination operations is the discharge of the RO/NF brine, backwash and concentrated brine streams. Toxicity of the PPS brine will be identified by initial testing. The most sensitive species will be determined and follow-up testing for both salinity and contaminant toxicity on those species will be performed. Dry-season conditions represent highest ambient salinities, whereas wet-season conditions represent highest contaminant concentrations associated with storm runoff.

2.2 Project Limitations

Due to time and budget limitations, the pilot study will not provide information on:

1. Alternative membrane pretreatment configurations, such as pressurized outside-in modules. Work is based on recommendations in Technical Memorandum No. 3B, prepared by the MWH Team, dated December 20, 2007.
2. Alternative RO/NF trains and configurations. Work is based on recommendations in Technical Memorandum No. 4A and Technical Memorandum No. 4B, prepared by the MWH Team, dated January 3, 2008 and July 28, 2008, respectively.
3. Detailed effects of various alternative chemicals, such as antiscalants, acids, or oxidants.
4. Coagulation improvements due to dedicated flocculation processes.
5. Long term recovery or cleaning intervals (more than 1,000 hours).
6. Pathogen reduction through the membrane pretreatment and/or RO/NF processes.

7. Competing RO/NF membrane element manufacturers, except as described in this Experimental Plan.

Source water quality has been investigated by the MWH Team and is summarized in **Attachment A** herein. Water quality and resulting pilot performance which may occur outside of the PPS period will not be evaluated, unless the PPS is extended.

Section 3 - Pilot Program Schedule

Following a one month period for pilot plant shakedown and startup, piloting will be conducted from July 2008 through December 2008. Work will be conducted in multiple stages as described in Section 4.

The pilot schedule is shown in **Figure 3-1**.

Figure 3-1
Pilot Testing Schedule

	Month (2008-2009)						
	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Startup and Shakedown	■						
Pretreatment Chemical Cleaning	▲		▲	▲		▲	
Exp No. 1A: Jar Tests	▲						
Exp No. 1B: Jar Test Confirmation	■						
Exp No. 2A: Pretreatment - Low Flux		■	■				
Exp No. 2B: Pretreatment - Mid Flux			■	■			
Exp No. 2C: Pretreatment - High Flux					■	■	
Exp No. 2D: Pretreatment - Optimal Flux						■	■
RO Chemical Cleaning	▲		▲	▲		▲	
Exp No. 3A: RO Dry Weather Baseline Flux [1]		■	■				
Exp No. 3B: RO Dry Weather High Flux [1]			■	■			
Exp No. 3C: RO Wet Weather Baseline Flux [1]					■	■	
Exp No. 3D: RO Wet Weather High Flux [1]						■	■
Finished Water Quality Testing				▲			▲
Biological Sampling			■				■
Brine Toxicity Testing			■				■
Finished Water Compatibility Testing					■	■	■
Monthly Progress Reports	●	●	●	●	●	●	●

1. Experiment No. 3 baseline flux determination will be performed for RO and NF trains.

In addition to the above activities weekly or twice-weekly integrity testing will be conducted for the pretreatment systems as described in Section 4.

The following deliverable schedule has been developed for the PPS testing results and findings:

Draft Pretreatment Technical Memorandum	June 7, 2009
Draft RO Technical Memorandum	July 19, 2009

Upon conclusion of the pilot study, draft and final reports will be submitted to the partner agencies in accordance with the following dates:

Draft Pilot Plant Study Report	September 14, 2009
Final Pilot Plant Study Report	October 30, 2009

Section 4 - Performance Evaluation

This section provides a summary of the performance evaluations that will be conducted on each of the membrane systems. A general process schematic diagram for the proposed pilot system has been developed based on pretreatment and RO/NF evaluations conducted by the MWH Team, and is included in **Figure 4-1** herein. Refer to pilot system Piping and Instrumentation Diagrams (P&ID) for specific subsystems and instruments.

4.1 Start-Up and Shakedown

Startup and initial system shakedown for the BARDP pilot equipment will be performed to insure proper system and subsystem operation, prior to conducting specific pretreatment and RO test trials. A series of four test trials are then proposed to evaluate specific treatment parameters and operational responses.

Start-up and shakedown will involve the following activities:

- Ensure all components of the pilot units are operational and calibrated.
- Conduct clean water flux tests on each pretreatment system to assess specific flux to ensure proper installation and response.
- Conduct membrane integrity tests on each pretreatment system.
- Assess conductivity rejection and specific flux of the RO system, after the pretreatment clean water flux tests, to make sure elements and equipment are installed correctly and responding as expected, encompassing a few hours of testing.
- Provide operator training, as appropriate

Baseline conditions are established with the pretreatment clean water flux tests and the RO assessment.

Start-Up and Shakedown is expected to last for two to three weeks beginning in late September 2008, depending on equipment delivery and successful site modifications.

4.1.1 Membrane Integrity Testing

Membrane integrity tests are used to monitor and control the integrity of membrane systems. The methods may be used to identify relative changes in the integrity of a system, or used to provide a means of quantifying the integrity in terms of log reduction value.

The integrity of the membranes in a pretreatment system is assessed using a pressure decay test (PDT). During the automated PDT, the lumen side of the membranes are drained of liquid and pressurized to a pressure below the bubble point of the membrane. Once the test pressure has

FIGURE 4-1
BARDP PILOT SCHEMATIC
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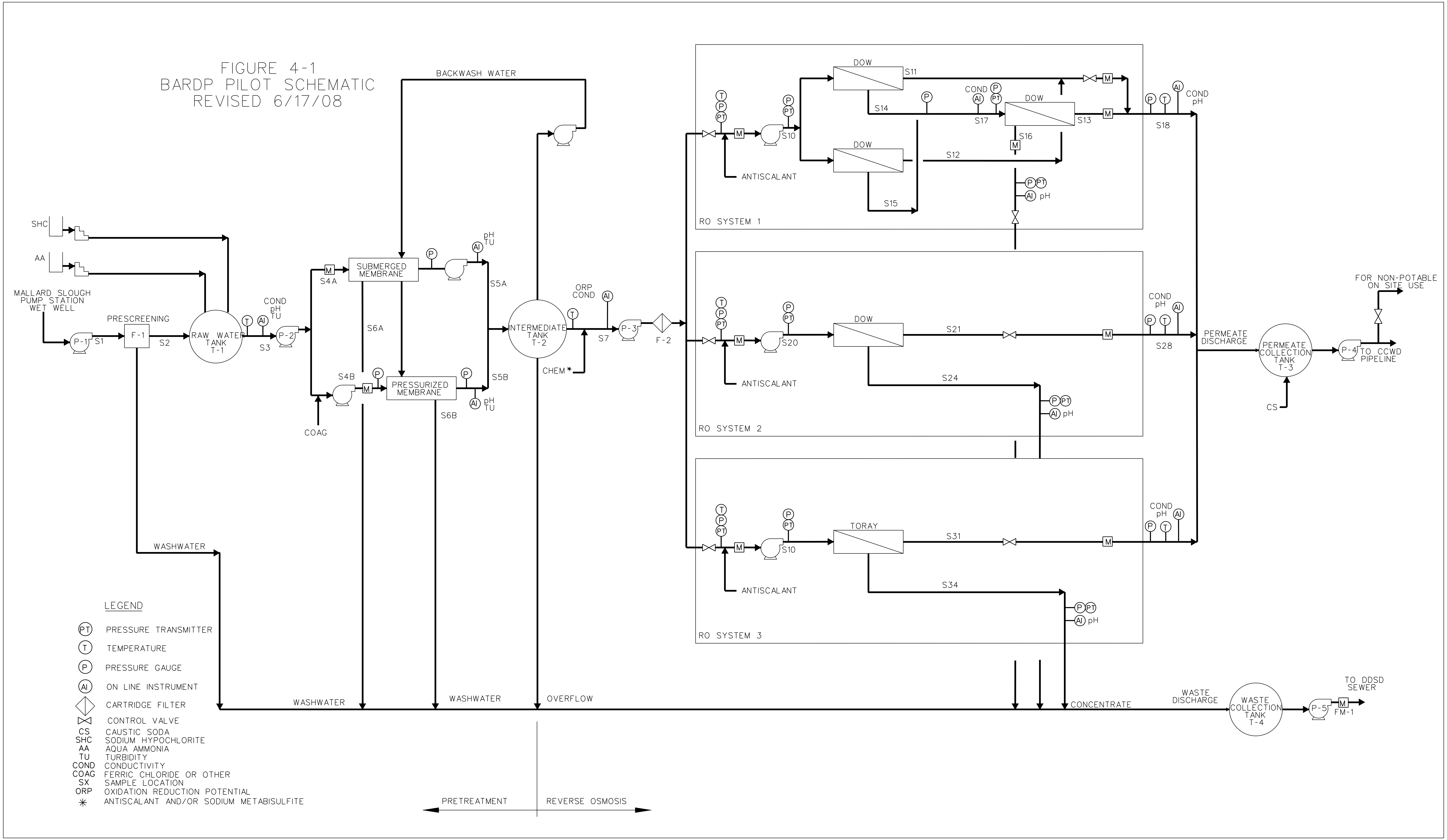

been reached, the filtrate (lumen) side is sealed and the feed side is vented to atmosphere. The drop in filtrate pressure with time is monitored. The pressure decay is directly related to the flow of air across the membrane, and hence system integrity.

The initial PDT on each pretreatment system will confirm that the new membranes are intact. PDTs will be conducted one to three times per week, as discussed in Section 7 herein.

4.2 Experiment 1: Coagulant Assessment

The purpose of Experiment 1 is to determine the need for coagulant addition for each of the pretreatment systems. There are two steps involved, which are summarized below and tabulated in **Table 4-1**.

- Trial 1A will consist of initial jar testing before the pilot plant is commissioned. Coagulants at manufacturer-recommended dose ranges will be added to the raw water and run through a 0.45 um filter. Effectiveness of each coagulant type and dose will be visually determined based on settleability, and the sample with the best results may be further evaluated for other parameters such as filtrate TOC, turbidity, metals, or UV_{254} if schedule permits. Otherwise, Trial 1 B will be operating based on the coagulant and dose that provide the best settleability. These jar tests will serve to identify an appropriate coagulant type and range of doses for the raw water based on the jar testing protocols. Jar tests may be conducted by the membrane manufacturer for their input on the optimal coagulant type and dose.
- Trial 1B will consist of dose confirmation runs on each pretreatment system, conducted after the clean water flux tests. The subtrials will confirm the jar test results from Trial 1A on each pretreatment system with 100 hour operating periods. Trial 1B may be operating concurrently with Trial 2A if scheduling permits. During these periods, water quality results will be analyzed, and operating conditions such as TMP evaluated. By the completion of Trial 1B, an optimum coagulant type and dose for each pretreatment system will be identified and verified. Based on initial discussions with the manufacturers, Siemens/Memcor may not need any coagulant for pretreatment process optimization due to its outside-in, air-liquid backwash configuration, while Norit may require up to 5 ppm ferric chloride.

Table 4-1
Experiment 1 Summary

Trial No.	Name	Subtrial No.	Duration	Flux (gfd)	Coag Type	Coag Dose (mg/L)	Outcome for future testing
1A	Jar Tests	1A1	jar test	N/A	N/A	0	Optimum coagulant type and dose range for the raw water
		1A2			Ferric chloride	Range	
		1A3			PACl	Range	
1B	Jar Test Confirmation	1B1	100 hrs	TBD	N/A	0	Optimum coagulant type &dose for each pre-treatment system
		1B2	100 hrs	Match Trial 1B1	Type identified in Trial 1A	Range identified in Trial 1A	

4.2.1 Criteria for Successful Confirmation of Membrane System

Performance criteria for each pretreatment system for Experiment 1 are provided in **Table 4-2**.

Table 4-2
Experiment 1 Performance Criteria for Pretreatment Systems

Trial No.	Parameter Measured	Performance Criteria	Action if Performance Criteria not met
1A	Settled water	Maximum settled particle depth	Modify mixing time, dose and/or coagulant type and repeat jar test.
1B	Filtrate TOC	< 5 mg/L, each	End trial; eliminate that coagulant type/dose combination from consideration. Repeat trial with new coagulant type/dose.

4.2.2 Parameters of Evaluation of Performance

Table 4-3 lists the data that will be measured and recorded in order to evaluate the performance of each pretreatment system in its completion of Experiment 1. Water quality and operational parameters will be collected according to the schedule in **Tables 6-2** and **6-4**. Membranes will be cleaned after Experiment 1. Trial 1B may be conduced concurrently with Trial 2A (low flux testing). Membranes will be clean a the end of Trial 2A.

Table 4-3
Experiment 1 Parameters of Evaluation for Pretreatment Systems

Pretreatment feed water quality (turbidity and TOC)*
Pretreatment filtrate water quality (turbidity and TOC,)*
Coagulant type
Coagulant dose (mg/L)
Integrity Test Results
TMP
Specific Flux

* Additional water quality analysis shown in Table 6-4 will be conducted if Trial 2B and 1A are conducted concurrently.

4.3 Experiment 2: Pretreatment Flux and Recovery Testing

The purpose of Experiment 2 is to test various flux rates for the pretreatment systems to determine effect on filtrate productivity (net recovery), water quality, and cleaning efficiency and frequencies. There are four trials involved, which are summarized below and tabulated in **Table 4-4**:

- Trials 2A through 2C represent flux trials, where the pretreatment membranes are tested at incrementally higher flux rates. The test flux on any system will not be higher than any DPH-approved flux for that system. After Trials 2A through 2C, the optimal flux for each pretreatment system will be identified, for the purposes of testing in Trial 2D.
- Trial 2D represents a final flux trial. Each pretreatment system will be tested at its optimal flux and coagulant dose recommended from Trials 2A through 2C to test best results under variable raw water quality conditions (turbidity, TOC).

Each trial will be a total of 960 hours, after which a CIP will be conducted. The temperature-corrected specific flux decline will be monitored, and if it is decreasing too rapidly on either pretreatment system, the MW chemical, procedure, and/or frequency will be modified.

Throughout the pilot study, a minimum pretreatment recovery of 94% will be targeted, including downtime for washing. Care will be taken to ensure that the recovery calculations provided by both manufacturers are comparable. The recovery rate will be studied during fouling events.

Table 4-4
Experiment 2 Summary

Trial No.	Name	Duration	Flux (gfd)	Coagulant Dose (mg/L)	Outcome for future testing
2A	Pretreatment Low Flux	960 hrs	Mfr recommend-dation less 10%	From Trial 1B, adjust as needed	One optimum combination of flux and intervals of BW, MW, and CIP for each pretreatment system
2B	Pretreatment Mid Flux	960 hrs	2A + 10%	From Trial 1B, adjust as needed	
2C	Pretreatment High Flux	960 hrs	2A + 20%	From Trial 1B, adjust as needed	
2D	Pretreatment Optimal Flux	960 hrs	TBD from 2A through 2C	TBD from 2A through 2C	

4.3.1 Criteria for Successful Confirmation of Membrane System

Performance criteria for each pretreatment system for Experiment 2 are provided in **Table 4-5**.

4.3.2 Parameters of Evaluation of Performance

Table 4-6 lists the data that will be measured and recorded in order to evaluate the performance of each pretreatment system in its completion of Experiment 2. Water quality and operational parameters will be collected according to the schedule in **Tables 6-2** and **6-4.**

Table 4-5
Experiment 2 Performance Criteria for Pretreatment Systems

Parameter Measured	Performance Criteria	Action if Performance Criteria not met
Temperature-Corrected Specific Flux decline	Throughout trial, trending to <15% change from start of trial to 960 hours	Modify MW chemical, procedure, and/or frequency to decrease rate of flux decline.
Pressure Decay	< 0.725 psi/min	Repair damaged fiber(s)
Turbidity	Filtrate peak<0.15 NTU or 24hr avg<0.10 NTU	Perform PD test. repair damaged fiber(s)
SDI (30 psig, 15 min, 0.45 um)	Filtrate<3.0	Perform PD test. repair damaged fiber(s)

Table 4-6
Experiment 2 Parameters of Evaluation for Pretreatment Systems

Operating Flux (gfd)
Pretreatment feed water quality (turbidity, TOC, SDI, temperature, metals, UV_{254}, TSS; see **Table 6-4**)
Pretreatment filtrate water quality (turbidity, TOC, SDI, metals, UV_{254}; see **Table 6-4**)
Overall Recovery (%)[1,3]
Operating Recovery (%)[2,3]
Feed pressure (psi)
TMP (psi)
Average Backwash Water Flow (gpm)
Average Backwash Air Flow (cfm)
Average Backwash Duration (sec)
Average Backwash Frequency (min)
Average Chemical cleaning frequency (days)
Backwash water characterization – at least twice to determine landfill suitability
Chemical cleaning waste flow and characterization – at least twice for landfill suitability
Integrity Test Results
Clean water flux test results
Coagulant dose (mg/L)

1. Overall (net) recovery includes system downtime and water use due to washes and CIP.
2. Operating recovery includes system downtime and water use due to backwashes only.
3. Detailed settings for these procedures, including timing and flow rates, will be included in pilot calculations.

4.4 Experiment 3: RO Flux and Recovery Testing

The purpose of Experiment 3 is to test flux and recovery for the RO systems to determine effect on salt rejection, operating pressures, water quality, and cleaning efficiency and frequencies. There are four trials involved, which will be conducted simultaneously on each RO system. These trials are summarized below and tabulated in **Table 4-7**.

It is anticipated that throughout the pilot study, feed water temperatures will steadily drop due to falling ambient temperatures. The salinity in the feed water, on the other hand, will steadily rise through the fall and winter until approximately November or December, when snowmelt and runoff influence becomes significant. Consequently, the feed water quality in any given trial is expected to vary. However, in case dramatic changes are not experienced, an alternative final run is proposed to increase the range of conditions tested.

- Before any trials begin, a scaling analysis will need to be conducted to determine the recoveries for each RO/NF system for the first trial. This will be conducted during the design of the pilot plant, with the intent of setting two recovery goals for each RO/NF system – a baseline flux corresponding to the anticipated recovery that will safely meet all water quality goals, and a challenge flux corresponding to a higher recovery that will stress the RO/NF membranes.
- Trial 3A represents a flux trial where the RO/NF membranes are tested at the baseline flux and resulting recovery recommended by manufacturer models, given the ambient feed water salinity. Feed water salinity data will be analyzed before the trial, and manufacturer membrane models will be run to determine the appropriate baseline flux.
- Trial 3B represents a similar flux trial where the RO/NF membranes are tested at a challenge flux and resulting recovery, given the ambient feed water salinity. Feed water salinity data will be analyzed before the trial, and manufacturer membrane models will be run to determine the appropriate challenge flux.
- Trial 3C represents a baseline flux trial very similar to Trial 3A, except that it is expected that the ambient feed water salinity will be higher and temperature lower than the conditions in Trial 3A. Feed water salinity data will be analyzed before the trial, and manufacturer membrane models will be run to determine the appropriate baseline flux.
- Trial 3D represents a flux trial where the RO/NF membranes are tested at a challenge flux and resulting recovery, given the higher feed water salinity and lower temperature. Feed water salinity data will be analyzed before the trial, and manufacturer membrane models will be run to determine the appropriate challenge flux.
- An alternative Trial 3D represents a final flux trial where RO concentrate is blended with the feed water to simulate salinities higher than the ambient Mallard Slough water. Under this scenario, the baseline or challenge flux could be used, or a flux in between, depending on the success of the high flux Trial 3B.

