

# From macroscale to nanoscale: USF assists the City of Dunedin to optimize its reverse osmosis membrane water treatment plant

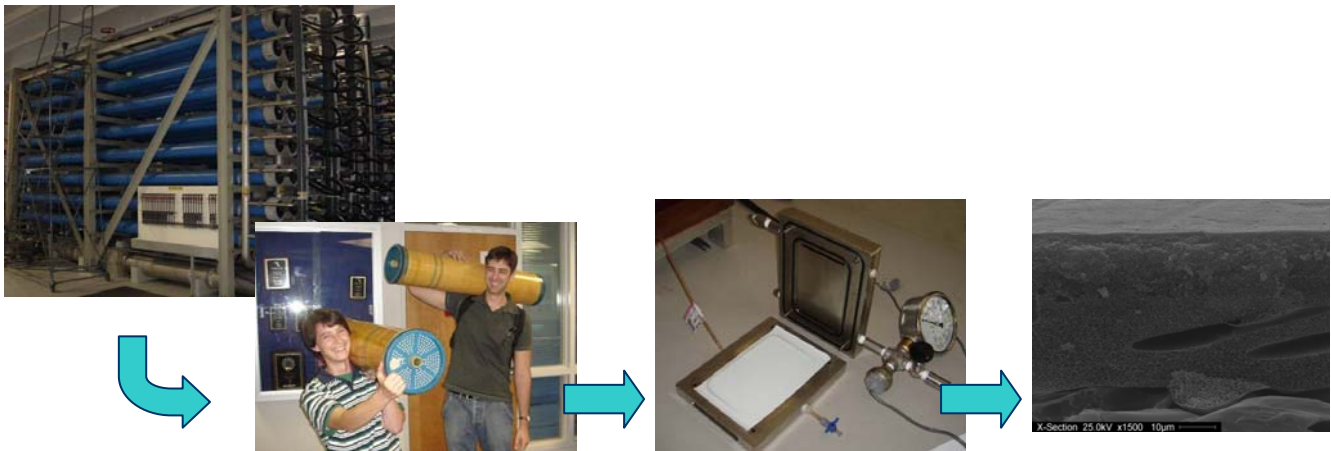
By Dr. Daniel Yeh

Located in Pinellas County on the Florida gulf coast, the City of Dunedin is a municipality of approximately 40,000 residents. To provide ample and high quality drinking water to its residents, the City owns and operates a 9.5 million gallon per day (MGD) reverse osmosis (RO) membrane filtration facility which draws the source water from an aquifer. Reverse osmosis is a technology which uses engineered thin polymeric films, operated under pressure, to extract high purity water from brackish or saline water. In fact, this is the same technology currently used by Tampa Bay Water for seawater desalination to augment the Region's water supplies. Worldwide, RO technology receives tremendous commercial interests and widespread application to meet the growing global demand for freshwater.

Although RO was first developed about 40 years ago and significant advances in the technology have occurred over the years, two problems continue to challenge manufacturers and researchers alike: energy consumption and membrane fouling. RO systems operate under high pressure (several hundred psi) to overcome the osmotic pressure associated with high ionic strength water; hence, the saltier the feed water the more pressure is required for operation. In view of the current state of energy, there is great interest in developing systems that can operate under lower pressure. Fouling is the accumulation of undesirable materials (e.g., mineral scalants, colloidal organic matter or biofilm) on the membrane surface which decreases the performance of the membrane, increases operational costs (due to higher energy and frequent cleaning) and decreases the lifetime of the membrane. Naturally, there is a quest in the industry for the ultimate non-fouling membranes. Until then, the reality is that all existing membranes will foul. The question is: what can be done to manage and mitigate the fouling and decrease the reliance on cleaning.

Membrane cleaning is a multi-part process done in-place within the production skid. It is not unusual for cleaning to span several days, involve a series of chemicals. Aside from loss of water production during cleaning and the time demand on operators, there is also the issue of cleaning chemical disposal. Further, over-cleaning will shorten the life expectancy for membranes. Hence, there is great interest to optimize the cleaning process. During the summer of 2006, a project was initiated for USF to investigate improved cleaning strategies for Dunedin and how it may ultimately extend the lifetime of the membrane, thereby saving the City money. The project involves macroscale system performance testing and nanoscale membrane characterization and foulant analysis. The investigators on the project are CEE professors **Daniel Yeh** and **Jeff Cunningham** and Prof. **Don Duke** from Environmental Science & Policy. Working on the project are ESP master student **Josh Goldman** and CEE PhD student **Russell Ferlita**. Josh interned for the City during the summer of 2006 and is investigating the cleaning evaluations for his MS thesis.

The relationship between CEE and the City of Dunedin goes back many years. **Dr. Bob Carnahan**, former Assoc. Dean of Research at the College of Engineering who recently retired from the CEE Department, assisted the plant in its early years on its design and troubleshooting. Dr. Carnahan played an important role in helping to initiate the current project with the City.



Multi-scale analysis of the water treatment reverse osmosis system at Dunedin, FL: (l-r) production skid, single elements, flat sheet testing, SEM cross section image of RO membrane. The students are Josh Goldman (l) and Russell Ferlita (r).

USF is a member of the National Water Research Institute's *National Centers of Water Treatment Technologies*, a consortium of research and testing institutes. For the Dunedin Project, USF received assistance from two Center partners: the Bureau of Reclamation's Water Quality and Improvement Center in Yuma, AZ and the Orange County Water District in California. Yuma assisted in providing a difficult-to-obtain single element pressure vessel for membrane testing, while OCWD, widely-regarded as one of the world's premier authorities in membrane characterization and analysis, assisted in the initial membrane autopsy. Membrane autopsy is the post-mortem analysis of membrane to determine the cause of failure, for the purpose of preventing further failures. Autopsies involve a variety of physical, chemical and microbial techniques including advanced instrumentation and nanoscale characterization. Last Fall, Yeh, Ferlita and Goldman visited OCWD to observe the membrane autopsy and received valuable pointers from OCWD researchers.



USF has just submitted a proposal to the City for a long-term study to optimize its RO system. As part of his doctoral research, Russell Ferlita will be studying the chemical and biological ecology of membrane fouling and devising innovative approaches to control fouling. Through future external funding, additional USF researchers from a variety of disciplines and industrial collaborators may be involved on the project from different angles.

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