Collaborating to conserve, protect and create reliable water resources

City of Santa Cruz Water Department – Soquel Creek Water District

November 2008

scwd² Reverse Osmosis Seawater Desalination Pilot Test Program Update

Preliminary Pilot Testing Results and Key Findings

March – September 2008

In March 2008, the City of Santa Cruz Water Department and Soquel Creek Water District officially began seawater reverse osmosis (SWRO) desalination pilot testing at the scwd² Pilot Test Plant at UCSC's Long Marine Lab. A minimum of 12 months of testing is being conducted to evaluate the best and most cost-efficient desalination technologies. The pilot testing provides water quality data, as required by the California Department of Public Health (CDPH), to evaluate issues related to public safety, environmental protection and plant operations for the potential full-scale project. Each plant requires its own pilot testing to determine site-specific treatment guidelines to ensure public safety. The water produced from this pilot study is for testing purposes only and not served to the public for drinking.

The 12 months of testing will provide a full range of performance information that can be used to plan for the potential full-scale seawater desalination facility. During the first six months of testing (March-September 2008), the ocean water quality was very good due to a lack of major storm events or algae blooms (i.e., red tides). While this high quality of water is optimal for treatment processes, in order to fully test the plant's process, less-than-optimal water quality conditions are required. It is anticipated that the next six months will include a red-tide event (as is typical in winter months) and wintertime storms. Pilot testing includes the following investigations:

- **Pretreatment Technology Comparison**
- **Reverse Osmosis Technology Performance Evaluation**
- **Water Quality Testing**
  - o Boron Rejection
  - o CDPH and EPA Water Quality Standards
  - o Algal Toxins (Red-tide Events)
  - o Disinfection By-products Formation
  - o Distribution System Water Quality and Corrosion Control
- **Salty Water Concentrate Disposal**
- **Operation and Equipment Performance Investigations**
  - o New on-line method to test RO Membrane Integrity

Pretreatment Technology Comparison

The four pretreatment processes tested at the pilot plant are slow sand filtration, conventional treatment using granular media filters, pressurized ultrafiltration (UF) filters and submerged UF filters. Pretreatment is necessary to remove organic matter and particulates that can damage the desalination RO equipment.

Each pretreatment alternative has different implications in terms of life-cycle costs, energy consumption, land requirements, chemical use, and reliability to handle challenging variations in seawater quality. Selecting the right treatment technique is important to design a full-scale desalination facility that will reliably deliver water at the lowest possible cost. Key parameters for the comparison include chemicals used, energy and maintenance requirements, and production capacity.

Coagulant addition, mixing and settling is a pretreatment process that reduces the amount of turbidity, or cloudiness caused by floating particles, in the ocean water. With coagulant addition, mixing and settling, ocean turbidity is reduced from 1-7 NTU to 0.5-2 NTU. NTU (Nephelolometric Turbidity Units) is a measurement of the amount of suspended particles in water. It is also critical to monitor the characteristics of the raw ocean water entering the treatment facility. The Silt Density Index (SDI) is a measurement taken to determine the amount of particulate in raw ocean water to calculate and monitor the fouling potential of the filter. See the Pretreatment Process Testing Results figure below for details.

Pressurized ultrafiltration membrane system

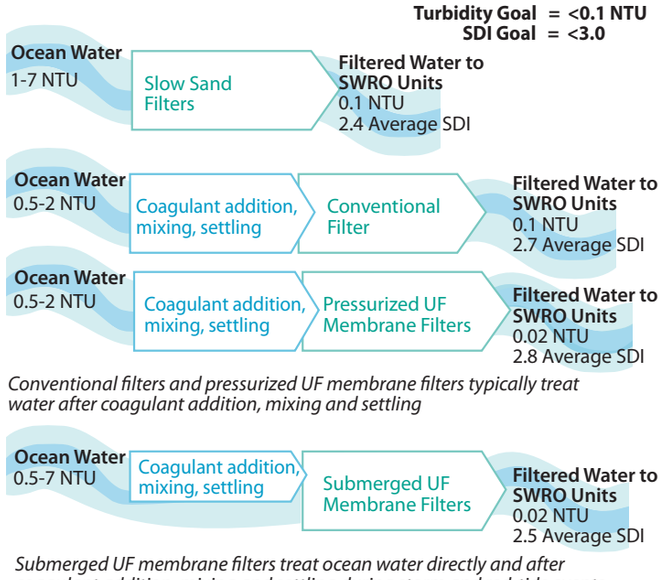
Results To Date: The four pretreatment systems have been performing well in effectively clarifying the seawater and removing suspended solids and other foulants. All of the pretreatment processes have consistently produced filtered water that has met the goals for pretreated water quality.

Additional testing information during red-tide episodes and wintertime storms is needed before a decision can be made regarding which treatment technique is optimal for the potential scwd² full-scale desalination project.