Table 4-7
Experiment 3 Summary

Trial No.	Name	Duration	Seasonal TDS	Seasonal Temp.	Flux (gfd)
3A	RO/NF Dry Weather Baseline Flux	960 hrs	Medium/High	High	Baseline
3B	RO/NF Dry Weather High Flux	960 hrs	Med/High	High/Med	Challenge
3C	RO/NF Wet Weather Baseline Flux	960 hrs	High	Low	Baseline
3D	RO/NF Wet Weather High Flux	960 hrs	High (or Very Low)	Low	Challenge
3D Alternate	RO/NF Wet Weather Salinity Spiking	960 hrs	Spike (artificial) to simulate East Contra Costa sites	Low	TBD

If, during the pilot test, one manufacturer demonstrates inferior performance, the RO/NF membranes will be switched out for another manufacturer, depending on available project budget and schedule constraints.

4.4.1 Criteria for Successful Confirmation of Membrane System

Performance criteria for each RO/NF system for Experiment 3 are provided in **Table 4-8**.

Table 4-8
Experiment 3 Performance Criteria for RO/NF Systems

Parameter Measured	**Performance Criteria**	**Action if Performance Criteria not met**
Rate of Temperature Corrected Specific Flux Decline	Throughout trial, trending to <15% change from start of trial to 960 hours	Continue to run system to >15% decline and document; clean and restart if needed, and start new trial; adjust recovery in future trials.
Differential Pressure Increase in Feed to Concentrate	Throughout trial, trending to <15% change from start of trial to 960 hours	Continue to run system to >15% decline and document; clean and restart if needed, and start new trial; adjust recovery in future trials.

4.4.2 Parameters of Evaluation of Performance

Table 4-9 lists the data that will be measured and recorded in order to evaluate the performance of each RO/NF system in its completion of Experiment 3. Water quality and operational data will be collected according to the schedule in **Tables 6-2** and **6-4.**

Table 4-9 **Experiment 3 Parameters of Evaluation for RO/NF Systems**
Operating flux (gfd)
Feed water quality (TDS, temperature; see **Table 6-2**) (TOC, turbidity, and SDI are measured in pretreatment filtrate; therefore, they are not included here)
Permeate water quality (TOC, TDS; see **Table 6.2**)
Overall water recovery (%)[1]
Operating pressure (psi)
Concentrate pressure (psi)
Average chemical cleaning frequency (days)
Concentrate water characterization
Chemical cleaning waste flow and characterization
Post-treatment chemical consumption

1. Overall water recovery is the ratio of combined permeate to feed flow and does not include downtime or water use for cleaning.

4.5 Experiment 4: Cleaning Efficiency

The purpose of Experiment 4 is to determine the efficiency / effectiveness of each chemical cleaning procedure that is conducted on both the pre-treatment and RO/NF systems. Every chemical clean will be evaluated for its effectiveness so the chemical cleaning process can be optimized, and projections for full-scale operations will be accurate. There are no distinct trials associated with this experiment, because it will take place every time a chemical cleaning is performed on any membrane system. This will occur at minimum between each Trial in Experiments 2 and 3.

4.5.1 Criteria for Successful Confirmation of Membrane System

Performance criteria for each chemical clean of each membrane system for Experiment 4 are provided in **Table 4-10**.

4.5.2 Parameters of Evaluation of Performance

Table 4-11 lists the parameters that will be evaluated to assess each pretreatment and RO system in its completion of Experiment 4. These parameters would be measured before, during, and after each chemical clean of each membrane system. Water quality and operational parameters will be collected according to the schedule in **Tables 6-2** and **6-4.**

Table 4-10
Experiment 4 Performance Criteria for Membrane Chemical Cleans

Parameter Measured	Performance Criteria	Action if Performance Criteria not met
Recovery of Temperature-Corrected TMP (Pre-Treatment Systems)	Recovery of 80% of total TMP increase since initial membrane start-up.	Perform CIP again, extending the duration of chemical solution exposure. Restart. If recovery is still unsuccessful, switch cleaning solutions.
Recovery of Temperature Corrected Specific Flux (RO Systems)	Recovery of 80% of total flux decline since initial membrane start-up.	Perform CIP again, extending the duration of chemical solution exposure. Restart. If recovery is still unsuccessful, switch cleaning solutions.
Recovery of Differential Pressure Increase in Feed to Concentrate (RO/NF Systems)	Recovery of 80% of total differential pressure increase since initial membrane start-up.	Perform CIP again, extending the duration of chemical solution exposure. Restart. If recovery is still unsuccessful, switch cleaning solutions.

Table 4-11
Experiment 4 Parameters of Evaluation for All Membrane Systems

Cleaning solution properties (manufacturer, name, pH, active compounds)
Duration of cleaning solution exposure
Nature of cleaning solution exposure (soak vs. recirculation)
Temperature-corrected specific flux before clean
Temperature-corrected specific flux after clean
Number of operational hours prior to cleaning

4.6 Experiment 5: Finished Water Quality

The purpose of Experiment 5 is to confirm that finished water from the pilot plant can meet state and Federal primary and secondary drinking water regulations. To accomplish this, samples will be obtained at intervals during the pilot study from the combined permeate of the two stage RO system (Train No. 1). Permeate will be analyzed for all compounds that have state and federal MCLs. Some of the parameters, like pH and alkalinity may not meet state and Federal parameters without post-treatment adjustment for finished water compatibility.

Based on the anticipated schedule for the pilot trials, it is anticipated that sampling will occur near the end of Trial No. 3B and Trial No. 3D in order to represent higher salinities and fouled membranes.

4.6.1 Criteria for Successful Confirmation of Membrane System

Performance criteria for Experiment 5 are provided in **Table 4-12.**

Table 4-12
Experiment 5 Performance Criteria for Finished Water

Parameter Measured	Performance Criteria	Action if Performance Criteria not met
Federal Primary MCLs	Finished water meets drinking water standards	Eliminate from consideration the specific combination of operating conditions (membrane configuration, flux, pressure) that were in place when the sampling was conducted
California MCLs	Finished water meets drinking water standards	Eliminate from consideration the specific combination of operating conditions (membrane configuration, flux, pressure) that were in place when the sampling was conducted

4.6.2 Parameters of Evaluation of Performance

State and Federal MCLs (primary and secondary), plus California lead and copper action levels, will be evaluated to assess combined pretreatment filtrate and two-stage RO system permeate for Experiment 5.

Water quality and operational data will be collected according to the schedule in **Tables 6-2** and **6-4.**

4.7 Additional Experimental Activities

The experimental plan includes additional testing and analyses to fully evaluate impacts associated with organisms present in the source water; to understand compatibility of RO/NF permeate with existing EBMUD supplies; and to identify post-treatment chemical treatment requirements for alkalinity and pH adjustment. The additional testing activities are described below.

4.7.1 Source Water Biological Sampling and Analyses

Attachment B includes a description of biological sampling and analysis. Entrainment sampling from the pilot plant intake will be conducted on two separate occasions over the 6-month pilot study (one day and one night event each). Entrained fish eggs and larvae will be sampled by diverting water from the intake, and comparisons will be made to species present in the Mallard Slough.

4.7.2 Finished Water Compatibility Investigations

Attachment C includes a description of water quality compatibility investigations to be conducted with RO Train No. 1 permeate. Finished water will be analyzed andcompared to water being conveyed in the various conveyance facilities currently owned and operated by EBMUD and CCWD.

Also described in **Attachment C** are procedures for testing RO Train No. 1 permeate for post-treatment requirements associated with alkalinity and pH adjustment. Desktop models and bench tests will be utilized to estimate required chemical dosages, and work will include varying ratios of permeate with water from potential distribution systems. A specific protocol for these investigations will be developed before the testing begins.

4.7.3 Brine Toxicity Testing

Attachment D includes a description of brine toxicity testing to be conducted on RO Train No. 1 concentrate produced by the pilot plant. Bioassay tests will incorporate up to three species, with a dilution series of RO brine and laboratory control water.

Section 5 - Process Description

Normal operations of the pilot system will involve pumping of raw water from behind the existing MSPS intake screens at the south end of Mallard Slough, through inline self-cleaning screens (prescreening) and into a raw water tank. After the addition of pre-oxidant and coagulant chemicals, water will be pumped to two parallel trains of low pressure membrane systems (pretreatment). The screens will backwash with prescreened raw water, and pretreatment membranes will backwash with pretreatment filtrate.

Filtrate from the two pretreatment systems will be combined into an intermediate tank that will serve as a common feed water for the parallel RO/NF systems. Unused pretreatment water will overflow to discharge.

During the process, small quantities of process chemicals will be added in the treatment process. RO/NF permeate will be stored and used onsite for nonpotable purposes, with excess sent to the CCWD raw water supply via an existing onsite raw water pipeline which discharges into Mallard Reservoir. Concentrate will be sent to a wastewater treatment plant operated by DDSD via an existing sewer line approximately 800-feet south of the MSPS.

A process flow diagram of the pilot system is provided in Section 4. A Piping and Instrumentation Diagram (P&ID) is provided in **Attachment E**.

5.1 Operating Requirements and Conditions

The pilot plant will require daily status checks of all major equipment and tanks. Treatment upsets, irregularities, equipment failures, or other events will need to be documented in the pilot logbook. In addition to staffing requirements for daily checks, staff will be required for the startup and shakedown period; manual cleaning where necessary; sampling at various points in the pilot process; onsite analyses; preparation of samples and shipment to the offsite laboratory; transitions between process trials and subtrials; and other efforts as needed.

The pilot systems will be automated to the greatest extent possible within project budget and fabrication scheduling constraints. Each system and subsystem will have individual variations due to unique manufacturer and design configuration. Notably, the daily maintenance wash procedures for the systems will be automated.

5.1.1 Control of High Pressure Pumps under Varying Salinity

Mallard Slough water quality has been documented by CCWD and available data is summarized in **Attachment A**. Most of the data were obtained for the period following 1996 and show a wide range of TDS from 70 to about 5,700 mg/L. Since the MSPS was operational during data collection, it is believed that these data reflect a fair amount of influence from the estuary. Unlike the proposed PPS, however, which will draw water from a relatively stagnant Mallard

Slough. Consequently, selection of source water TDS for the PPS is difficult and somewhat imprecise.

Additional data was collected from the slough during non-pumping conditions at the close of the dry season in 2007 and is also included in **Attachment A**. The 2007 data were compared to online data from the main Delta Channel, and show that the slough dampens tidal fluctuations when the pump station is not operating. Additional analyses were also conducted for additional parameters that were not available in historic data, including metals and boron.

An on-line conductivity analyzer was installed in the slough at the MSPS screen in June 2008. Data obtained to-date demonstrate TDS will likely be as high as 10,000 mg/L when the pilot plant is eventually commissioned in late September 2008.

To address tidal variations (ambient in Mallard Slough and when feed water is spiked with concentrate), the high pressure pumps that feed the RO/NF membranes will need to be adjusted based on feed water conductivity. Pilot system design will address daily and seasonal variations.

5.1.2 Remote Monitoring and Control of Pilot Plants

MWH will seek to install a satellite or cellular based data link onsite for remote monitoring and control by operations staff and manufacturers. In addition, data will be downloaded from the pilot units and uploaded into a data server on a regular basis, up to several times per week.

5.2 Prescreening

To protect membranes from debris and other large particles present in the Mallard Slough that may penetrate the intake screen, an inline self-cleaning screen will be employed, each sized to handle the proposed PPS flow. Screen size is anticipated to be 100 micron, and will be coordinated to match each of the pretreatment systems. Units will be model TAF as manufactured by Amiad Filtration Systems, or equivalent equipment as manufactured by Arkal Filtration Systems.

Motor driven backwash will be initiated by differential pressure, by a predetermined time interval, or by manual operator intervention. Duration of each backwash will range from 15 to 30 seconds, with spent backwash water and trapped particles discharged ultimately to the DDSD sanitary sewer. Rate of fouling and screenings will not be monitored.

A brief description of prescreening equipment is presented in **Table 5-1**. All data should be verified with the actual unit installed at the site.

Table 5-1
Prescreening Equipment

Manufacturer and unit, proposed	Amiad Super TAF[tm]
Screen size, micron	100
Flow rate, gpm max.	110
Working pressure, psi	30 to 120
Filter area, sq. inches	72
Inlet & Outlet diameter, inches	2
Backwash cycle time, seconds	15 to 30
Backwash flow, gpm	18
Backwash pressure, psi min	22
Backwash water use, gal.	4.7

5.3 Membrane Pretreatment Systems

The RO/NF process requires a high quality feed water to minimize fouling, maximize membrane life and operate efficiently. The principle objective of pretreatment is to reduce the concentration of fouling constituents in the feed water to a level that will produce long-term stable performance that prolongs the life-span of the membranes.

The pilot study will evaluate two pretreatment membrane systems, which will be leased to the PPS by each membrane system supplier. One unit is provided by Layne Christiansen Company and will contain membranes manufactured by Norit Americas, Inc. It represents a pressurized inside-outside, liquid backwash scheme. Membranes are placed in a vertical arrangement. The second unit represents a submerged, outside-in, air-liquid backwash process scheme as manufactured and supplied by Siemens/Memcor.

An alternative UF system manufactured by GE/Zenon that represents a similar submerged system was found to be suitable technically, but the pilot unit itself is not available to meet the terms and conditions of the PPS.

A summary of membrane pretreatment pilot characteristics is furnished in **Table 5-2**.

5.3.1 Norit Americas Inc.

The Norit system is a pressure driven UF system with polyethersulfone hollow fiber membranes housed in 8-inch diameter pressure vessels assembled vertically on the skids. Flow range up to approximately 24 gpm may be achieved by the proposed equipment, depending on feed water quality and operational parameters.

In Technical Memorandum No. 3B Prescreening and Pretreatment Technology Evaluation, Norit's Seaguard^{tm} membrane module system was proposed for the PPS. The Seaguard^{tm} unit has a large pore size (approximately 65 nm) and was developed specifically for seawater pilot applications where downstream reverse osmosis are utilized. California DHS; however has not granted disinfection credit for the Seaguard^{tm} unit. Since one goal of PPS is to make recommendations for a full scale treatment plant, and since multiple disinfection carriers are desirable for any public water supply, MWH has elected to utilize the Norit SXL^{tm} membrane in lieu of the Seaguard^{tm} because pathogen reduction credit has been granted by California DHS for the SXL^{tm} module.

5.3.2 Siemens/Memcor Water Technologies

The Memcor pressurized membrane system is a vacuum driven UF system that operates in an outside-in flow pattern. Membrane modules are horizontally immersed directly into an open process tank and connected to permeate collection headers and aeration hoses. Permeate pumps apply a slight vacuum to the end of each membrane fiber.

5.3.3 GE/Zenon Water Process Technologies

The GE/Zenon system is an immersed membrane, vacuum driven membrane system operating in an outside-in flow pattern. PVDF hollow fiber membranes horizontally oriented and potted at both ends into cassettes that are immersed directly into open process tanks. The cassettes are connected to permeate collection headers and aeration hoses. Permeate pumps apply a slight vacuum to the end of each membrane fiber.

Table 5-2
Membrane Pretreatment Pilot Unit Summary

Manufacturer:	**Siemens/Memcor**	**Layne Christiansen/Norit**	**GE/Zenon**
Product Name	L20 (4 modules total)	SXL-225	ZeeWeed 1000
Technology	UF membrane	UF membrane	UF membrane
Configuration	Submerged	Pressurized	Submerged
Flow Direction	Outside-In	Inside-Out	Outside-In
Flux Range, gfd	30 to 35	45 to 55	25 to 30
Pilot Unit Production, gpm	25 to 30	24-33	24
Membrane Material	PVDF	Polyethersulfone	PVDF
Operating TMP, psi (operational)	12 max.	15 max.	n/a
Fiber Dimensions, um (OD/ID)	800/500	800 (ID only)	n/a
Pore size, um (nominal)	0.04	0.025	0.04
Clean Water Permeability, gfd/psi)	TBD	5 to 20	TBD
Dimensions			
Diameter, inches	5.2	8	4
Length, inches	46.7	60	n/a
Membrane Area, sf, all modules	1,200	860	1,500
Membrane Type	Hollow Fiber	Hollow Fiber	Hollow Fiber
Backwash Mechanism	Combined air & liquid	Liquid Only	Combined air & liquid
Coagulant type	Not generally required	Ferric chloride	PACl or ferric chloride

Coagulant Dose, mg/L if required, approximate	n/a	0.5 to 1.5 (as 100% iron)	2.0 to 7.0 (as product solution)
Maximum, mg/L	n/a	6	n/a
Footprint, approximate	Three skids (largest is 8' x 4') including compressor, controls, membrane modules	Main Membrane skid (10' x 5'-8") Three other small skids for coagulant, instruments, controls, & equipment, + at least one tank at 5' dia	20' x 20' for all equipment
Weight, approx. maximum	TBD	4000 lbs (empty)	3200 lbs (empty)

5.4 RO and NF Membrane Systems

Filtered water from the pretreatment systems will be drawn from a storage tank and processed through 5-micron cartridge filters located upstream of high pressure pumps that will feed the pretreated source water to the RO/NF treatment trains. Cartridge filters are commonly utilized as additional protection for the RO/NF membrane elements to capture any final particles of suspended solids that may enter the feed stream.

From the cartridge filters, the filtered water will then flow to two high feed pressure pumps. The two stage RO/NF has a dedicated feed pump. The two single stage RO systems may share a feed pump depending on final design. Flow is controlled via a flow control valve. The two stage RO feed pump will pressurize the feed water to the RO system to the required supply pressure for the entire membrane array. There is no inter-stage booster pumping.

Each system will be fed by high pressure pumps through the membranes. RO/NF feed pressure requirements would depend upon a number of factors including filtrate water temperature, feed water salinity, extent of membrane fouling and membrane compaction, and feed pressure estimates will be determined during design phase.

5.4.1 Membrane Element Selection

The pilot system will have three different RO/NF systems run in parallel. Elements will be from a single vendor, as shown in **Table 5-3**.

The two stage RO system (RO Train No. 1) will be configured in a 2:1 array, with seven 4-inch diameter elements per pressure vessel. A total of 21 RO membrane elements will be required for the two stage RO system. The single stage RO system (RO Train No. 2) and the single stage RO/NF system (RO/NF Train No. 3) will be configured with six elements each, 4-inches in diameter.

