

RECLAMATION

Managing Water in the West

Desalination and Water Purification Research and Development
Report No. 117

Microfiltration/Reverse Osmosis Ocean Water Desalination Pilot Plant Project

Submitted by:

West Basin Municipal Water District
17140 Avalon Blvd.
Carson, CA 90746-1296



West Basin Municipal Water District

Agreement No. 05-FC-81-0838

Executive Summary

West Basin Municipal Water District (WBMWD) conducted an ocean water desalination pilot study at the El Segundo Power Facility in El Segundo, CA. The study was very successful, meeting its objectives and providing a body of data not previously available. The study investigated the use of microfiltration (MF) and ultrafiltration (UF) membrane processes as pretreatment to reverse osmosis (RO). The objectives of the study were to evaluate and optimize the performance of MF, UF and RO operating parameters on power plant intake water as well as warmer power plant post-condenser effluent water, and to expose the project to the variability of the ocean itself. The research indicates that these membranes will work effectively at the full scale level with the information and experience gained from this pilot project. The long time frame of the testing provides confidence in the results.

The study began in 2002, and was separated into two phases of testing, Phase A and Phase B. Phase A testing occurred from June 2002 to June 2004 and Phase B from July 2004 through September 2007.

Phase A was an evaluation of MF and RO performance, establishing operating parameters such as MF backwash frequency and membrane flux rates on power plant intake water. Phase A testing showed that the Siemens CMF-S MF system provides excellent quality filtrate to be used as a feed to RO, and that the use of chlorine in the MF backwash was beneficial to keeping fouling of the MF under control. Permeate water produced by the RO membranes was consistently of high quality, with TDS generally less than 300 mg/l and boron concentrations between 0.6 and 1 mg/l.

Phase B was separated into three different sub-phases as follows:

- Phase B1 evaluated four “next-generation” or recently developed RO membranes on microfiltered power plant influent water. These recently developed membranes had the highest boron rejection available.
- Phase B2 evaluated MF and next generation RO membranes on power plant effluent and the Zenon UF System on power plant influent.
- Phase B3 identified two of the four next generation RO membranes for longer-term testing and evaluated all systems on power plant effluent.

Phase B demonstrated that the optimized Phase A MF operating parameters on influent water were unchanged on the warmer effluent water source. Both the MF and UF produced excellent quality filtrate for use as RO feedwater. No differences in RO fouling were observed that could be attributed to differences in filtrate quality between the MF and UF processes.

Operating the RO systems at the elevated temperatures of the effluent stream did result in lower RO feed pressure requirements, but also resulted in higher permeate concentrations of TDS, boron and other constituents, as expected. The RO systems were also affected by biofouling to a greater extent on the warmer effluent water than on the colder influent water.

The MF, UF and RO systems operated through several algal bloom events (Red Tides) during the course of Phase B testing. Periodic testing for algal toxin domoic acid indicated no detection in any RO permeate samples, despite elevated concentrations in feedwater as a result of the Red Tide events. The ocean water contained domoic acid levels as high as 2 to 3 $\mu\text{g/L}$ during red tide events yet the RO permeate levels were consistently below the detection limit of 0.002 $\mu\text{g/L}$. This demonstrated the RO treatment process to be an excellent barrier to this constituent. However, the MF and UF systems did experience loss of permeability during the more severe algal blooms, which temporarily impacted their filtration capacity.

Data was collected on the "next generation" RO membranes which indicated improved performance (lower permeate concentrations of key constituents) over the previous versions tested in Phase A. Each of the "new-generation" RO membranes tested demonstrated the capability of providing permeate water less than 200 mg/L total dissolved solids (TDS) across the power plant influent water temperature range and less than 300 mg/L across the power plant effluent temperature range. Additionally differences were noted in salt rejection performance among the new membranes that provide options to achieve lower chloride or boron concentrations. For example, both the Hydranautics SWC4+ and Dow SWHRLE4040 membranes provided excellent boron rejection, with permeate water levels typically less than 0.7 mg/L. However, SWC4+ produced a permeate water with less than 50 mg/L chloride ion, substantially less than the Dow membrane.

From environmental, financial, operational and other aspects the pilot testing provided a wealth of data and information to support and provide confidence in the implementation of full scale ocean water desalination.