Reverse Osmosis Technology Performance

Reverse osmosis (RO) membranes remove dissolved solids (salts) from water through a pressure-driven process. Side-by-side reverse osmosis

Pretreatment Process Testing Results for March-September 2008



Conventional filters and pressurized UF membrane filters typically treat water after coagulant addition, mixing and settling

Submerged UF membrane filters treat ocean water directly and after coagulant addition, mixing and settling during storm and red-tide events

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performance testing has evaluated four commercially available seawater reverse osmosis (SWRO) desalination membranes. The primary objectives of the RO performance evaluation are to determine the energy requirements, cleaning intervals, and to verify salt rejection of each RO membrane tested during the pilot study.

Reverse osmosis system

Results To Date: The desalination process at the pilot plant has reliably produced water that meets CDPH water quality standards. Testing is now focused on evaluating different flow (flux) rates and feed pressures for the SWRO membranes to optimize performance and energy usage. Also to be tested are a partial second pass RO membrane configuration to enhance boron removal and an innovative two-stage brackish water RO and seawater RO membrane configuration to potentially reduce energy consumption.

Water Quality Testing

Ensuring that desalinated water is safe and meets drinking water health standards set by USEPA and CDPH is a critical part of the pilot testing. The pilot plant study includes water quality testing for over 150 constituents, including many that are required for surface and groundwater sources. This includes testing for contaminants such as arsenic, mercury and iron. With ocean water as the source of freshwater, the removal and rejection of boron, algae species and algal toxins are also being tested during the pilot program.

Testing at the scwd² Pilot Plant

Results To Date: During the initial six months of testing, the ocean water off Santa Cruz has had low levels of suspended solids and organics levels, typical of summertime conditions. It is anticipated that the next six months of testing will include red-tide events and wintertime storms that will increase organics and suspended solids in the ocean source water. With a full year of testing results, the pilot plant program will provide a full-range of performance information that can be used to plan for the potential full-scale seawater desalination facility.

Preliminary water quality results for boron rejection, CDPH and EPA water qualitry standards and algal toxins are:

Boron Rejection: Boron is a naturally occurring element found in all oceans. The key objective of the boron rejection investigation is to identify the optimal RO membrane configuration that efficiently reduces boron to comply with California's goal of 1mg/L for drinking water. To date, the pilot plant has demonstrated that RO membranes remove boron. In the coming months, projections on RO membrane lifespan, pH, and temperature will be evaluated to ensure that the boron goal of 1mg/L can be continuously achieved for a full-scale plant.

CDPH and EPA Water Quality Standards: The RO membrane technology tested at the pilot plant has shown to effectively produce potable water that meets all federal (EPA) and state (CDPH) drinking water standards. A Watershed Sanitary Survey is concurrently being conducted to identify all potential contaminant sources, including chemical and biological, that the SWRO process will need to remove during pilot testing.

Algal Toxins (Red-tide Events): Periodic blooms of algae are a natural phenomenon that occurs in marine and freshwater bodies throughout the world, including the Monterey Bay. Although many blooms are merely an aesthetic nuisance, some species of algae create toxins in the water. So far, a red tide has not occurred while the pilot plant has been in operation. It is anticipated that the next six months of testing will include red-tide events and wintertime storms. The pilot plant will study the ability of the treatment processes to handle a red- tide event.

Red Tide event in Australia

Salty Water Concentrate Disposal – Testing to begin November 2008

Seawater RO membranes can effectively remove 99.5 percent of the salt in seawater to create drinking water. However, only about 50 percent of the seawater processed by the RO membranes is turned into drinking water. The other 50 percent of the seawater contains the salt removed by the RO membranes, and is called the RO concentrate. To ensure that a full-scale desalination plant would not adversely impact the local ocean ecosystems, evaluation for the disposal of the concentrate will be conducted. If a full-scale SWRO desalination facility is built, the proposed plan would pipe the RO concentrate to the City's wastewater treatment plant (WWTP), combine it with the WWTP-treated water, and discharge it into the ocean through an approximately 12,000-foot-long outfall pipe. The investigation will characterize the impact of potential blends of RO concentrate and WWTP-treated water to verify that it is non-toxic to marine organisms.

Operation and Equipment Performance Investigations

The pilot study is also conducting other investigations which include:

New On-line Method to Test RO Membrane Integrity: Testing will be used to help develop a new on-line method to monitor integrity and functionality of RO membranes to ensure that salt and other impurities are effectively monitored and removed by the desalination process. In the final month of the program, an RO membrane will be deliberately breached with a dye to determine if it is measured accurately.

Disinfection By-products Formation: The objective of this investigation is to confirm that adding chlorine to desalinated seawater will not create disinfection by-products that exceed drinking water regulations. Testing began in October 2008.

Distribution System Water Quality and Corrosion Control: This investigation will evaluate post treating the desalinated water to (1) enhance taste so it is consistent to existing water and (2) control/minimize its potential for corrosion of existing pipelines. Tests began in September 2008 and it is too soon to draw any conclusions.