Table 5-3 RO Train Summary			
	RO System No. 1	**RO System No. 2**	**RO/NF System No. 3**
Vendor	Dow/Filmtec	Dow/Filmtec	Dow/Filmtec
First Stage			
Membrane Type (mfg model) [1]	Brackish (BW30-4040)	Low pressure seawater (SW30HRLE-4040)	Nanofiltration (NF90)
Element Number (Surface Area, sf)	7 (78)	6 (85)	6 (82)
Target Flux, gfd	15	14	14
Feed Flow, gpm	19	9	8
Permeate Flow, gpm	11	5	5
Concentrate Flow, gpm	7.5	3	3
Recovery, %	58	56	62
Feed pH, approx.	8.4	8.4	8.4
Antiscalant Dose, mg/L	TBD	TBD	TBD
Size, inch	4	4	4
Second Stage			
Membrane Type (mfg model)	Low pressure seawater (SW30HRLE-4040)		
Element Number (Surface Area, sf)	7 (85)		
Target Flux, gfd	10		
Feed Flow, gpm	8		
Permeate Flow, gpm	4		
Concentrate Flow, gpm	3.75		
Recovery, %	50		
Feed pH, approx.	8.12		
Antiscalant Dose, mg/L	TBD		
Size, inch	4		
Total System			
Average System Flux, gfd	13.2	14	14
Recovery, %	80	56	62

1. Data is furnished for average water quality conditions. Refer to calculations for exact values.

With this arrangement, the PPS configuration will serve the following dual purposes:

- Comparing system performance provides information about which configuration (2 stage brackish-seawater membranes vs. single stage seawater system or single stage NF water system) is advantageous with respect to fouling, recovery and energy consumption.

- Comparing the performance of RO Systems 1 and 2 provides an analysis of the same seawater membrane with different levels of pretreatment.
- Comparing the performance of RO Train No. 2 and RO/NF Train No. 3 provides an analysis of two membrane types for the same tidally influenced brackish source water as available at the CCWD site.

Unlike the pretreatment systems, where self-contained membrane skids are leased to the project by the selected pretreatment vendors, RO and NF vendors will simply provide their elements to be tested, with element enclosures, peripheral equipment, controls, etc. added by the MWH Team and customized for each specific application. The MWH team will fabricate each skid as necessary to assist with meeting overall project objectives and to match the needs of the proposed pilot plant.

Each RO and NF skid will include of the following components:

- Seawater RO, brackish RO or NF membranes as described herein, 4-inch diameter and 40-inches in length, approximately.
- Pressure vessels as manufactured by Codeline, Protec, or other comparable vendor, rated for between 600 psi (brackish) and 1,000 psi (seawater) and equipped with six or seven elements per vessel.
- High pressure centrifugal feed water pumps with VFD. Separate feed water pumps are illustrated in **Figure 4-1**, however, other arrangements will be evaluated during pilot fabrication involving a single common pump with separate control valves, or booster pumping.
- Instrumentation, controls and communications.
- Piping, valves, chemical injection ports and related mechanical components.

Electrical power supply is anticipated to be 480V, 3 phase supplied to each skid from existing motor control centers at the MSPS. Transformers will be provided for low voltage requirements.

5.4.2 System Control

Variable frequency drives (VFDs) will be utilized to control the RO feed pumps. These devices would serve to match the pump output to the required conditions of service at any given time. These pumps are PLC-controlled. Through the automated control system, the VFDs will continuously optimize the electrical consumption efficiency.

As described in Section 4, selected test trials may spike TDS to simulate the tidal fluctuations which may be encountered at CCWD full-scale sites. In this case, the VFD pumps may need to be controlled by an online salinity or conductivity reading, requiring additional controls. Such controls may not be designed into the initial pilot plant, but may be implemented later if time and budget are available for additional testing.

Pump selection and system design are important factors for the high pressure feed system for each train. Pressure switches will be used to prevent cavitation by activating alarms and stopping pump operation if a predetermined minimum pressure is reached at the inlet of the pump.

5.4.3 Flushing

The RO/NF trains will be automatically flushed with permeate when the system is shut down in order to prevent the direct osmosis flow and damage of the membranes. The volume provided for flushing will be equal to 120% of the internal volume of the RO/NF system. This will significantly reduce the potential for membrane fouling.

The flush sequence will involve the following steps:

1. Concentrate valves opens, filtrate flow control ramps down to zero.
2. High pressure feed pump off.
3. Antiscalant dosing pump off (also applies to other chemicals).
4. Transfer pump off.
5. Shut train inlet valve, open permeate dump valve.
6. Start flush pump.

Before the flushing of the membranes starts, the RO/NF system will be isolated. Pretreatment will continue to operate but the pretreated water will be diverted to overflow. Pumps downstream of the cartridge filters will be stopped prior to diverting flow.

Flushing is also performed during plant start-up and after a CIP.

5.4.4 Monitoring

Feed flow rate, temperature and pressure are critical membrane performance parameters and will be monitored at various points in the RO trains. Instrumentation will serve the following functions:

- A flow transmitter will measure the flow rate for feed to each stage either directly or through a mass balance of other metered streams. If the value falls below the set value, high pressure pumps will be stopped and feed to the unit interrupted until the problem has been solved and the flow can be restored back to normal value.
- A temperature indicator and transmitter located upstream of the RO and NF vessels will measure the feed flow temperature. If the value is above 40ºC, feed pumps will be stopped and the flow temperature problem will be addressed.
- A pressure transmitter will measure the feed flow pressure at each stage. If the value is below the preset value, feed pumps will be stopped and flow pressure problem addressed.
- A pressure indicator located immediately before the each array will serve as a double check measure to ensure feed to the membranes is in appropriate conditions.

- Membrane pressure drop from the feed to the concentrate is an important parameter to consider at this stage and will also give the operator an idea of possible scaling on membranes. For this reason, pressure transmitters will be mounted in-line for each stage.

Other optimized RO/NF parameters to be calculated based on monitored by on-line analyzers or grab samples will be as follow:

- Operating Flux (gfd) – calculated based on flow.
- Recovery (%) – calculated based on flow.
- Feed turbidity – on-line instrument.
- Feed temperature – on-line instrument.
- Feed pH (high and low) – on-line instrument.
- Chemical doses (mg/l) – calculated based on chemical and RO/NF feed flows.
- Conductivity, TDS, and rejection of chloride and other constituents – grab samples and on-line instruments.
- Other operating pressures and flow rates not noted above.

5.4.5 Clean in Place

Periodically, the RO/NF membranes will require chemical cleaning to remove fine particulates and other fouling materials that accumulate on the surface of the membranes over time during the routine operation of the RO/NF system. Fouling is evidenced by a decline in MTC, permeability or specific flux or an increase in feed-brine pressure differential. Membrane elements should be cleaned between RO trials of 960 hours each.

In a full-scale installation, operational parameters trigger CIP procedures. These parameters may include:

- The normalized permeate flow drops by 10%.
- The normalized salt content of the product water increases by 10%.
- The differential pressure (feed pressure – concentrate pressure) increases by 15% from the reference conditions (initial performance established during the first 24 to 48 hours of operation).

Pilot test results will be projected to determine when these conditions could be encountered, if they are not encountered during the pilot trials. Minimum frequencies will be established.

The CIP solutions for use at the PPS will be prepared by mixing the cleaning product with RO permeate. Heating may be required by per manufacturer's protocols. Chemicals that are anticipated to be used in the typical chemical cleaning process are citric acid (2% solution) and a high pH detergent cleaner (EDTA, sodium hydroxide, trisodium phosphate). The cleaning procedure may be altered depending on the type of membrane foulant(s) and may require additional chemicals to improve membrane cleaning.

5.4.6 Miscellaneous Equipment and Field Devices

Although not shown in **Figure 4-1,** each RO train will be provided with other equipment and devices as needed to assure a well-operating system.

- RO/NF System inlet control valve, cleaning inlet valves, and permeate flush valves.
- Tank level transmitter for tank status, refill and pump protection functions.
- Cleaning system accessories such as flow meters, filters, inlet and filter outlet pressure gauges, temperature indicators and transmitters.
- A cartridge filter upstream of the RO/NF systems, located either on the combined feed water at the intermediate tank outlet, or on each RO/NF skid.

Feed, permeate and concentrate flow streams will be metered. Where necessary, flow streams will be calculated based on the flow balance.

5.5 Other Equipment and Site Considerations

Additional equipment on the site will include some or all of the following:

- A first aid kit.
- Fire extinguishers and other devices as called for by the Health and Safety Plan and Security Memorandum.
- Designated chemical storage areas.
- Handheld analyzers and other equipment including stopwatches, buckets, and gloves .
- Temporary covering for equipment.
- Lighting.
- A potable water tank and/or a utility water tank with hoses and related equipment as required by the vendors.
- An eye wash station.
- A sanitary facility including portable toilet and handwashing facilities.
- A dedicated security camera if possible.
- Satellite or cellular service for communications.

5.6 RO/NF Concentrate and Pretreatment Residuals Discharge

The waste streams produced from the desalination process could include:

- Screenings from intake screen/strainer.
- Backwash water from pretreatment.
- RO/NF process concentrate.
- Chemical cleaning waste from pretreatment and RO/NF.
- Intermittent backwash/cleaning waste from biological growth control

The RO/NF desalination process produces two significant liquid streams; a product water stream consisting of high quality permeate water that has passed through the RO/NF membrane and a concentrate, or brine stream that contains the water and salts rejected by the membrane. Pretreatment residuals and other intermittent liquid waste streams from cleaning and flushing operations in the plant may be treated independently. For the purposes of this Experimental Plan, the term "concentrate" includes the RO/NF membrane concentrate/reject and "residuals" will be understood to include those pretreatment residuals and/or cleaning solutions that may be discharged along with the concentrate or an alternative discharge through the sanitary sewer or off-site disposal.

The RO/NF permeate will be sent to the CCWD raw water supply via an existing onsite raw water pipeline that flows to Mallard Reservoir. The RO/NF concentrate will be combined with the washwater from the prescreen and pretreatment systems and discharged to the DDSD waste water treatment plant via an existing sewer line near Mallard Slough Pump Station. Spent chemical cleaning solutions will be adjusted and bled into the same existing sewer line if possible, or will be transported offsite as appropriate.

5.7 Pilot Plant Operational Monitoring

Operational parameters and considerations which are anticipated to be monitored and calculated during each test trial are summarized in **Table 5-4**.

5.8 Chemical Use and Storage

There are a number of potential steps within the typical desalination process where chemicals could be introduced to enhance performance or protect the membranes. The pilot test is designed to identify an optimized mode of operation (coagulant, disinfectant, antiscalant, acid dose) for the pilot plant. The pilot plant will have the ability to accommodate the addition of each chemical.

It is not anticipated that hazardous chemicals will be encountered on the site. Once operational, it is expected that the plant will store only a minimal amount of materials on-site. Those materials would be typical of materials/chemicals common to typical water treatment facilities and would be stored and utilized on-site as part of the desalination plant operations. These chemicals would be required for disinfection, pretreatment and membrane cleaning. All chemicals will be safely stored on-site with 110% spill containment and away from public access areas for safety purposes. Chemical transportation, storage and use would comply with state and federal requirements.

Table 5-4 PPS Operational Parameters	
Pre-Screening	Backwashing frequency and backwashing time Differential pressure
Pretreatment	Specific flux Transmembrane pressure Backwashing optimum frequency and sequence CIP characteristics, sequence, frequency etc. Dose and type of Coagulant UV_{254} reduction TOC reduction SDI reduction Fouling evaluation through TMP increase
RO/NF	pH control Physical parameters (conductivity, turbidity) SDI values of feed water to the RO unit Chemical dose requirements Differential pressure Membrane performance (recovery and differential pressure) Optimum flux and specific flux average Boron removal efficiency TOC removal efficiency Membrane fouling Operational pressures
CIP Efficiency	Conductivity Integrity monitoring Pressure

5.8.1 Chemical Application Points

Some of the treatment processes require chemical addition to adjust water quality parameters to meet treatment goals, optimize performance and costs, and maintain process equipment. Treatment chemicals will be applied at several locations along the main treatment process, to the residual streams, and to the cleaning processes for the disc filters, pretreatment and RO/NF membranes. In some cases, optional chemical addition will be installed to allow flexibility in operation.

Potential chemical application points are summarized in **Table 5-5**.

Additional cleaning chemicals will be required for maintenance wash procedures for each pretreatment system on a daily basis. The chemical and dose will be as required by each vendor.

Table 5-5
Chemical Application Points

	Raw Water	Before Pretreatment System	Before RO/NF System	Before Second Stage RO System	For CIP of Pretreatment and RO/NF Systems	For Neutralization of Spent Cleaning Solutions
Sodium Hypochlorite		X			X	
Aqueous Ammonia		X				
Ferric Chloride, PACL or other coagulant		X				
Sodium Metabisulfite			X			X
Antiscalant			X			
Sodium Hydroxide, if necessary				X	X	X
Sulfuric Acid, if necessary			X			X
Citric Acid					X	

5.8.2 Chemicals and Chemical Feed Systems

Chemical feed systems consist primarily of metering pumps and bulk tanks. Chemical solutions will be delivered to the application points using diaphragm metering pumps and chemical-specific piping systems. The chemical storage tanks will be designed to allow at least 7 days storage for maximum dose rates. Pumps will feed directly from the storage tanks.

Based on operation on the expected feed water quality, anticipated process chemical consumption for major chemicals is summarized in **Table 5-6**.

5.8.2.1 Sodium Hypochlorite

Sodium hypochlorite (NaOCl) solution is an effective disinfectant and oxidant. It will be combined with aqueous ammonia to create pre-formed chloramines and injected upstream of the pretreatment process as an optional pretreatment disinfection to decrease biological fouling of the pretreatment and RO/NF membranes. Sodium hypochlorite will also be applied as a cleaning agent in the pretreatment chemically enhanced backwashes and as a cleaning agent for the filters and pretreatment systems.

Table 5-6
Chemical Consumption

Chemical	Dose (mg/L)*	gal/d**	7 Day Storage (gal)	gal/mo	gal/6 mos.
Scale Inhibitor	2	0.2	1.1	4.9	29.3
	5	0.4	2.9	12.2	73.4
Ferric Chloride	5	0.7	4.8	20.4	122.2
	15	2.0	14.3	61.1	366.6
Sulfuric Acid	40	2.0	14.0	60.0	360.0
	50	2.5	17.5	75.0	450.0
Aqua Ammonia	0.125	0.1	0.4	1.8	11.0
	0.75	0.4	2.6	11.0	66.2
Hypochlorite	0.5	0.7	4.7	20.2	121.1
	3	4.0	28.3	121.1	726.7
Sodium Bisulfite	2	0.3	2.3	9.7	58.5
	12	1.9	13.6	58.5	350.8

*Minimum and maximum doses required for each chemical

**Calculated using anticipated flows of 60 gpm

5.8.2.2 Aqueous Ammonia

Aqueous ammonia solution (NH_4OH) is an alkaline chemical manufactured by dissolving ammonia into deionized or softened water at high pH. Aqueous ammonia will be applied to the treatment process, along with sodium hypochlorite, for pre-formed chloramine production in the feed water upstream of the pretreatment system as an optional pretreatment disinfectant to minimize biological fouling of the pretreatment and RO/NF membranes

5.8.2.3 Coagulant

Ferric chloride ($FeCl_3$) is one of the most commonly used water treatment chemicals for coagulation. Ferric chloride will be dosed upstream of the pretreatment system as recommended by the pretreatment system manufacturer and/or during periods resulting in elevated levels of turbidity, solids, algae, organics, etc. which can increase fouling of the pretreatment and RO/NF membranes.

Polyaluminium chlorodydrate (PACL) is an effective inorganic macromolecule flocculant used widely in water purification and wastewater treatment and may be used as an alternative to ferric chloride. The product can cause quick formation of flocs that can be easily backwashed from the surface of pretreatment membranes. PACL is not a hazardous chemical. It is moderately acidic in nature and can be slightly corrosive.

5.8.2.4 Sodium Metabisulfite

Sodium metabisulfite ($Na_2S_2O_5$) is dosed upstream of the RO/NF membranes to remove any oxidants that may be carried in the feed water to the RO/NF after a pretreatment backwash or chemical clean and harm the RO/NF membranes.

5.8.2.5 Antiscalant

Addition of antiscalant to the RO/NF system operation is used to inhibit scaling of inorganic constituents and metal oxides on the RO membranes. An organo-phosphonate based antiscalant is recommended over sodium hexametaphosphate or polymeric organic antiscalants. The objective is to maintain inorganics in a dissolved state and inhibit crystal growth so that precipitates, such as calcium carbonate and barium sulfate, do not form in the membrane surface and potentially irreversibly foul the membranes.

There are several manufacturers of antiscalants chemicals specifically designed to aid in the pretreatment of RO/NF feed waters.

5.8.2.6 Sodium Hydroxide

Sodium hydroxide, or caustic soda (CaOH), is used to raise the pH and the alkalinity of the source water. Sodium hydroxide will be used as both a chemical cleaning agent for the RO/NF membranes and to raise the pH in the first stage RO/NF permeate water prior to feed into the second pass stage RO/NF system to increase the boron rejection of the second pass brackish water membranes.

5.8.2.7 Acid

Sulfuric acid (H_2SO_4) is one of the most widely used and produced chemicals in the world. It is also one of the least expensive acids to use. Sulfuric acid is a strong mineral acid and most commonly used for neutralization of alkaline solutions or materials.

As an alternative, citric acid ($C_6H_8O_7$) is a weak organic acid that is effective at removing iron and other inorganic contaminants from fouled membranes. Citric acid would be used as a chemical cleaning agent for both the pretreatment and RO/NF membranes.

5.8.2.8 Site and Power Requirements, Preliminary

The site layout for the pilot site is provided in **Figure 5-1**. A final site plan will be developed once site survey information is available.

Preliminary power requirements are listed in **Table 5-6** and will be confirmed during pilot plant fabrication.

