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Technical Memorandum No. 4

To: Bob Castle, MMWD
David Furukawa

From: Val Frenkel, Kennedy/Jenks
Tom Pankratz, CH2M HILL

Reviewed: Lisa Henthorne, CH2M HILL
Jim Lozier, CH2M HILL

Subject: SWRO System Objectives and Operations
MMWD Seawater Desalination Pilot Plant Program
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INTRODUCTION

Separate technical memoranda describe the preliminary performance objectives and operations for the different primary components of the MMWD Seawater Desalination Pilot Plant program. The Pilot Plant Program Technical Memoranda (TM) include:

- TM No. 1: Intake and Return Water System Objectives and Operations
- TM No. 2: MF/UF Filtration System Objectives and Operations
- TM No. 3: Conventional Treatment System Objectives and Operations
- TM No. 4: SWRO System Objectives and Operations
- TM No. 5: Solids Handling System Objectives and Operations
- TM No. 6: Water Quality Sampling and Analysis Program
- TM No. 7: Post Treatment System Objectives and Operations

This memorandum, TM-4, outlines the preliminary performance objectives and operations plan for the first pass seawater reverse osmosis (SWRO) systems for the MMWD Seawater Desalination Pilot Plant Program. The second pass RO system for the pilot plant is described in TM-7. Process and Instrumentation Diagrams (P&ID) P-5, P-6 and P-8 shows detailed schematic diagrams of the pilot plant SWRO Systems.

SEAWATER REVERSE OSMOSIS SYSTEM COMPONENTS

Two similar SWRO systems will be provided for the pilot plant. One SWRO System treats MF/UF filtrate while the other treats effluent from the conventional treatment system. Each The SWRO system includes:

- SWRO Booster Pump
- Chemical Injection and Cartridge Filtration Pretreatment
- SWRO Unit (see P&ID P-8)

- Common RO Flush Tank
- RO CIP System (see P&ID P-9)

SWRO Feed Pump

Filtered water from the MF/UF Filtrate Tank and from the GMF Filtrate Tank will be pumped to the inlet of SWRO Unit No. 1 and SWRO Unit No. 2, respectively. The SWRO Booster Pumps pump the filtrate through the cartridge filters and provide the suction head for the SWRO high pressure pumps.

Chemical Addition and Cartridge Filter

The pilot plant will have the ability to add antiscalant and acid (optional), and dispersant (optional) ahead of the cartridge filters for the SWRO units to control RO membrane scaling and fouling, respectively. The cartridge filters will protect the membranes by removing particles 5 microns and larger. Sodium Bisulfite can also be dosed down-stream of the cartridge filters to reduce any residual chlorine in the feed water.

SWRO Units

The SWRO units will to be pre-engineered units from Osmonics with minor modifications to permit testing membrane seawater RO elements from different suppliers. The SWRO units require approximately 35 gpm of feed water and will produce approximately 15 to 20 gpm of permeate at a 40 to 60-percent recovery. The average flux rates will be 10 gallons-per-square-foot-per-day (GFD).

Each SWRO train will be configured to operate with three different types (suppliers) of RO elements in a single stage/single pass configuration. The elements will be 4-inch diameter, 40-inch long, spiral wound, high rejection, thin film composite type. The proposed membrane suppliers are: 1) Dow/Filmtec; 2) Hydranautics; and 3) Toray. The following specific parameters of the RO elements will be provided once the final element selection is complete:

- element model number and serial number
- membrane material
- membrane area, ft2
- salt rejection, %
- molecular weight cutoff (MWCO), Daltons

Based on preliminary discussions with MMWD, the SWRO units are shown with energy recovery (see P&ID P-8). The energy recovery device is primarily for public outreach to help the public understand that the full-scale SWRO facility would incorporate advanced energy recovery to minimize power requirements. The energy recovery device will also help to reduce the

energy demands of the pilot plant. The energy recovery device is a turbine-type booster unit (FEDCO). Since the SWRO are non-standard units, Osmonics can supply the SWRO units with or without the energy recovery. Before we order the SWRO units, we will need direction from MMWD on whether to include the energy recovery device on the SWRO units.

RO Permeate/Flush Tank

Permeate from the RO systems will be directed to the RO Permeate/Flush Tank. The tank provides a volume of permeate water for osmotic suck back into the RO elements upon shutdown and a source of low TDS water for flushing of the SWRO systems. The tank also can provide make-up water for clean-in-place (CIP) operations for both the SWRO and MF/UF membrane systems. Excess permeate will overflow the RO Permeate/Flush Tank into the Return Water Tank.

SWRO SYSTEM OBJECTIVES

The SWRO System objectives are grouped into water treatment objectives and system performance objectives. The system performance objectives described below are general guidelines for the pilot study and will be reviewed and revised as necessary during the study. These performance objectives will help guide the conduct of the pilot study and set the performance goals for the proposed full-scale system.

Source Water Quality

The source water quality from the North San Francisco Bay will be described in more detail in Technical Memorandum No. 6. The general, expected source water quality is summarized below to assist in developing the preliminary pilot system objectives and operations plans.

Table 1: Expected North San Francisco Bay Source Water Quality

		Source Water		
Parameter	**Units**	**Average**	**Maximum**	**Minimum**
Total Dissolved Solids	mg/L	29,900	32,100	27,000
Temperature	° C	15	20	5
pH	units	8.1	8.0	8.2

SWRO System Water Treatment Objectives

The general water treatment objectives for the first pass SWRO system will be to verify the water quality projections of the three tested membrane elements to confirm that these projections can be used for full-scale design. Additional treatment of the first pass SWRO permeate water with a second pass RO system is discussed in TM No. 7, Post Treatment Systems.