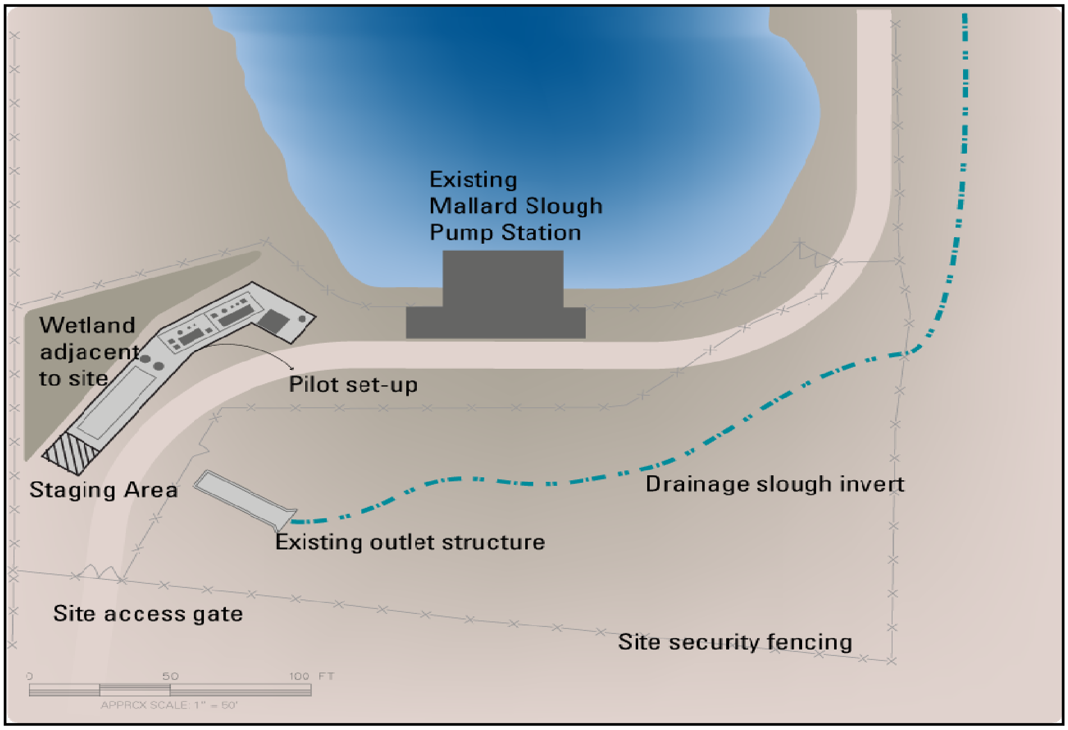

Figure 5-1 Site Layout

Table 5-7 Electrical Requirements		
Pilot Equipment Power Requirements for Major Equipment		
Pretreatment Systems	**Electrical Requirements**	
Layne Christiansen/Norit	15 Amps (480V, 3 phase)	
Memcor/Siemens	24 Amp (480V, 3 phase)	
RO and RO/NF Systems	**Specific Energy(kWh/kgal) at 50 deg F**	
	Low TDS, 2000 mg/L	**High TDS, 11,000 mg/L**
RO Train No. 1	3.7	7.4
RO Train No. 2	11.1 [1]	TBD
RO/NF Train No. 3	1.8	5.6

1. Calculated at 6,000 mg/L TDS.

5.9 Responsibilities of the Membrane Manufacturer

Anticipated responsibilities of the two pretreatment membrane manufacturers are described below.

1. Manufacturer will provide equipment preparation, equipment shipment to site or to the contractor storage yard, commissioning services supervision, including equipment start up, and checking mechanical, hydraulic and electrical connections.
2. Manufacturer will provide testing, including remote monitoring and manpower, and operator training
3. Manufacturer will provide pretreatment pilot units including level-controlled feed tank, product storage, tank air compressor, interconnecting PVC piping, manually flushable feed strain, meters, feed pump, backwash pump, coagulant dosing setup, chemical day tanks and dosing pumps for membrane cleaning, pneumatic process valves with controls, pressure vessels and tanks, control systems, and dry compressed air supply, and online instrumentation (feed and filtrate turbidity analyzers, pH analyzers, etc.)
4. Manufacturer will also provide limited field visits on an as-needed basis.
5. Manufacturer will provide decommissioning assistance and shipping (to the site).

The RO/NF membrane manufacturer will provide only the RO/NF membrane elements and limited support with interpreting performance software projections.

5.10 Responsibilities of the Engineering Team

Responsibilities of the MWH Team, as included in each vendor's subcontract, are described below.

1. Operating labor for day-to-day operations, including data collection, recharge of chemical day tanks and normal adjustment of controls.
2. A suitable site, graded bedding, shelter for equipment (as needed), power source, licensed contractors, nonpotable service water (potable water is not possible for the MSPS site), equipment offloading and set up.
3. Pumps, tanks and piping not provided by the pretreatment manufacturers.
4. Pretreatment chemicals, cleaning chemicals, chemical disposal, chemical waste handling equipment and/or neutralization chemicals, spill containment, permits, sampling and laboratory analysis.
5. Trailer for housing and transport of the three RO/NF systems.
6. Shipping where not provided by others.

Section 6 - Standard Procedures

The PPS will produce significant and valuable data and other information crucial to project success. A set of predetermined and mutually accepted procedures have been developed for monitoring, collecting and recording of all data, and any other project information so that pilot results are verifiable, reliable, and understood to the greatest extent possible.

6.1 Data Requirements

Pilot plant schematic diagram illustrating sample locations is shown in **Figure 4-1**. Sampling locations are described in **Table 6-1**.

Table 6-1
Sample Locations

Sample Identifier	Sample Location	Comments
S1	Pilot Plant Feed	Also utilized for biological sampling
S2	Prescreening Feed	
S3	Pretreatment Feed, common	
S4A	Pretreatment Feed, Submerged	
S4B	Pretreatment Feed, Pressurized	
S5A	Pretreatment Filtrate, Submerged	
S5B	Pretreatment Filtrate, Pressurized	
S6A	Pretreatment Backwash, Submerged	
S6B	Pretreatment Backwash, Pressurized	
S7	Pretreatment Filtrate, Combined	
S8 – S9	Not Used	
S10	RO 1 Feed	
S11	RO 1 Stage 1 Permeate, No. 1	
S12	RO 1 Stage 1 Permeate, No. 2	
S13	RO 1 Stage 2 Permeate	
S14	RO 1 Stage 1 Concentrate, No. 1	
S15	RO 1 Stage 1 Concentrate, No. 2	Also utilized for brine toxicity study
S16	RO 1 Stage 2 Concentrate	
S17	RO 1 Stage 2 Feed	
S18	RO 1 Permeate, Combined	Also used for finished water compatibility study
S19	Not Used	
S20	RO 2 Feed	
S21	RO 2 Permeate	
S22 – S23	Not Used	
S24	RO 2 Concentrate	
S25 – S29	Not Used	
S30	RO/NF 3 Feed	
S31	RO/NF 3 Permeate	
S32 – S33	Not Used	
S34	RO/NF 3 Concentrate	

The suggested pilot online instruments are listed in **Table 6-2**. These devices will be confirmed with the pilot system manufacturers as design is developed further.

Table 6-2
Discrete and Online Instruments for Primary Systems [1]

Instrument Identifier	Instrument Type or Parameter	Instrument Location
TBD	Pressure	Raw Water
TBD	Pressure	Prescreened Water, downstream of prescreening unit
TBD	Temperature	Pretreatment Feed
TBD	pH	Pretreatment Feed (not included in current pilot design)
TBD	Conductivity	Pretreatment Feed
TBD	Pressure	Pretreatment Feed
TBD	Flow	Pretreatment A Feed
TBD	Temperature	Pretreatment A Feed
TBD	Pressure	Pretreatment A Filtrate
TBD	Flow	Pretreatment A Filtrate
TBD	Turbidity	Pretreatment A Filtrate
TBD	Tank Level	Pretreatment A (at the submerged membrane & backwash tanks)
TBD	Conductivity	Pretreatment B Feed
TBD	Turbidity	Pretreatment B Feed
TBD	Temperature	Pretreatment B Feed
TBD	Pressure	Pretreatment B Feed
TBD	Pressure	Pretreatment B Filtrate
TBD	Flow	Pretreatment B Filtrate
TBD	Turbidity	Pretreatment B Filtrate
TBD	Equipment Status	Pretreatment A (as determined by system manufacturer)
TBD	Equipment Status	Pretreatment B (as determined by system manufacturer)
TBD	ORP	RO Feed, combined at the Intermediate Tank outlet
TBD	Pressure	RO Feed Screen, upstream
TBD	Pressure	RO Feed Screen, downstream
TBD	Temperature	RO 1 Feed, high pressure pump inlet
TBD	Flow	RO 1 Feed, high pressure pump inlet
TBD	Pressure	RO 1 Feed, high pressure pump outlet & orifice plate
TBD	Flow	RO 1 Stage 1 Permeate, combined from both stage 1 vessels
TBD	Flow	RO 1 Stage 2 Permeate
TBD	Pressure	RO 1 Permeate, combined all stages and vessels
TBD	pH	RO 1 Permeate, combined all stages and vessels
TBD	Conductivity	RO 1 Permeate, combined all stages and vessels
TBD	Pressure	RO 1 Stage 1 Concentrate, combined from both stage 1 vessels
TBD	Conductivity	RO 1 Stage 1 Concentrate, combined from both stage 1 vessels
TBD	Pressure	RO 1 Stage 2 Concentrate
TBD	Flow	RO 1 Stage 2 Concentrate
TBD	pH	RO 1 Stage 2 Concentrate
TBD	pH	RO 2 Feed, high pressure pump inlet
TBD	Temperature	RO 2 Feed, high pressure pump inlet
TBD	Conductivity	RO 2 Feed, high pressure pump inlet
TBD	Flow	RO 2 Feed, high pressure pump inlet
TBD	Pressure	RO 2 Feed, high pressure pump outlet
TBD	Flow	RO 2 Permeate

TBD	Conductivity	RO 2 Permeate
TBD	Pressure	RO 2 Concentrate
TBD	Flow	RO 2 Concentrate
TBD	pH	RO/NF 3 Feed, high pressure pump inlet
TBD	Temperature	RO/NF 3 Feed, high pressure pump inlet
TBD	Conductivity	RO/NF 3 Feed, high pressure pump inlet
TBD	Flow	RO/NF 3 Feed, high pressure pump inlet
TBD	Pressure	RO/NF 3 Feed, high pressure pump outlet
TBD	Flow	RO/NF 3 Permeate
TBD	Conductivity	RO/NF 3 Permeate
TBD	Pressure	RO/NF 3 Concentrate
TBD	Flow	RO/NF 3 Concentrate

1. Level switches at tanks are not listed. Ancillary cleaning and compressed air systems are not included.

Monitoring requirements and frequency are summarized in **Table 6-3**.

Table 6-3
Monitored Operational Parameters

Operational Parameter [1]	Data Collection/Calculation
Pretreatment TMP (kPa)	On-line, each pre-treatment system
Pretreatment Instantaneous Flux (lmh)	Calculated using on-line flow meter, each pre-treatment system
Pretreatment Instantaneous Flux at 20^{o}C (lmh)	Calculated using flow meter & temperature gauge, each pre-treatment system
Pretreatment Specific Flux at 20^{o}C(lmh/kPa)	Calculated using flow meter, pressure gauges & temperature gauge, each pre-treatment system
Pretreatment Filtrate Flow (m^3/h)	On-line, each pre-treatment system
Pretreatment PDT (kPa/min)	Manual, each pre-treatment system
RO Feed Flow (m^3/hr)	On-line, each array
RO Recovery (%)	Calculated using On-line flow meters
RO Differential Pressure, DP (kPa)	On-line, each array and each stage
RO Feed Pressure (kPa)	On-line, each array and each stage
RO Permeate Flow (m^3/hr)	On-line, each array and each stage
RO Concentrate Flow (m^3/hr)	On-line, each array and each stage, calculated for RO 1 Stage 1
RO Clean Membrane DP (kPa)	Average of On-line data, each array and each stage
RO Fouled Membrane DP (kPa)	Average of On-line data, each array and each stage
RO Instantaneous Flux at 20^{o}C (lmh)	Calculated using on-line and calculated flows noted above, each array and each stage
RO Specific Flux at 20^{o}C (lmh/kPa)	Calculated using on-line and calculated flows and pressures noted above, each array and each stage
RO New Membrane Flux (lmh)	Average of Calculated data, each array and each stage
RO Fouled Specific Flux	Average of Calculated data, each array and each stage

1. May also be reported in English units.

Monitoring of organic water quality parameters of the feed, permeate, and backwash water, such as total organic carbon (TOC), and ultraviolet absorbance (UVA) will be performed as shown in **Table 6-3**, to evaluate organics removal from the source water. Additional parameters of concern for assessment of membrane performance include alkalinity, total and calcium hardness, total dissolved solids, and chlorine residual.

Operational data, laboratory data, and chemical analyses will occur during the membrane filtration testing process. Operational and water quality data shall be collected at regular intervals during the period of membrane testing, as indicated in **Tables 6-3 and 6-4** respectively.

For verification of particulate removal, turbidity in filtrate waters shall be monitored continuously using on-line analytical instruments as provided by the pretreatment system manufacturers.

Table 6-4
Sampling and Analysis Schedule

Parameter	Unit		Test Facility	Sample Locations	Frequency
On-Site Analytical Testing					
Temperature	deg C		On-site	S2, S3	Daily
Temperature (cv)	deg C		On-site	S3, S4A, S4B, S10, S20, S30	Weekly
pH	-		On-site	S2, S3, S21, S24, S31, S34	Daily
pH (cv)	-		On-site	S3, S16, S18, S20, S30	Weekly
Conductivity	µS/cm		On-site	S2, S10-S16, S24, S34	Daily
Conductivity (cv)	µS/cm		On-site	S3, S4B, S7, S17, S18, S20, S21, S30, S31	Weekly
SDI			On-site	S7, S18, S21, S31	2 per week
Monochloramine	mg/L		On-site	S3	Daily
Total Chlorine Residual	mg/L		On-site	S3, S7	Daily
Oxidation reduction potential (cv)	mV		On-site	S7	Weekly
Turbidity[6]	NTU		On-site	S10, S18, S20, S21, S30, S31	Daily
Turbidity (cv)	NTU		On-site	S3, S4B, S5A, S5B	Weekly
Off-Site Analytical Testing					
Alkalinity/Hardness					
Total Alkalinity as $CaCO_3$	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Total Hardness as $CaCO_3$	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Bicarbonate Alkalinity	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Carbonate Alkalinity	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Total Cations/Anions[1]	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Metals					
Aluminium	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Barium	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Boron	ug/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Iron	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Manganese	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Metals Primary List[2]	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Monthly

Minerals					
Bromide	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Chloride	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Cyanide	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Fluoride	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Silica	mg/L		Lab[3]	S1, S7, S16-S18, S21, S24, S31, S34	Weekly
Total Suspended Solids	mg/L		Lab[3]	S3, S10, S16-S18, S20, S21, S24, S30, S31, S34	Weekly
Total Dissolved Solids	mg/L		Lab[3]	S3, S10, S16-S18, S20, S21, S24, S30, S31, S34	Weekly
Nutrients					
Nitrite as Nitrogen	mg/L		Lab[3]	S1, S18, S21, S31	Weekly
Nitrate as Nitrogen	mg/L		Lab[3]	S1, S18, S21, S31	Weekly
Phosphate, Ortho (Reactive) (as P)	mg/L		Lab[3]	S1, S18, S21, S31	2 per month
Phosphorus, Total (as P)	mg/L		Lab[3]	S1, S18, S21, S31	2 per month
Total Organic Carbon					
TOC	mg/L		Lab[3]	S1, S7, S13, S18, S21, S31	2 per week
UV_{254}	AU		Lab[3]	S1, S7	2 per week
Radionuclides					
Alpha particles	pCi/L		Lab[3]	S1, (S16, S24, S34)	once[5]
Beta particles & photon emitters	pCi/L[4]		Lab[3]	S1, (S16, S24, S34)	once[5]
Radium 226/228 combined	pCi/L		Lab[3]	S1, (S16, S24, S34)	once[5]
Uranium	pCi/L[4]		Lab[3]	S1, (S16, S24, S34)	once[5]
Strontium 90	pCi/L[4]		Lab[3]	S1, (S16, S24, S34)	once[5]
Tritium	pCi/L[4]		Lab[3]	S1, (S16, S24, S34)	once[5]
Other					
Algae Count	#/100 mL		Lab[3]	S1 ,S3	1 per month
MTBE	ug/L		Lab[3]	S1, S18, S21, S31	Monthly
Perchlorate	ug/L		Lab[3]	S1, S18, S21, S31	Monthly

CV = calibration verification

[1] Includes sodium, potassium, calcium, magnesium, sulfate, ionic balance, total hardness

[2] includes antimony, arsenic, boron, barium, beryllium, cadmium, chromium (total), cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, zinc.

[3] Off-site laboratory (MWH Labs or other)

[4] Unit selected based on California drinking water standard

[5] Raw water radionuclides will be tested at start of PPS. Concentrates may be further tested depending on magnitude found in raw water.

[6] Permeate from each array and stage will be evaluated further depending on turbidity values measured in combined permeate (S18, S21, S31).

6.2 Standard Sampling Methods

To ensure the accuracy of all collected data, consistent sampling methods with respect to location, timing, and the technique must be maintained. Additionally, for samples analyzed at off-site laboratories, consistency in sample preservation, packaging and shipping is required. Membrane operational parameters such as flow, pressure, and time since last backwash will be recorded at the time of sampling.

Both on-line and handheld analytical equipment will be used for on-site analyses. For parameters where both on-line and handheld instruments are used (such as turbidity or pH), comparisons between the two readings will be made to check for data consistency. At a minimum, these comparisons will be made weekly.

All analyses will be performed according to Standard Methods[1]. All laboratory analyses will be performed at a laboratory of one of the four Partner Agencies, MWH Laboratories, or another State-certified or EPA-accredited laboratory.

6.3 Data Handling Protocol [2]

The successful implementation of the verification testing will require detailed coordination and constant communication between all testing participants. All verification activities shall be thoroughly documented. Documentation shall include field logbooks, photographs, data sheets, and chain-of-custody forms.

6.3.1 Field Notes

Field notes shall be kept in a bound logbook. Each page shall be sequentially numbered and labeled with the project name and number. Field logbooks shall be used to record all water treatment equipment operating data. Completed pages shall be signed and dated by the individual responsible for the entries. Errors shall have one line drawn through them and this line shall be initialed and dated.

6.3.2 Chain-of-Custody Forms

Chain-of-custody forms shall accompany all samples delivered to the Partner Agency Laboratory, MWH Laboratories or other laboratory. A copy of each chain-of-custody shall be retained and filed.

6.3.3 Data Management System

The data management system used in the pilot testing program shall consist of a spreadsheet for each data type, i.e. offsite laboratories, onsite laboratories, and online data. Data sources include laboratory reports, log books, and SCADA output spreadsheets. The computer spreadsheets

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[1] American Public Health Association, American Water Works Association, Water Environment Federation. Standard Methods for the Examination of Water and Wastewater, 19th Ed.

[2] NSF International. Protocol for Equipment Verification Testing for Physical Removal of Microbiological and Particulate Contaminants. May 14, 1999. (Reprinted with Permission.)

shall be located in the MWH ProjectWise file sharing platform which has been established for the BARDP project, Folder No. 6.2.4. Access is privileged.

Results will be shared with the partner agencies by means of the project FTP site.

The database for the project shall be set up in the form of custom-designed spreadsheets that minimizes the amount of time spent on data entry. The spreadsheets shall be capable of storing and manipulating each monitored water quality and operational parameter from each task, each sampling location, and each sampling time.

Each experiment (e.g. each membrane test run) shall be assigned a run number which will then be tied to the data from that experiment through each step of data entry and analysis. As samples are collected and sent to the Partner Agency Laboratory, MWH Laboratories or other laboratory, the data will be tracked by use of the same system of run numbers.

6.3.3.1 Offsite Laboratory

Data from the outside laboratories will be received and reviewed by the field testing operator. These data will be entered into the data spreadsheets, corrected, and verified in the same manner as the onsite laboratory data.

6.3.3.2 Onsite Laboratory

All data from the laboratory notebooks and data log sheets will be entered into the appropriate spreadsheet. All recorded calculations will also be checked at this time. Following data entry, the spreadsheet will be printed out and the print-out shall be checked against the handwritten data sheet. Any corrections will be noted on the hard-copies and corrected on the screen, and then a corrected version of the spreadsheet shall be printed out. Each step of the verification process shall be initialed by the testing operator or engineer performing the entry or verification step.

6.3.3.3 PLC Output to database

Programmable Logic Controllers (PLC) will be installed on each of the two pretreatment pilot units, and one PLC will be furnished for all three RO pilot units, for a total of three PLCs. Online instruments (flow meters, conductivity analyzers, turbidimeters, particle counters, etc.) are connected to the PLC as well as a datalogger. All control functions and data display are carried out via operator interface panels.

Data will be downloaded from the PLCs at least once per week to an Excel (or similar spreadsheet software). Two possible methods for download will be employed: connection to the PLC with a laptop computer via Ethernet cord, or wireless phone connection. Once the data has been downloaded, specific parcels of operational and water quality data stored in the database will be imported into the spreadsheet. These specific database parcels shall be identified based upon discrete time spans and monitoring parameters. In spreadsheet form, the data will be manipulated into a convenient framework to allow analysis of membrane equipment operation. At a minimum, backup of the computer databases to compact disk will be performed every other week.

6.3.3.4 <u>SCADA Output from log books</u>

In the case when a SCADA system is not available, operators will record data and calculations by hand in laboratory notebooks. (Daily measurements shall be recorded on specially-prepared data log sheets as appropriate.) The notebooks will be stored on-site; copies will be forwarded to the project engineer at least once per week during each testing phase. Operating logs will include a description of the membrane equipment (description of test runs, description of any problems or issues, etc.); such descriptions will be provided in addition to experimental calculations and other items.

Section 7 - Quality Assurance/Quality Control

Quality assurance and quality control of the operation of the membrane equipment and the measured water quality parameters will be maintained during the PPS. When specific items of equipment or instruments are used, the objective is to maintain the operation of the equipment or instructions within the ranges specified by the Manufacturer or by Standard Methods. Maintenance of strict QA/QC procedures is important, in that if a question arises when analyzing or interpreting data collected for a given experiment, it will be possible to verify exact conditions at the time of testing.

7.1 General

A routine daily walk-through during testing will be established to verify that each piece of equipment or instrumentation is operating properly. Flowrates and associated signals will be routinely documented and recorded; chemical feed and flow rates will be confirmed; main process and sidestream flow rates will be verified; chemical concentrations will be checked; on-line instrumentation will be checked to coordinate local and remote indications with the actual values being recorded; and visual observations will made regarding overall operation and performance. The items listed are in addition to any specified checks outlined in the analytical methods

7.2 Weekly QA/QC Verifications

Pressure decay tests (PDT) will be performed once per week if the process is manual. If automation is included in the pretreatment units, PDTs will be performed three times per week. Chemical feed pump flowrates and in-line turbidimeter flowrates will be verified volumetrically over a specific time period). In-line turbidimeter readings will be checked against a properly calibrated handheld model.

7.3 QA/QC Verifications Performed Every Two Weeks

In-line flowmeters/rotameters will be cleaned equipment to remove any debris or biological buildup and verify flow volumetrically to avoid erroneous readings.

7.4 QA/QC Verifications Performed Each Month

In-line turbidimeters will have reservoirs cleaned and will be recalibrated. Differential pressure transmitters will be verified with gauge readings and electrical signals verified using a pressure meter. Tubing and connections will be checked and replaced if necessary.

7.5 On-Site Analytical Methods

The analytical methods utilized in this study for on-site monitoring of raw water and filtered water quality are described herein. On-line equipment is recommended for its ease of operation and because it limits the introduction of error and the variability of analytical results generated by inconsistent sampling techniques. On-line equipment is required for measurement of turbidity for feed water and filtered water and for other parameters as noted.

7.5.1 pH

Analyses for pH shall be performed according to Standard Method 4500-H+. A 2-point calibration of the pH meter used in this study shall be performed once per week or more frequently when the instrument is in use. Certified pH buffers in the expected range shall be used. The pH probe shall be stored in the appropriate solution defined in the instrument manual. Transport of carbon dioxide across the air-water interface can confound pH measurement in poorly buffered waters. If this is a problem, measurement of pH in a confined vessel is recommended to minimize the effects of carbon dioxide loss to the atmosphere.

7.5.2 Temperature

Readings for temperature shall be conducted in accordance with Standard Method 2550. Raw water temperatures shall be obtained at least once daily. The thermometer shall have a scale marked for every 0.1 °C, as a minimum, and should be calibrated weekly against a precision thermometer certified by the National Institute of Standards and Technology (NIST). A thermometer having a range of -1°C to +51°C, subdivided in 0.1 °C increments, would be appropriate for this study.

7.5.3 Turbidity Analysis

Turbidity analyses shall be performed according to Standard Method 2130 or EPA Method 180.1 with either an in-line or bench-top turbidimeter. In-line turbidimeters will be used for measurement of turbidity in the filtrate waters, and either an in-line or bench-top turbidimeter may be used for measurement of the feed water (and concentrate where applicable). During each verification testing period, the in-line and bench-top turbidimeters shall be left on continuously. Once each turbidity measurement is complete, the unit will be switched back to its lowest setting.

Glassware used for turbidity measurements will be cleaned and handled using lint-free tissues to prevent scratching. Sample vials shall be stored inverted to prevent deposits from forming on the bottom surface of the cell.

Pilot testing personnel will be required to document any problems experienced with the monitoring turbidity instruments, and will also be required to document any subsequent modifications or enhancements made to monitoring instruments.

7.5.3.1 Bench-top Turbidimeters.

Grab samples shall be analyzed using a bench-top turbidimeter. Readings from this instrument shall serve as reference measurements throughout the study. The bench-top turbidimeter shall be calibrated within the expected range of sample measurements at the beginning of verification testing and on a weekly basis using primary turbidity standards of 0.1, 0.5, and 3.0 NTU.

Secondary turbidity standards shall be obtained and checked against the primary standards. Secondary standards shall be used on a daily basis to verify calibration of the turbidimeter and to recalibrate when more than one turbidity range is used.

The method for collecting grab samples shall consist of running a slow, steady stream from the sample tap, triple-rinsing a dedicated sample beaker in this stream, allowing the sample to flow down the side of the beaker to minimize bubble entrainment, double-rinsing the sample vial with the sample, carefully pouring from the beaker down the side of the sample vial, wiping the sample vial clean, inserting the sample vial into the turbidimeter, and recording the measured turbidity. For the case of cold water samples that cause the vial to fog preventing accurate readings, the vial shall be allowed to warm up by partial submersion in a warm water bath for approximately 30 seconds.

7.5.3.2 In-line Turbidimeters

In-line turbidimeters shall be used for measurement of turbidity in the filtrate water during verification testing and must be calibrated and maintained as specified in the manufacturer's operation and maintenance manual. It will be necessary to verify the in-line readings using a bench-top turbidimeter. Although the mechanism of analysis is not identical between the two instruments, the readings should be comparable. Should the comparison suggest inaccurate readings, then all in-line turbidimeters should be recalibrated.

In addition to calibration, periodic cleaning of the lens should be conducted, using lint-free paper, to prevent any particle or microbiological build-up that could produce inaccurate readings. Periodic verification of the sample flow should also be performed using a volumetric measurement. Instrument bulbs should be available and replaced on an as-needed basis. It should also be verified that the LED readout matches the data recorded on the data acquisition system, if the latter is employed.

7.5.4 Organic Parameters: Total Organic Carbon and UV_{254} Absorbance

Samples for analysis of TOC and UV_{254} absorbance will be collected in glass bottles supplied by MWH Laboratories or other laboratory and shipped at 4°C. These samples will be preserved, held, and shipped in accordance with Standard Method 5010B. Storage time before analysis shall be minimized, according to Standard Methods.

7.5.5 Microbial Parameters: Heterotrophic Plate Counts

Samples for analysis of Heterotrophic Plate Counts (HPC) will be collected in bottles supplied by MWH Laboratories or other laboratory and shipped with an internal cooler temperature of approximately 4°C for processing at the time specified for the relevant method. Laboratory will keep the samples at approximately 4°C until initiation of analysis. HPC densities will be reported as colony forming units per milliliter (cfu/mL).

7.5.6 Inorganic Samples

Inorganic chemical samples, including, alkalinity, hardness, aluminum, iron, and manganese, will be collected and preserved in accordance with Standard Method 3010B, paying particular attention to the sources of contamination as outlined in Standard Method 3010C. The samples will be refrigerated at approximately 4°C immediately upon collection, stored in a cooler for delivery, and maintained at a temperature of approximately 4°C during shipment. Samples will be processed for analysis by MWH Laboratories or other laboratory within 24 hours of collection. The laboratory shall keep the samples at approximately 4°C until initiation of analysis.

7.5.7 Chlorine Residual

Residual chlorine measurements will be conducted according to Standard Method 4500-Cl G. DPD Colorimetric Method. All glassware used for sampling and the preparation of agents will be chlorine demand free. Chlorine demand free glassware will be prepared by soaking glassware in a 50 mg/L chlorine bath for a period of 24 hours. At the end of this time, all glassware will be rinsed three times with organic-free water that has a TOC concentration of less than 0.5 mg/L.

ATTACHMENTS

BAY AREA REGIONAL DESALINATION PROJECT
PILOT TESTING AT MALLARD SLOUGH

ATTACHMENT A
SOURCE WATER QUALITY

I N T E R N A L   M E M O R A N D U M

Bay Area Regional Desalination Project
Pilot Study at Mallard Slough ***DRAFT***

Subject:	**Feed Water Quality Characterization Technical Memorandum No. 3A**		
Prepared by:	Mary Carr Portillo, P.E.	**Reference:**	1481449/6.2.3
Reviewed by:	Stephanie Harrison, P.E. Charlie Bromley, P.E. Dawn Guendert	**Date:**	November 21, 2007

This technical memo summarizes the feed water quality available for sample points in or near Mallard Slough and provides recommendations for additional pre-pilot water characterization sampling and analysis. In general, the water quality of the proposed source water is highly variable depending on tidal fluctuations and seasonal changes, with decreasing total dissolved solids (TDS) during spring runoff and increasing TDS during fall and winter months. Recommendations contained herein will focus on assuring sufficient data are available to evaluate and select pilot plant process options.

During pilot testing, source water quality will be monitored regularly to evaluate pilot processes and ongoing system performance. Recommended water quality data collection procedures for the pilot will be presented once pilot processes have been selected.

1.0 Available Water Quality Data

Existing water quality data is available from several sources for sample points in or near Mallard Slough:

- the Bay Area Regional Desalination Pre-feasibility Study and Feasibility Study,
- Contra Costa Water District (CCWD), and
- California Department of Water Resources (DWR) data collection.

The Pre-feasibility Study was published in 2003 and the Feasibility Study was published in July 2007. Both contain water quality data for Mallard Slough (1996-2000) provided by CCWD in **Table 1-1**. Source documents do not indicate how often or when, during the five year period, data was collected.

In addition CCWD provided MWH with Mallard Slough water quality data extending from 2001 to 2005, as shown in **Table 1-2**. As with the 2003 Pre-feasibility Study and the 2007 Feasibility Study, information is not available in the source document regarding sample period frequency and sampling methodology. Data are not available for TOC and for silica in the period from 2001 to 2005.

Table 1-1: Summary of Water Quality for Mallard Slough (1996-2000)

Constituent	unit	Max	Min	Avg
Turbidity	NTU	146	4.09	24.1
Calcium	mg/L	276	3.9	35.2
Magnesium	mg/L	190	5.6	78.7
Sodium	mg/L	1600	10	595.2
Chloride	mg/L	3100	13	766
Potassium	mg/L	200	1.2	20.2
Sulfate	mg/L	420	10	151.5
Nitrate	mg/L	3.7	0.23	1.56
Phosphate	mg/L	3.4	<0.2	0.31
Silica	mg/L	23	13	17
Hardness	mg/L	960	36	295
pH		8.4	6.22	7.67
Alkalinity	mg/L	82	22	61.61
Conductivity	uS/cm	9550	130	2792.2
TDS	mg/L	5737	70	2137.8
Ammonia	mg/L	0.25	<0.1	0.1
TOC	mg/L	5.7	0.5	2.7
Source: Feasibility Study – July 2007				

Table 1-2: Summary of Water Quality for Mallard Slough (2001-2005)

Constituent	unit	Max	Min	Avg
Turbidity	NTU	58.1	11.4	27.7
Calcium	mg/L	92	12	33
Magnesium	mg/L	258	7.5	73.3
Sodium	mg/L	1700	18	450
Chloride	mg/L	1260	16	349
Potassium	mg/L	69	2.2	19.3
Sulfate	mg/L	32	12.3	19.4
Nitrate	mg/L	2	<0.1	1.4
Phosphate	mg/L	<0.2	<0.2	<0.2
Silica	mg/L	No Data		
Hardness	mg/L	1140	62	345
pH		8.3	7.5	7.8
Alkalinity	mg/L	89	67	76.5
Conductivity	uS/cm	10230	220	2828
TDS	mg/L	7130	110	2448
Ammonia	mg/L	<0.1	<0.1	<0.1
TOC	mg/L	No Data		
Source: CCWD – September 2007				

When comparing these data, average values within the two data sets are fairly similar, with the exception of sodium, chloride and sulfate which are each observed to much less during the 2001 to 2005 period. Lower minimum values are consistently observed with the 1996 to 2000 data set, while maximum values are somewhat scattered. Major anion (chloride, sulfate) average and maximum values are substantially higher in the 1996 to 2000 data set. Alkalinity, hardness, conductivity, and TDS average and maximum values are consistently observed to be highest from 2001 to 2005. Turbidity and major cation (calcium, magnesium, sodium, and potassium) values do not present a clearly discernible pattern.

Data scatter may be due in part to variations in sampling location, time-of-year, time-of day, depth of measurement, and use of preservative within the sample containers. Units of measurement are not fully defined in the tables and source documents, particularly for such components as Sulfate (S or SO_4), Nitrate (N or NO_3), Phosphate (P or PO_4), Silica (Si or SiO_2), Hardness (as $CaCO_3$), Alkalinity (as $CaCO_3$), and Ammonia (N or NH_3)

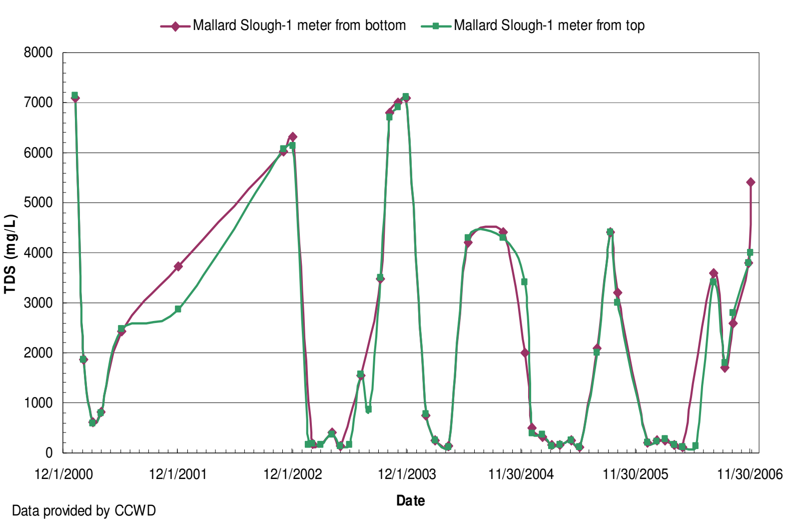
For these data to be completely understood, additional research and evaluation for number of samples, frequency, time period, dissolved solid constituents, and sampling/testing methodology may be necessary as the project moves forward into the proposed membrane evaluation activities.

1.1 Total Dissolved Solids, Mallard Slough

TDS is measured regularly throughout the year in Mallard Slough, as shown in **Figure 1-1,** at water depths one meter below the water surface and one meter above the slough bottom. Data provided by CCWD is from the five year period between 2001 through 2006.

Sample depth does not appear to make a significant difference in TDS. Peaks are generally observed in the fall and winter months and are attributed to tidal variations causing decreased TDS during spring run-off and increased TDS during the drier fall and winter months.

Figure 1-1: TDS for Mallard Slough (2001-2006)



Further analysis of the data has been performed to demonstrate percentile TDS distribution. Lower Mallard Slough TDS levels were observed in the years preceding 2000 as evidenced by **Table 1-1**.

Table 1-3: Percentile Distribution of TDS for Mallard Slough (2001-2006)

Percentile	TDS (mg/L)
Max	7130
95	6954
90	6304
75	3800
50	1540
25	230
10	140
Min	110

1.2 Total Dissolved Solids, Sacramento Delta

Hourly water quality data has also been provided by DWR from the California Data Exchange Center (CDEC) database Pittsburg station "PTS". Data presented in **Table 1-4** are converted from conductivity measurements using the Delta Wide Conversion Factor of 0.64 from the *CALFED Water Quality Program Assessment Report – June 2005*.

These data are understood to be representative of the delta/bay complex only. Tidal variations are quite evident and result in TDS levels much greater than observed in Mallard Slough, particularly in the higher percentile ranges.

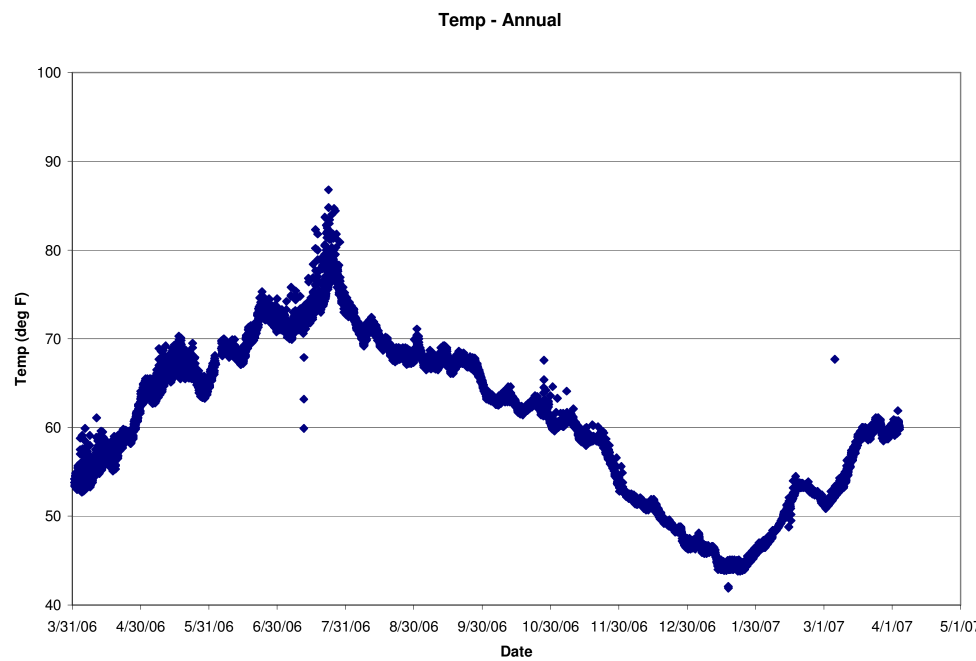
Table 1-4: Percentile Distribution of TDS for Pittsburg Site, near Mallard Slough (Jan. 2003 through Apr. 2007)

Percentile	TDS (mg/L)	24-hour TDS (mg/L)
Max	22458	11188
95	10577	6438
90	8445	5479
75	4851	3143
50	1458	1134
25	292	199
10	152	98

1.3 Temperature

Sacramento delta water temperature as recorded at the PTS site is illustrated in **Figure 1-2**. Data are observed to vary between 43 deg F and 88 deg F throughout the year. Temperature is important with respect to membrane evaluations and it does not appear that data are specifically available for Mallard Slough water for the proposed period of pilot testing.