SWRO System Performance Objectives

The SWRO System performance objectives include:

- Compare performance of different membrane types (permeate quality and stability, fouling rate, cleaning efficiency)
- Assess differences in rate of change of RO performance parameters depending on the type of pretreatment: MF/UF and conventional pretreatment
- Determine need for and dose requirements of pretreatment chemicals (antiscalant, acid and dispersant)
- Compare cartridge filter replacement rate treating conventional and MF/UF filtrate
- Optimize SWRO flux rate versus cleaning frequency (for each pretreated water)
- Determine optimum between recovery, permeate quality and energy consumption
- Determine need for second pass (brackish) RO treatment to meet water quality objectives (this is discussed further in TM-7).

PROPOSED SWRO SYSTEM OPERATIONS PLAN

The following SWRO operational parameters will be monitored during the course of the pilot study:

- Feed, concentrate and permeate pressure for each individual pressure vessel/membrane type
- Bconcentrate and permeate flow for each individual pressure vessel/membrane type
- Feed conductivity, temperature, ORP and pH
- Concentrate and permeate conductivity for each individual pressure vessel/membrane type
- Cartridge filter inlet and outlet pressures (differential pressure)

The following performance parameters will be calculated and monitored during the course of the pilot study:

- Differential pressure of each individual pressure vessel/membrane type
- Membrane flux rate and water recovery
- Salt rejection (based on conductivity)
- Normalized product flow
- Normalized salt passage
- Pressure drop coefficient
- Cartridge filter replacement frequency
- Membrane cleaning frequency

Water Sampling and Analysis Plan

The water sampling and analysis for the pilot plant program will be described in more detail in Technical Memorandum No. 6. The following water quality parameters will be monitored and analyzed as part of the evaluation of the SWRO system based on–line instrumentation and periodic collection of grab samples.

- SWRO Feed Water On-line Instruments: Conductivity, Temperature, ORP (shutdown signal only)
- SWRO Feed Water grab samples: Turbidity, TOC, UV-254, EFS, SDI, Conductivity, pH, TDS
- Permeate On-line Instruments: Conductivity
- Combined Permeate grab samples: TOC, UV-254, TDS, pH
- Individual RO element permeate grab samples: Conductivity
- Combined concentrate grab samples: Conductivity, pH, TDS

Preliminary Operations Plan

It is critical to the successful long-term operation of the SWRO system that the pre-treatment units first be commissioned and optimized to produce a consistent and high quality feedwater prior to initiating SWRO operation. The standards established in this testing for SWRO feedwater quality are:

i. SDI value <4.0 (target of <3.0)

ii. Turbidity value <1.0 NTU (target of <0.2 NTU)

Once we are confident that the pretreated water meets the standards indicated above, the SWRO elements will be installed in each respective SWRO unit and the SWRO system commissioned.

We will begin SWRO train operation with the system at 45% recovery with antiscalant addition only. The system control variables are shown below:

SWRO System Control Variables

Variable	Initial Variable Range
Pretreatment	
Antiscalant	4 ppm
Dispersant (Optional)	None
Acid (H_2SO_4) (Optional)	None
Sodium Bisulfite	1-2 ppm

Variable	Initial Variable Range
SWRO	
Membrane manufacturer	Dow/FilmTec, Hydranautics and Toray
RO recovery	40 - 60 percent
RO flux rates	10 GFD
Cleaning regime and frequency	Citric Acid, sodium hydroxide

To objectively compare the performance of different membrane element types (from the three suppliers), each supplier's elements will be installed in separate and parallel six-membrane element (6M) pressure vessel (two 3M vessels in series) and operated at equivalent flux and recovery. Each vessel will be equipped with a manual feed and concentrate valve, feed and permeate flow meters, feed pressure gauges. The overall system also has a common gauge for measuring differential pressure between the feed and concentrate. A common concentrate and permeate flow meter are used for overall system control. Flux and recovery of each membrane type will be adjusted on a daily basis to setpoints by adjustment of feed and concentrate valves based on the total area of each supplier's membrane elements.

Membrane cleanings will be performed when changes in one or more of the following performance parameters reach the following thresholds:

- Normalized product flow – 15% decrease
- Normalized salt passage – 30% increase
- Pressure drop coefficient – 30% increase

SWRO Concentrate

Concentrate from the SWRO units will be sent to the Return Water Tank where it will be blended with the permeate and flows from other unit processes (see PID 7) and pumped back to the bay. Analyses to be performed on the concentrate in addition to that listed above is discussed in more detail in TM No. 6.

CIP Operations

Periodic Clean-In-Place (CIP) operations will be conducted to restore losses in performance of the SWRO membrane elements due to fouling or scaling. The spent CIP cleaning solutions will be neutralized, sent to the Spent Washwater Tank and pumped at a controlled rate to the sanitary sewer.

TM No. 4 Document Review History:

1. Lisa Henthorne first Draft review completed 11/4/04.
2. Tom Pankratz and Todd Reynolds reviewed first Draft 11/5/04 and incorporated Lisa's comments. Phone discussion with Jim Lozier.
3. Todd Reynolds prepared Final Draft (dated 11/9/04).
4. Jim Lozier reviewed Final Draft on 11/23/04.
5. Todd Reynolds and Val Frenkel incorporated comments 12/20/04.
6. Jim Lozier reviewed in conference call 12/22/04.

cc: Joel Faller
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