Figure 1-2: Temperature, Pittsburg Site (2006-2007)



2.0 Implications for the BARDP Pilot Study

Additional information is needed for key membrane design parameters (metals and physical characteristics) to assist in membrane selection and pilot system design. Additional water quality sampling of Mallard Slough water during wet and dry months will help close this data gap and provide assurance pilot configuration suitability for pretreatment as well as RO components. As a result, it is recommended to complete the following activities at up to two different seasonal periods:

1. Collect additional water quality parameters needed for the RO modeling software. Process selection will be made based on water quality data evaluation. At this time, MWH is considering several membrane options including low pressure UF/MF and high pressure RO. While, the low pressure UF/MF and high pressure RO process train provides an absolute barrier to solids, the dissolved solids removal is variable depending on which RO membrane is selected. Refer to **Table 2-1** for a list of suggested

parameters. Suggested parameters would be measured concurrently with Recommendation No. 2 below.

Table 2-1: Supplemental Water Quality Parameters, Proposed

Metals	Physical Properties	Other
Iron	Conductivity	Ammonia
Barium	Turbidity	Algae
Strontium	pH	Hardness, total
Fluoride	Temperature	Bicarbonate
Phosphate		UVA
Boron		Carbon Dioxide (calculated)
Manganese		Silica
Selenium		Carbonate Alkalinity
Aluminum		Bicarbonate Alkalinity
		Total Organic Carbon
		Dissolved Organic Carbon
		Salinity, 24 hour profile
Note: All parameters are to be measured from a sample collected at Mallard Slough at the Mallard Slough Pumping Station intake screen.		

2. Collect algae, TOC and DOC water quality data to evaluate the pretreatment alternatives. Sampling would be performed once during the dry fall and winter season and once during the Spring run-off season, beginning immediately. Sampling during these two periods would be done over a 24 hour period with samples taken during low tide and high tide.

3. Collect E.Coli, Enterocci, and HPC to evaluate pretreatment alternatives and bio-fouling potential of membranes. Sampling would be done after start-up and successful integrity testing of pretreatment systems and prior to start-up of the RO system.

4. Collect data to develop a 24 hour tidal salinity profile (one sample per hour) in Mallard Slough, beginning immediately. Data will be compared to online hourly salinity data collected automatically at DWR's PTS station in the main delta waterway. The comparison will help identify differences in tidal ranges between the local pilot plant source water intake water quality and the potential full-scale intake water quality, and will help provide an understanding of hourly tidal influences in the slough.

5. Include temperature, turbidity, and conductivity measurements when sampling any of the above recommended parameters and throughout the pilot testing period.

It should be noted that parameters essential for preliminary process evaluation and selection will be further identified and evaluated during pilot testing.

Bay Area Regional Desalination
Mallard Slough Pump Station
Water Quality Sampling

TM 3A, Feedwater Quality Characterization, recommended the collection and analysis of Mallard Slough water quality for additional parameters that have not been characterized in the known set of data. These samples were recommended to be collected during high tide and low tide, and during periods of the year when snowmelt is high (wet season) and low (dry season).

Dry season sampling was conducted in December, 2007. MWH conducted water quality sampling at the Mallard Slough Pump Station located in Pittsburg, California. High tide samples were taken the morning of December 4, 2007 at approximately 10:30 AM. At that time a multiparameter probe was installed to collect continuous data for approximately two days. The site was revisited on the morning of December 6, 2007 (at approximately 8:00 AM for additional sampling at low tide. Analytical work was performed by MWH Labs in Monrovia, California.

This memorandum transmits the results of the dry season Mallard Slough water quality sampling, including high and low tide analyses, and two-day continuous monitoring. The first seasonal rain occurred on December 4, and up to 0.2 inches of rain fell during the sampling period. It is expected that this limited rainfall did not affect tidal patterns at Mallard Slough.

Additional sampling may be conducted in the Spring of 2008 during the wet season.

High Tide Sampling

High tide water samples were collected from Mallard Slough on December 4, 2007 from the area of the slough directly below the Mallard Slough Pump Station balcony and above the Pump Station screen. Samples were retrieved using a Masterflex Industrial Process Peristaltic Pump with a Masterflex I/P Standard Pump Head, both rented from Equipco Rental Services in Concord, California. Tygon Tubing, 3/16 x 3/8, was used through the pump head, and attached to 30 feet of Teflon Tubing, 3/16 x 1/4. Both tubes were brand new and sterile. A stainless steel weight was attached to end of the Teflon tubing and lowered over the balcony sidewall to 3 ft below the water surface, and remained there for the duration of sampling. The pump was then run for 2 minutes, completely flushing the tubing.

Initial sampling began at 10:21 AM and was completed at 10:45 AM. Following installation of a multiparameter probe, at 11:37 AM, a final sample was taken for TDS analysis. There was a high tide on December 4, 2007 at 11:19 AM. All samples were collected in bottles provided by MWH Labs. Preservatives were provided in the bottles as necessary for specific samples. Samples were sent overnight to MWH Labs on December 4, 2007.

Non-metal results provided by the lab are in Tables 1. Results from the metals scan are in Table 2.

Table 1. Mallard Slough Pump Station - High Tide Lab Results (Non-Metals)

	Units	
Algae	#/ml	130
Alkalinity in $CaCO_3$	mg/l	83
Bicarb. Alk as HCO_3	mg/l	100
Carbon Dioxide, Free	mg/l	3.3
pH		7.7
Specific Conductance	mS/cm	9.43
Total Hardness as $CaCO_3$	mg/l	1000
Turbidity	NTU	5.8
Fluoride	mg/l	0.23
Flouride (dissolved)	mg/l	0.22
Orthophosphate as P	mg/l	0.07
Orthophosphate as P (dissolved)	mg/l	0.07
Silica	mg/l	16
Ammonia Nitrogen	mg/l	ND
TDS - High Tide	mg/l	5680
UVA_{254}	cm^{-1}	0.099
TOC	mg/l	1.1
DOC - High Tide	mg/l	1.5

Table 2. Mallard Slough Pump Station - High Tide Lab Results (Metals)

	Units	Total	Dissolved
Aluminum	ug/l	230	ND
Antimony	ug/l	ND	ND
Arsenic*	ug/l	2.5	3.6
Barium	ug/l	55	50
Beryllium	ug/l	ND	ND
Boron	mg/l	0.82	0.8
Cadmium	ug/l	ND	ND
Calcium	mg/l	76	74
Chromium	ug/l	4	1.1
Copper	ug/l	2.2	ND
Iron	mg/l	0.4	ND
Lead	ug/l	ND	ND
Magnesium	mg/l	200	190
Manganese	ug/l	59	48
Nickel	ug/l	ND	ND
Potassium	mg/l	62	67
Selenium*	ug/l	20	33
Silicon	mg/l	7.4	
Silver	ug/l	ND	ND
Sodium	mg/l	1700	
Strontium	mg/l	1.2	1.2
Thallium	ug/l	ND	ND
Zinc	ug/l	ND	ND

*These metals have lower total concentrations than dissolved concentrations as generally insignificant effects of laboratory procedures are more significant for metals present in lower concentrations.

Low Tide Sampling

Low tide water samples were collected from Mallard Slough on December 6, 2007 at the same location as described above for high tide sampling on December 4, 2007. The equipment, personnel, and sampling methods were consistent with the previous sampling. Initial sampling began at 8:06 AM. and was completed at 8:11 AM. There was a low tide on December 6, 2007 at 6:10 AM.

Samples were sent overnight on December 6, 2007 to MWH Labs. Results provided by the lab are in Tables 3.

Table 3. Mallard Slough Pump Station – Low Tide Lab Results

	Units	
TDS	mg/L	6700
UVA_{254}	cm^{-1}	0.098
TOC	mg/L	1.2
DOC	mg/L	1.5

Continuous Data

A YSI Model 600XLM / 650 MDS Kit Datalogging Multiparameter Probe & Flow Cell was rented from Equipco Rental Sales Services in Concord, California. Equipco calibrated the probe on December 4, 2007. All parameters on the device were selected for analysis. This included temperature, conductivity, dissolved oxygen percent, resistivity, oxidation reduction potential, pH, pHmV, dissolved oxygen charge, and dissolved oxygen concentration.

The probe was initially dropped into Mallard Slough from the Pump Station balcony sidewall at 11:05am while attached to the handheld device. A reading was taken that demonstrated that the probe was sampling properly. While the readings appeared to be reasonable, the time on the device was behind by exactly two hours. Using the handheld, the probe was then programmed to take readings every minute beginning at 9:07 am, which would have an actual start time of 11:07 am. The probe was secured over the balcony sidewall, suspended at an elevation of 5.75 ft below the current water level.

Based on the drawings for the existing Mallard Slough Pump Station, the average high tide water level is 2.6 ft above sea level, and the average low tide water level is 2.24 ft below sea level. The top of the submerged screens directly below the pump station balcony is 3.85 feet below sea level. With the probe submerged 5.75 ft, the probe is expected to have been 0.7 ft above the screen at all times, and 5.75 ft below the water level during high tide, and 0.9 ft below the water level during low tide.

The probe was removed from the slough at 8:20 AM on December 6, 2007. Data was downloaded from the probe using EcoWatch software.

A summary of the readings taken by the probe is presented in Table 4.

Table 4. Summary of Mallard Slough Pump Station Probe Data

	Units	Min	Max	Avg
Conductivity	mS/cm	7.436	8.907	8.306
Dissolved Oxygen Charge (DO Charge)		51	56	54
Dissolved Oxygen Concentration (DO Conc)	mg/L	6.51	11.56	9.63
Dissolved Oxygen Percent (DO %)	%	63.3	110.6	93.1
pH		7.18	7.68	7.44
pHmV	mV	-44.2	-16.9	-31.4
Oxidation Reduction Potential (ORP)	mV	116	222	149
Resistivity*	Kohm-cm	0.11	0.13	0.12
Salinity*	ppt	5.6	6.77	6.29
Specific Conductivity*	mS/cm	9.908	11.816	11.022
Total Dissolved Solids* (TDS)	mg/L	6440	7681	7165
Temperature	C	11.56	12.49	12.09

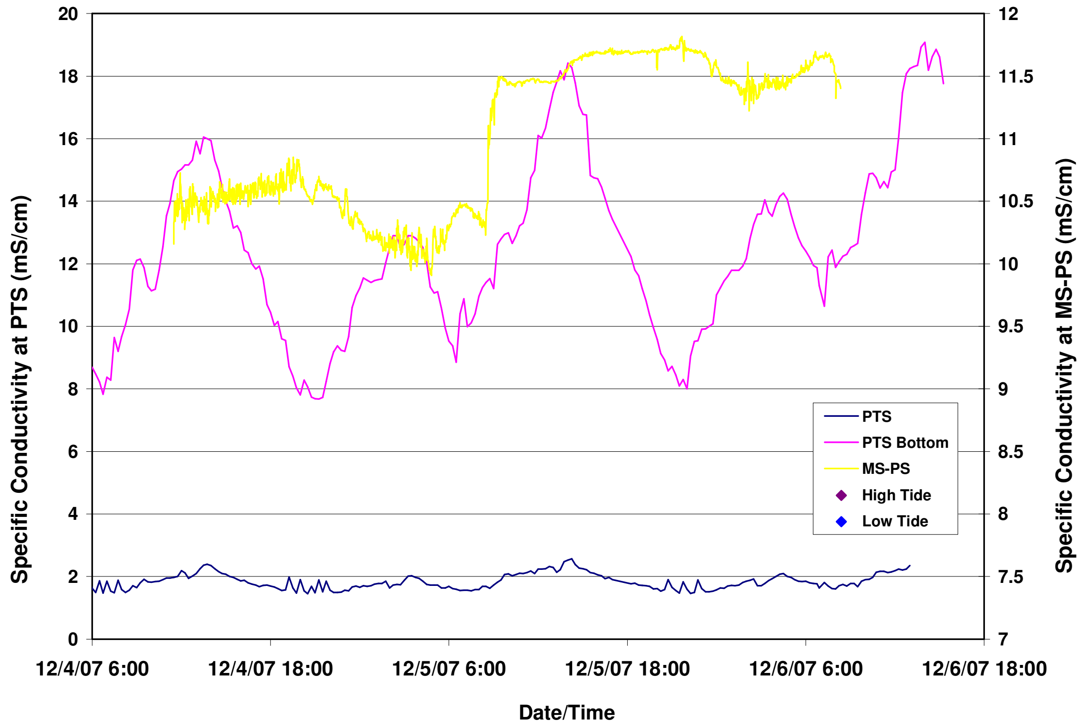
*Represents a calculated value. The probe is programmed to calculate these parameters from the measured conductivity, and they are therefore not measured directly. Specific conductivity is generated using the raw conductivity and temperature to correct to a specific conductance value compensated to 25^{o}C. Salinity is also determined using conductivity and temperature. TDS is converted directly from raw conductivity using a conversion factor of 0.65. Resistivity is converted directly from raw conductivity as it is the inverse of conductivity.

Results and Observations

Mallard Slough Pump Station Water Quality is Tidal, but Lags Behind Pittsburg Station

The continuous data collected at the Mallard Slough Pump Station (MSPS) is compared below to the data collected from the CDEC Pittsburg Station (PTS), located in the main channel of the Delta. Figure 1 compares specific conductivity at both stations, and Figure 2 compares temperatures at both stations. Both graphs indicate the high and low tides for the duration of the data.

Figure 1. Specific Conductivity Comparison
MS-PS and PTS

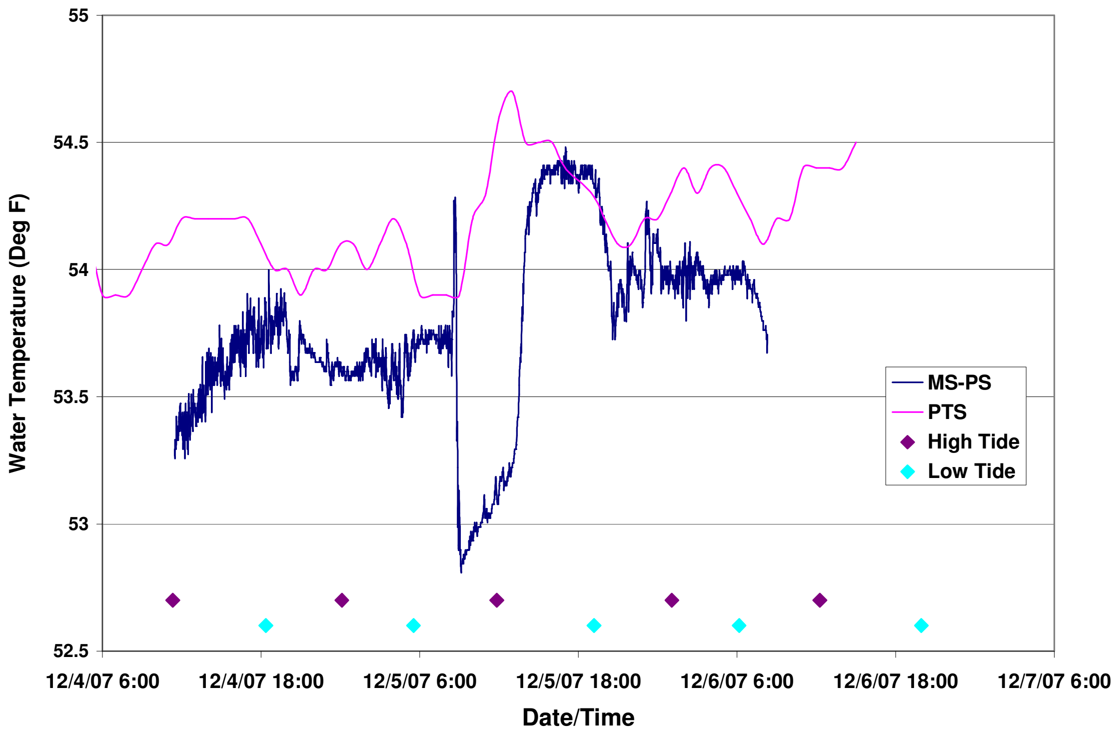


As shown in Figure 1, the specific conductivity at PTS clearly follows a tidal pattern, and roughly corresponds with the timing of high and low tide events with a lag of approximately 2 hours.

Specific conductivity at Mallard Slough Pump Station is significantly lower than specific conductivity at PTS. MS-PS specific conductivity ranged from 7.7 mS/cm to 9.9 mS/cm. PTS specific conductivity ranged from 11.8 mS/cm to 19.1 mS/cm. The specific conductivity at MS-PS follows a similar tidal pattern as at PTS, but has an overall lower salinity and a smaller magnitude of variation. Furthermore, there is a 7-hour delay from PTS to the tip of Mallard Slough where the probe was stationed. This illustrates the water quality buffering that occurs along the length of Mallard Slough when it is stagnant.

There appears to be an event around 8:00 AM on December 5, 2007 at the MS-PS that causes a sharp increase in specific conductivity. The same pattern was seen in all other parameters. The specific conductivity remains higher for the remainder of the sampling period. Specific conductivity at PTS also appears to be consistently higher following this time as well, with a less significant increase around 8:00 AM on December 5, 2007. There are no wind or storm events to explain this event. It is expected that the probe remained submerged. One possible explanation is a turnover of the shallow Mallard Slough.

Figure 2. Temperature Comparison
MS-PS and PTS



Higher temperatures are observed at PTS corresponding to high tides, demonstrating the greater influence of warmer seawater at high tide. Water temperatures at the mouth of the San Francisco Bay are typically higher than water temperatures in the Sacramento River at the Delta. Average temperatures at the Sacramento River at the Delta ranged from 45 ^{o}F to 49 ^{o}F for the duration of the sampling. Temperatures at the mouth of the San Francisco Bay averaged approximately 55 ^{o}F during that time[1]. The temperatures at MSPS and PTS exhibit the same tidal patterns and delays as salinity. There is an event around 8:00 am on December 5, 2007, that dramatically affects the temperature, as it did the specific conductivity.

Grab Samples for High Tide vs. Low Tide Are Similar

The parameters measured at MS-PS during both high tide and low tide are shown in Table 5. These values represent the measured results provided by MWH Labs, rather than the calculated values logged in the probe's data logger.

---

[1] Water temperatures at the mouth of the San Francisco Bay are reported by the National Oceanic and Atmosphere Administation (NOAA). Water temperatures of the Sacramento River at the Delta are reported by the California Data Exchange Center (CDEC).

Table 5. MS-PS - High Tide and Low Tide Comparison

	Units	High Tide	Low Tide
TDS	mg/l	5680	6700
UVA254	cm-1	0.099	0.098
TOC	mg/l	1.1	1.2
DOC	mg/l	1.5	1.5

The TDS readings were18% higher during low tide. UVA, DOC, and TOC readings were approximately the same during both tidal conditions. This limited sample set could indicate that there is lower TDS at high tide, but the results from the continuous sampling show specific conductivity (and therefore TDS) to increase during high tides, and this is consistent with the understanding that there is a greater seawater influence during high tide.

Two possible explanations are offered for the discrepancy:

1) Throughout the time frame of the high and low tide samples, specific conductivity increased overall; low tide was sampled 45 hours following the high tide samples.
2) There is a nine hour tidal lag between high water level (high tide) and Mallard Slough salinity peak (as discussed above). Therefore, high tide sampling one hour before high tide is actually ten hours before the resulting salinity peak, and low tide sampling two hours after low tide is actually seven hours before the salinity trough. The tidal results do not actually represent the peaks and troughs of the salinity tidal cycle.

Probe vs. Lab Data:

Table 6 shows results for parameters that were analyzed using both the multiparameter probe and samples collected for the labs.

Table 6. Multiparameter Probe and Lab Sample Comparison

	Units	Probe Continuous Data			Grab Samples	
		Min	Max	Avg		
Specific Conductivity	mS/cm	9.908	11.816	11.022		9.43
TDS (with 0.60 conv.)	mg/l	5969	7118	6640	High Tide	5680
					Low Tide	6700
pH		7.18	7.68	7.44		7.7

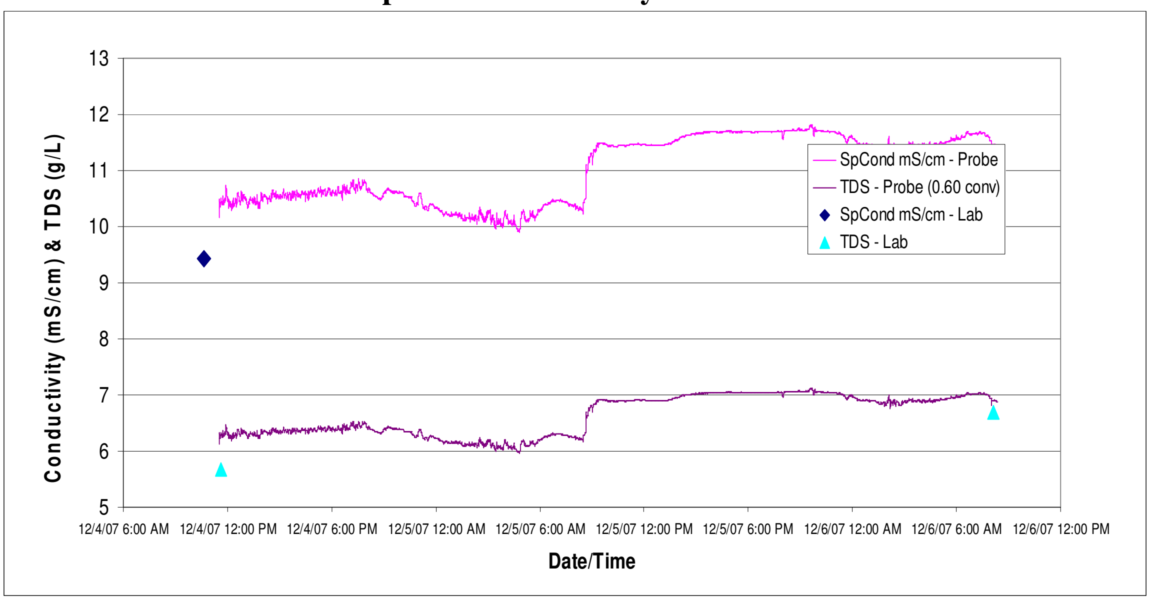
The TDS from the probe was calculated from the specific conductivity reading using a prescribed conversion factor. Therefore, TDS values from the probe's data logger cannot be directly compared to the TDS from the lab. The conversion factor used by the probe software was 0.65. Specific conductivity and TDS results from the lab indicate that 0.60

would be a more accurate conversion factor. Specific conductivity from the probe was therefore converted to TDS using the 0.60 conversion factor and those TDS values are compared to the lab results in Table 6 and Figure 3a.

The ratio between the high tide TDS values determined by the laboratory, and the specific conductance as reported by mutiparameter probe at the time of the high tide TDS sample collection, is 0.54. The corresponding ratio for low tide is 0.58. This is expected as the ratio typically increases at higher TDS concentrations such as those measured at low tide.

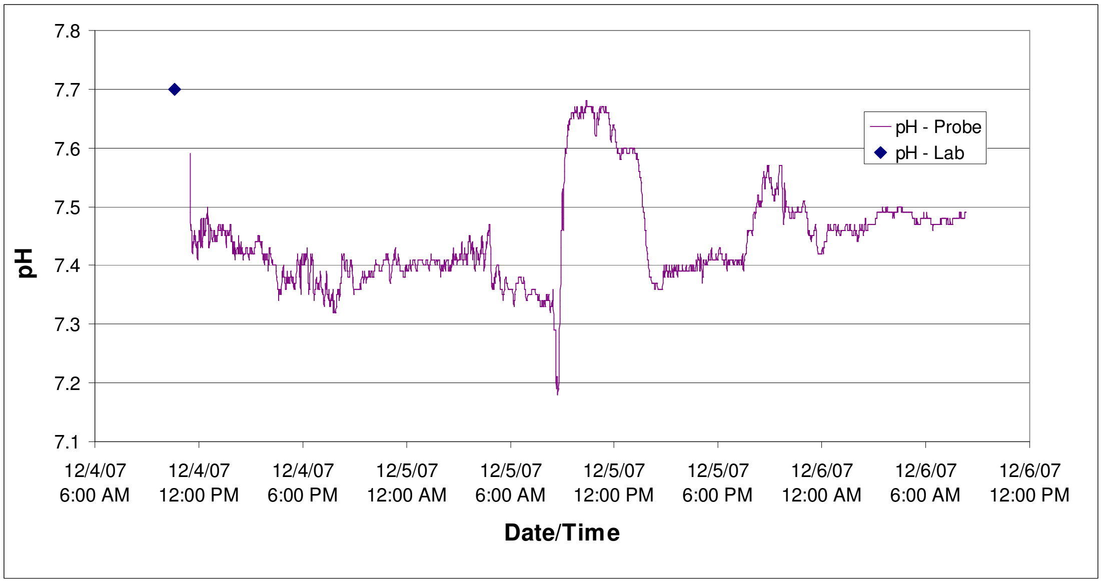
Figures 3a-3b show specific comparisons for the parameters measured both the probe and as lab samples.

Figure 3a. Multiparameter Probe and Lab Sample Comparison Specific Conductivity and TDS

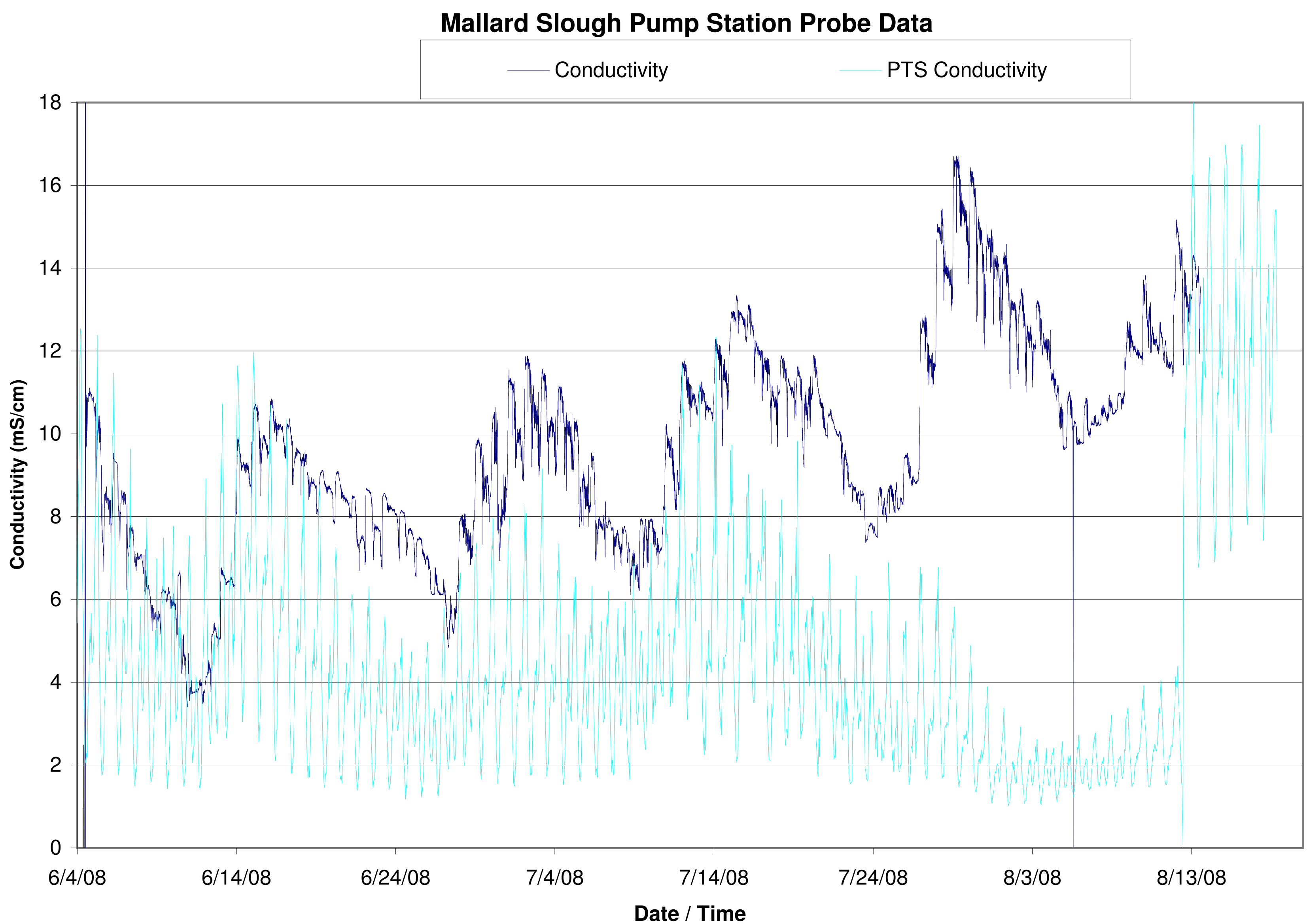


Specific conductivity and TDS were both measured slightly higher by the multiparameter probe than by the lab.

Figure 3b. Multiparameter Probe and Lab Sample Comparison pH



There is no significant variation between the pH read by the probe and that measured by the lab.


Mallard Slough Pump Station Probe Data
Conductivity
PTS Conductivity
Conductivity (mS/cm)
0
2
4
6
8
10
12
14
16
18
6/4/08
6/14/08
6/24/08
7/4/08
7/14/08
7/24/08
8/3/08
8/13/08
Date / Time

BAY AREA REGIONAL DESALINATION PROJECT
PILOT TESTING AT MALLARD SLOUGH

ATTACHMENT B
SOURCE WATER BIOLOGICAL SAMPLING AND ANALYSES

SOURCE WATER BIOLOGICAL SAMPLING AND ANALYSES

In place of a new open water intake to supply feed water to the pilot plant, existing intake and fish screens located at the Mallard Slough Pumping Station will be utilized. This sampling plan has been developed to investigate impingement and entrainment associated with this existing intake.

Entrainment and Source Water Sampling

Entrainment sampling from the pilot plant intake and source water sampling in the area of the intake will be conducted in the day and night during two seasons over a period of one year (four sampling events).

Entrainment samples will be collected downstream of the screened feed water intake to determine the number and kinds of entrained fish eggs and larvae that were not excluded by the project's intake screen.

Samples will be collected by suspending a 1-meter diameter, 505-pm mesh plankton net in the feed water pump discharge flow prior to the membrane pretreatment process. The use of the 505-pm mesh size, instead of the previously suggested 363-pm mesh, will produce standardized results that can be augmented with or compared to results from ongoing monitoring studies of Mallard Slough ichthyoplankton which have been performed for CCWD and the Interagency Ecological Program's ichthyoplankton monitoring in the river channel offshore of Mallard Slough. Both studies are conducted with 505-pm mesh plankton nets.

Total volume of water filtered and flow rate will be recorded by a flow meter installed within the water intake line, or other suitably accurate method. The flow meter readings will be used to calculate the concentration per cubic meter of the total number of various species of fish eggs and larvae collected in each entrainment sample.

The following tasks will be conducted:

1. Preserve the entire sample in formalin.
2. Sort the fish larvae and eggs from the sample contents.
3. Identify the sorted specimens to the most practical taxonomic level.
4. Dispose of preservative wastes.

Samples of the pilot plant source water will be collected and concentrations of fish eggs and larvae determined by means of a towed 0.25-meter bongo frame equipped with paired 505-pm mesh plankton nets. The bongo frame is designed to minimize larvae fish net avoidance. Readings of total volume of water filtered using calibrated flowmeters located in the center of each of the paired nets will be used to calculate the concentration per cubic meter using the total number of various species of fish eggs and larvae collected in each plankton tow sample. Source water samples will be processed in the laboratory in the same manner as the entrainment samples.

Source water sampling will be conducted four times during the study, concurrent with the intake entrainment sampling. This source water sampling will provide data to be used for the empirical transport modeling and proportional entrainment estimates.

The protocols for collecting plankton samples during the entrainment study are designed to provide useful data on vulnerability of different species and sizes of ichthyoplankton to entrainment through the pilot plant intake system. The protocols also serve to reduce damage to organisms during sampling to facilitate taxonomic identification and processing.

Evaluations

Numbers of each species entrained into the intake system during operation of the pilot plant and predicted entrainment assuming full-scale plant operations, with 95 percent confidence bounds, will be presented based on the entrainment sampling results. The results will also include the calculation of equivalent adult losses and fecundity hindcast estimates (for those species having the necessary life history information), and the empirical transport model calculations of proportional entrainment impacts to local populations. The analytical methods, assumptions, and data used in assessing entrainment impacts for both the pilot and full scale desalination plant operations will be documented in project technical memoranda.

Original project intent is for source water sampling to provide data to be used for the empirical transport modeling and proportional entrainment estimates. Findings based on the empirical transport model (ETM) calculations, however, may only be applied to the actual months of entrainment and source water sampling[1]. The ETM requires a complete sample of species annual cohort of larval production to assess the impact of proportional losses to the population. This assessment cannot be performed based on samples of the summer and fall months, particularly since this is the time of the year most species in the area of Mallard Slough have grown out the larval stage. However if there is no plan to operate the intake during any other time of the year, the proportional loss estimates based on source water and entrainment samples during these months are representative of intake impacts. These same sampling results can be used to estimate adult equivalent losses of any larvae entrained during the-summer and fall (for those species having the necessary life history information), since these estimates are independent of seasonal densities that affect ETM calculations.

Optional Services

While entrainment and source water sampling will be conducted based on two surveys in two seasons (summer and fall), monthly surveying during the pilot study might be considered by the partner agencies to enhance overall understanding of biological impacts due to Mallard Slough withdrawal.

BAY AREA REGIONAL DESALINATION PROJECT
PILOT TESTING AT MALLARD SLOUGH

ATTACHMENT C
FINISHED WATER COMPATIBILITY INVESTIGATIONS

FINISHED WATER COMPATIBILITY INVESTIGATIONS

Finished water from the BARDP must meet drinking water standards and be compatible with existing sources of supply that will be delivered with BARDP finished water. There are several specific issues that need to be considered in integrating the proposed desalinated water supply into the existing supply systems:

1. Water stabilization (corrosion control),
2. Maintenance of disinfectant stability,

Additional considerations regarding aesthetics of the finished water, TTHM and HAA formation, and potential mineral impacts on reuse are not addressed by these investigations. Such issues may be addressed in subsequent project development stages.

Bench Testing Program, General

The Bench Testing program will address several variables:

1. BARDP pilot plant product water from one source location, to be defined as RO permeate from one pilot train.
2. Current water supplies from the following sources: EBMUD Mokolumne Aqueduct and the CCWD Multipurpose Pipeline. The CCWD Canal, which contains San Joaquin River water, may be included as an optional task, but is not currently part of the test regime.
3. Tentative Post-Treatment Techniques involving three alternatives: Liquid / hydrated lime, Calcite (limestone filters /granules), and Calcium hydroxide.
4. Chemical Dose Rates involving three variable dosages and the optimum dose.

RO permeate quality will be determined from pilot plant activities and to avoid duplication of tasks. Only current supplies from the EBMUD Mokolumne Aqueduct and the CCWD Multipurpose Pipeline will be included.

Blending permeate with raw CCWD Canal water influenced by the lower quality San Joaquin River will result in double treatment (the full-scale BARDP and CCWD water treatment plants) and is not a justifiable consideration for these bench tests. Testing of raw EBMUD water (in the form of high quality Sierra Nevada Mountain Runoff contained in the Mokolumne Aqueduct), however, can be justified because of the extensive integration pipeline costs necessary to convey permeate to the EBMUD treatment plants. Blending permeate with CCWD treated water is being evaluated because it will reduce overall treatment costs.

The target blend water quality is summarized in **Table C-1**. These values will be verified with the partner agencies prior to testing.

Table C-1 Delivered Water Quality[1]							
		CCWD			EBMUD		
Parameter	unit	Avg[2]	High	Low	Avg[3]	High	Low
TDS	(mg/L)	253	449	130	101	200	38
Chloride	(mg/L)	58	128	14	7.7	13	3.8
TTHM	(mg/L)	19.6	59	5.3	38	58	21
Bromate	(mg/L)	6	15	ND	NR	NR	NR
Corrosivity	(SI)	+0.54	+1.3	-0.40	NR	NR	NR
pH		8.6	9.7	7.0	8.8	9.4	8.5
Hardness	(mg/l)	95	184	46	54	120	12

(1) Sources: Annual Water Quality Reports (2005)
(2) Average of delivered water averages for CCWD, DWD, City of Martinez, City of Antioch, City of Pittsburg.
(3) Average of finished water averaged from six water treatment plants

Bench Testing Test Plan

A Test Plan will be developed prior to initiating field activities for guiding the bench testing work, and will include the following components:

1. Testing objectives,
2. Selection of preferred post-treatment techniques,
3. Testing equipment and procedures description,
4. Bench testing program, including specific phases,
5. Sampling and monitoring,
6. Testing schedule, and
7. Participant responsibilities.

Bench Testing Approach

Bench testing will be conducted at the Mallard Slough pilot testing site and will include specific tests to address the variables outlined herein. It is expected that 6 particular test segments (Test Runs 1 through 6 for RO Train A) are required to cover the appropriate combinations of variables, shown on the matrix in Table C-2.

Analysis will not be conducted for the remaining two RO trains (RO Train B and RO Train C) since permeates from each of the three trains are anticipated to be chemically similar. Additional testing for RO Train B and RO Train C is not included in the project scope of work.

It is assumed that the bench testing will be conducted during the second half of the pilot testing schedule, tentatively scheduled to begin in November 2008 or December, 2008, to allow for pretreatment and RO process stabilization.

Table C-2
Preliminary Bench Testing Program Summary

Test Run	RO Permeate Train			Blended Supplies[1]		Post Treatment Techniques[2]			Dose Rates		
	A	B	C	EBMUD Aqueduct	CCWD Pipeline	Lime	Calcite	$CaOH_2$	1	2	3
1	x			X		x			x	x	x
2	x			X			x		x	x	x
3	x			X				x	x	x	x
4	x				X	x			x	x	x
5	x				X		x		x	x	x
6	x				X			x	x	x	x
7		x		X		x			x	x	x
8		x		X			x		x	x	x
9		x		X				x	x	x	x
10		x			X	x			x	x	x
11		x			X		x		x	x	x
12		x			X			x	x	x	x
13			x	X		x			x	x	x
14			x	X			x		x	x	x
15			x	X				x	x	x	x
16			x		X	x			x	x	x
17			x		X		x		x	x	x
18			x		X			x	x	x	x

(1) CCWD canal could be added as an optional service
(2) Subject to refinement in the Test Plan.

Post-Treatment Technical Memoranda

A technical memorandum will be prepared that summarizes the bench testing program results, and provides recommendations regarding the optimum post-treatment for the BARDP. It will be prepared initially in draft form, for inclusion in the Draft pilot plant technical memorandum. Based on review comments from the partner agencies, the technical memorandum will be revised for inclusion in the Pilot Plant Study report.

BAY AREA REGIONAL DESALINATION PROJECT
PILOT TESTING AT MALLARD SLOUGH

ATTACHMENT D
BRINE TOXICITY TESTING SUMMARY

T E C H N I C A L   M E M O R A N D U M

Bay Area Regional Desalination Project
Pilot Study at Mallard Slough

DRAFT

Subject:	**Brine Toxicity Testing Plan** **Technical Memorandum No. 1-B**		
Prepared by:	Jay Johnson, AMS Dane Hardin, AMS	**Reference:**	1481449
Reviewed by:	Dawn Guendert, MWH Charles Bromley, MWH	**Date:**	9/27/2007

The Bay Area's four largest water agencies, the Contra Costa Water District (CCWD), the East Bay Municipal Utility district (EBMUD), the San Francisco Public Utilities Commission (SFPUC), and the Santa Clara Valley Water District (SCVWD), are jointly exploring a regional desalination project that could provide the region an additional water source, diversify the area's water supply, and foster long-term regional sustainability. The Bay Area Regional Desalination project (RDP) could consist of one or more desalination facilities, with an ultimate total capacity of up to 71 million gallons per day.

Following preparation of an Initial Feasibility Study, the RDP is proceeding with testing the operation and maintenance of a joint facility on a pilot scale. The Pilot Plant Study (PPS) will be located at CCWD's Mallard Slough Pumping Plant site near Pittsburg, CA, adjacent to the San Francisco Bay Estuary at Suisun Bay. The capacity of the PPS shall be approximately 100 gpm. Water from Mallard Slough will flow through the existing intake screen at the Mallard Slough Pump Station, then undergo potential pre-screening prior to treatment by microfiltration (MF) pretreatment followed by reverse osmosis (RO) treatment to produce potable water. After testing and analysis, it is the intent of the PPS to mix the permeate and RO concentrated brine streams for subsequent discharge to a viable disposal route. The PPS will run between June 2008 and January 2009. This test period was selected to capture both wet and dry season conditions, which are anticipated to reflect extreme physical and chemical conditions of both source water and receiving water.

One of the major potential issues associated with potential full-scale desalination operations is the discharge of the RO brine, backwash and concentrated brine streams. The potential effects of brine on local organisms involve both increased concentrations of ions (e.g., salinity or total dissolved solids) as well as more concentrated contaminants from the source water (e.g., pesticides or heavy metals). The location of the proposed Bay Area Regional Desalination Project is relevant to both of these potential brine effects.

Partitioning the brine effects between salinity and contaminant effects is necessary to determine the operational solutions needed to minimize them and requires a combination of different types of toxicity tests. Furthermore, these toxicity tests must be conducted in a manner that allows the differentiation of the source of the toxicity due to salinity and/or contaminants.

1.0 Brine Toxicity Testing Approach

As outlined in 40 CFR Part 136 (Guidelines Establishing Test Procedures for the Analysis of Pollutants), chronic toxicity screening of the PPS brine discharge will occur in two tiers of testing; initial testing for determining the most sensitive species and follow-up testing for both salinity and contaminant toxicity on the species determined to be the most sensitive. However, unlike routine toxicity testing for ongoing year-round operational discharges for NPDES compliance purposes, for which 40 CFR Part 136 is principally intended, the proposed brine toxicity testing of the PPS is focused on evaluating the potential toxicity of brine effluent during extreme conditions for both the source water (wet and dry seasons) as well as for the receiving water. Therefore, repeated monthly testing of the brine for determining the most sensitive species and quarterly toxicity testing will not be conducted. Rather, testing will focus on the environmental extremes that will be encountered during potential operations and the toxicity data will be used to fine-tune water treatment processes, facility siting and potential permitting requirements. Planned toxicity test results will provide LC50 data, which will be used to determine how much additional source water may be required to dilute the brine below toxic concentrations and, in combination with any modeling that might be done, the best location for the brine discharge. Moreover, if it is found that brine effects are due either to toxicity or salinity, operations can be adjusted throughout the year, in anticipation of seasonal variation in source water characteristics.

To this purpose, the brine toxicity testing will focus on seasonal and operational extremes in both source and intended receiving waters, which typically occur during the dry and wet seasons of the year. Dry-season conditions represent highest ambient salinities, whereas wet-season conditions represent highest contaminant concentrations associated with storm runoff. Two types of testing will be performed in each season.

1.1 Tier 1 Testing

Tier I testing will consist of an initial round of survival and growth testing of the brine using the following estuarine test organisms:

- the diatom (plant), *Thallassiosira pseudonana*
- the mysid shrimp (crustacean), *Americamysis bahia*, and
- the inland silversides (vertebrate), *Menidia beryllina*.

1.2 Tier 2 Testing

Tier 2 will consist of a follow-up round of testing, in which the most sensitive species identified in the Tier 1 testing will be tested for both salinity and potential contaminant toxicity. Comparison of test results between the 'salinity' and 'brine' tests will provide information on the toxicity source. Any reductions in survival and/or growth greater than that observed in the salinity tests can be attributed to organic and inorganic contaminants in the source water that have been concentrated along with the brine salts.

1.2.1 Salinity Toxicity Testing: Following Tier 1 testing, **w**ater samples of the desalination brine will be analyzed to identify the composition of major anions and cations present. In the laboratory, artificial ”brine” will be created using de-ionized water and reagent-grade salts to duplicate the major ion composition and concentrations in the actual PPS brine. The most sensitive test organism in the Tier 1 test will be subjected to serial dilutions of the artificial brine to test for mortality and growth.

1.2.2 Brine Toxicity Testing: Concurrent with the salinity toxicity testing discussed above, the most sensitive species will be subjected to serial dilutions of the actual PPS brine discharge to test for effects on mortality and growth.

1.2.3 Reference Toxicity Testing: As an additional QA measure, a positive Control test (i.e., reference toxicant test) will be conducted concurrently with the salinity and brine toxicity testing.

1.3 Testing Protocols

All testing will be performed as described in the following US EPA toxicity testing manuals:

- *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms, First Edition* (EPA/600/R-95/136),
- *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms, Third Edition* (EPA-822-R-02-014).

1.4 Period of Testing:

Round 1: August-September 2008
Round 2: December2008-January 2009

2.0 Sample Collection

A sample of the brine discharge, representative of normal operations, will be collected from the PPS. For Tier 1 testing, this will involve the collection of one sample for the 7-day duration of the toxicity tests. For Tier 2 sampling, depending on the species being tested, either one sample will be collected and used for the entire test or collected every other day for the duration of the test. Upon collection, all samples will be stored and transported at 4˚C until delivered to the testing lab. Samples will be collected early enough in the day to allow testing to begin later the same day. Samples will be transported under chain-of-custody protocol.

3.0 Brine Test Treatments

The Lab Water Control media and the 100% brine will be used to prepare additional test treatments of 2.5%, 5%, 10%, 25%, and 50% brine.

4.0 QA/QC Measures

The toxicity testing will include standard QA/QC procedures to ensure that the test results are valid. Standard QA/QC procedures include the use of negative Lab Controls, positive Lab Controls, test replicates, and measurements of water quality during testing, as consistent with methods described in the US EPA testing guidelines The methods employed in this desalination brine testing program are detailed in standard guides and procedures maintained in the analytical laboratory.

The brine samples for the bioassay testing will be stored at ≤4°C and will be used within the established holding time period. All measurements of routine water quality characteristics will be performed as described in the Pacific EcoRisk Lab Standard Operating Procedures (SOPs). All biological testing water quality conditions will be within the appropriate limits. Laboratory instruments will be calibrated daily according to lab SOPs, and calibration data will be logged and initialed.

4.1 Negative Lab Control

The negative Lab Control will consist of clean water at the appropriate test salinity prepared using either:

- Reverse-osmosis, de-ionized water adjusted to the test salinity via addition of bioassay-grade artificial sea salts, or
- Pristine filtered natural seawater from the UC Granite Canyon Marine Laboratory, adjusted to the test salinity via addition of reverse-osmosis, de-ionized water.

4.2 Positive Lab Control

The accuracy of test organism response to toxic stress will be evaluated using positive Lab Controls (reference toxicant testing). The key test dose-response Effects Concentration (EC) point estimates determined for the test organisms will be compared to the reference toxicant test "typical response" ranges, to verify that these test species were responding to toxic stress in a typical fashion.

5.0 Routine Reporting

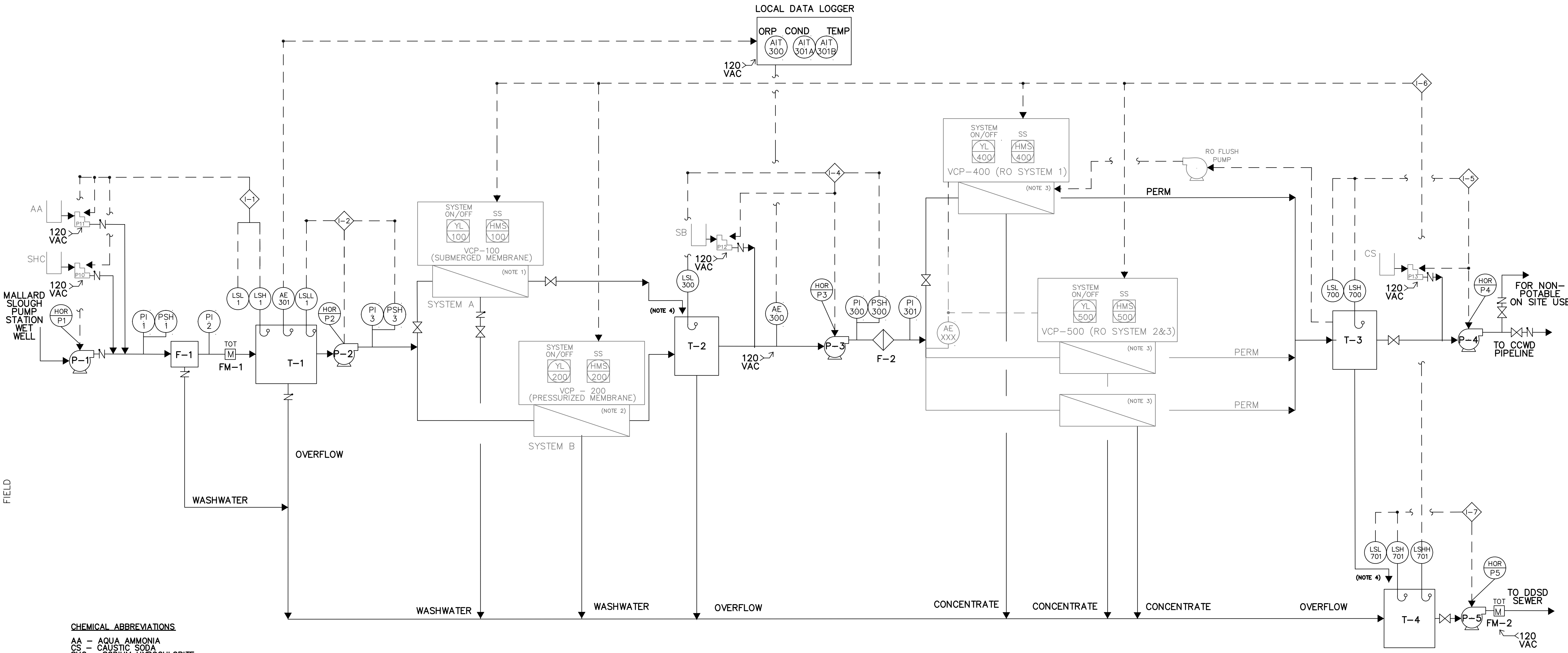
Reporting for each round of species screening testing will include the following, at a minimum, for each test.

- Sample date(s),
- Test initiation date,
- Test species,
- End point values for each dilution (e.g., number of young, growth rate, percent survival),
- No Observable Effects Concentration (NOEC) value(s) in percent brine or salinity,
- Inhibition Concentration (IC) and/or Effect Concentration (EC) point estimates [e.g., IC15, IC25, IC40, and IC50 values or EC15, EC25 ... etc.] in percent brine or salinity,
- TUc values (100/NOEC, 100/IC25, and 100/EC25),
- Mean percent mortality after 96 hours in 100% brine,
- Key EC and/or IC value(s) for reference toxicant test(s),
- Available water quality measurements (i.e., pH, D.O., temperature, conductivity, hardness, salinity, ammonia), and

- Evaluation of which of the tested species was the most sensitive

BAY AREA REGIONAL DESALINATION PROJECT
PILOT TESTING AT MALLARD SLOUGH

ATTACHMENT E
PIPING & INSTRUMENTATION DIAGRAM



CHEMICAL ABBREVIATIONS

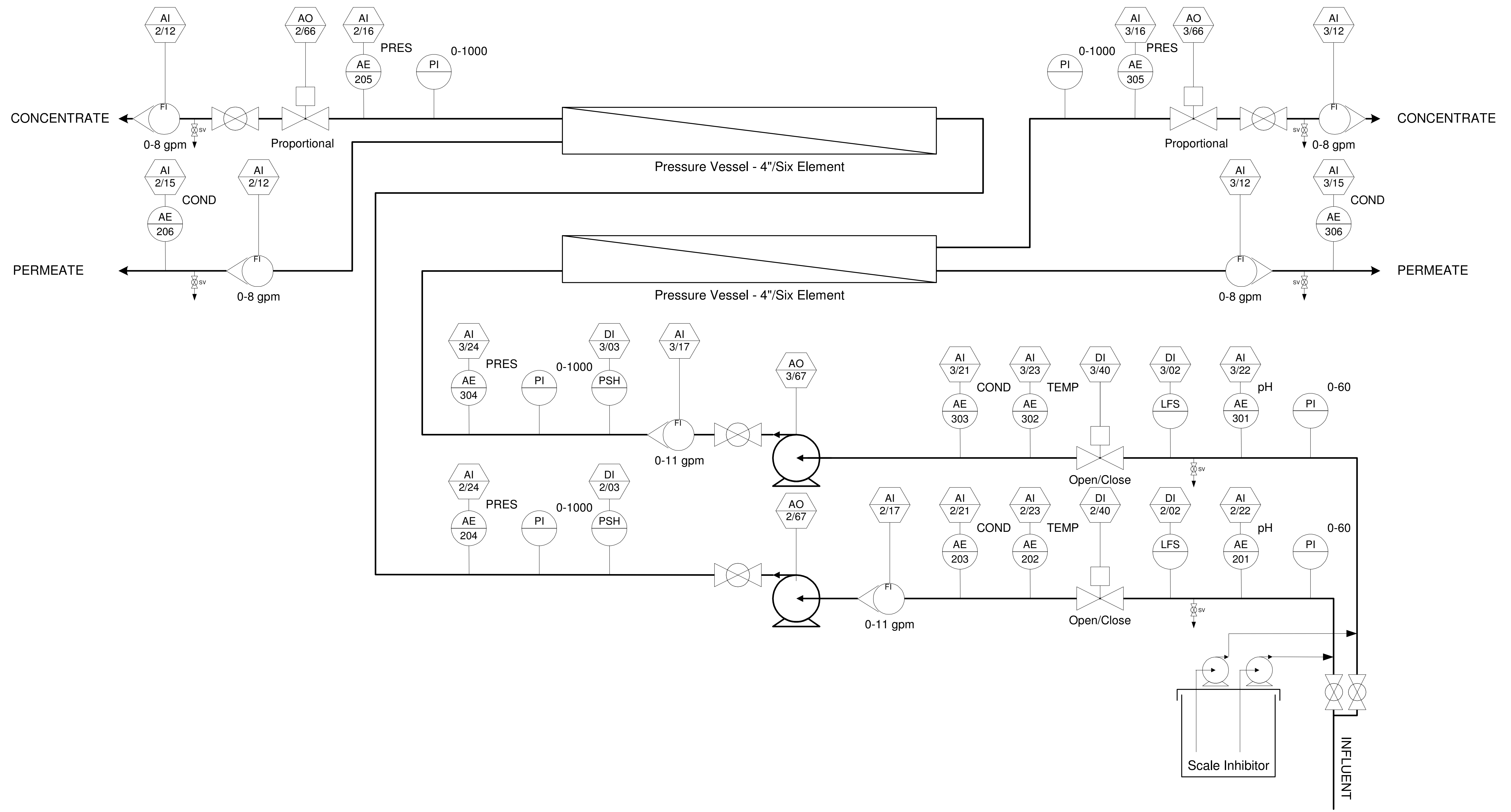
AA – AQUA AMMONIA
CS – CAUSTIC SODA
SHC – SODIUM HYPOCHLORITE
SM – SODIUM METABISULFITE

— PROVIDED BY OTHERS
N CHECK VALVE
⋈ ISOLATION VALVE

NOTES:

1. FOR SUBMERGED MEMBRANE SKID DETAILS, REFER TO SIEMENS/MEMCOR P&ID.
2. FOR PRESSURIZED MEMBRANE SKID DETAILS, REFER TO LAYNEC/NORIT P&ID.
3. FOR RO SKID DETAILS, REFER TO ENAQUA P&ID.
4. IF NO AIR GAP PROVIDED, CHECK VALVE MUST BE PROVIDED.

BARDP PILOT P&ID
REVISED 8/12/08



MWH

Project Manager:	Geno Lehman
Designer:	Eric Bruce
Drawn By:	Eric Bruce
Drawing Date:	September 2, 2008

PROCESS & INSTRUMENTATION DIAGRAM

REVERSE OSMOSIS MEMBRANE SYSTEM

TRAILER MOUNTED PILOT SYSTEM DESIGN

LEASE EQUIPMENT

CLIENT: MWH ARD

PROJECT NUMBER:

REVISION: 5

SHEET: 1