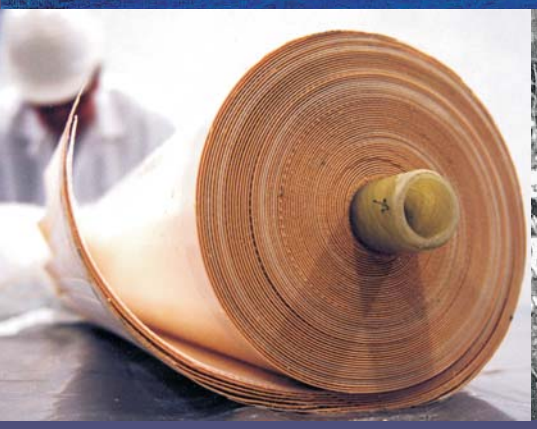
RECLAMATION

Managing Water in the West

Water Quality Improvement Center

Advanced Water Treatment Research 2007



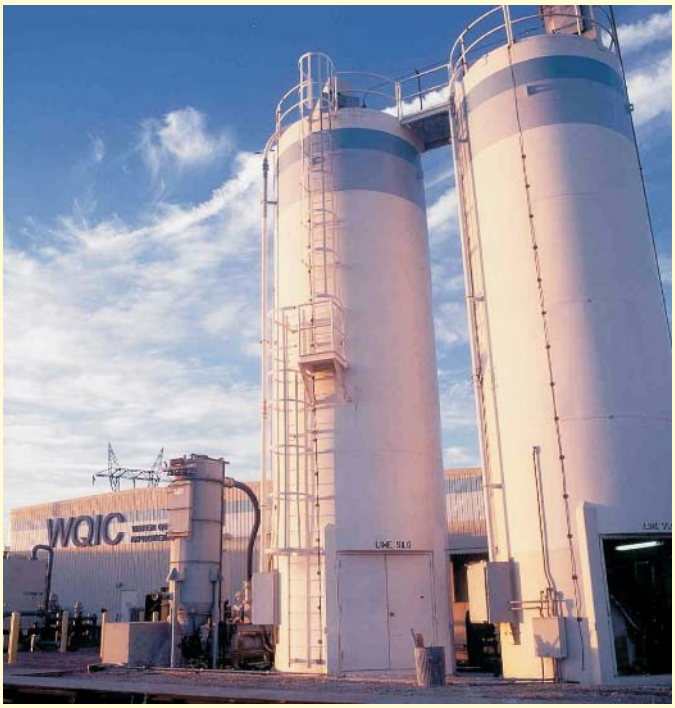
A profile of the in-house and partnered research conducted on brackish groundwater and Colorado River water at the Bureau of Reclamation's Water Quality Improvement Center, for the year beginning October 1, 2006.

U.S. Department of the Interior
Bureau of Reclamation

Our Mission

Ensure Tomorrow's Water Supply by Pioneering New Technologies

Exploring Ways to Reduce the Cost and Improve the Efficiency of Treating Water



The Water Quality Improvement Center helps increase usable water supplies by pioneering technologies and processes to improve water quality and make impaired water usable.

Drought Has Affected Western Water Supplies

More than 20 million people in Arizona, California, Nevada, and Northern Mexico depend on Colorado River water delivered by the Bureau of Reclamation through publically-funded dams and distribution systems. Water delivered grows our nation's crops, supplies our cities and rural communities, serves our industries, provides recreational opportunities, and sustains plants and animals.

For the last six-to-nine years, the Colorado River basin has suffered a drought that affects both water quantity and water quality. As of the end of calendar year 2004, Lakes Powell and Mead, the primary storage reservoirs for the lower Colorado, were 37% and 43% full, respectively. Some states (Nevada, Colorado) have already imposed mandatory water conservation measures; others (Arizona) are considering them.

No one can predict when the drought will end, but even when it does, water supply and quality issues will still remain.

Water quality is key to water availability - if a water is naturally low-quality (high in minerals, for example) or has been impaired by industrial or municipal use (for example, sewage effluent or plant wastewater), it would be re-usable for potable purposes **only** if extensively treated. The "recycled" water would increase the overall supply available for drinking, bathing, etc. However, treating low-quality water increases the overall cost of the water, and in many places in the U.S., this additional treatment is not economical.

That's where water treatment research comes in.

Water Research Identifies New Ways to Increase Water Availability

Research develops technologies and methods to economically improve water quality. Applying these water quality solutions makes more water available for use (agricultural, municipal, or environmental) in the U.S. and Mexico. Technology developed through research is also used to treat agricultural drainage for return or reuse. This gives Reclamation more options to manage groundwater.

WQIC research staff pursue two goals:

- identify processes and technologies to reduce the cost of operating the Yuma Desalting Plant (a 73 million-gallon-per-day, reverse osmosis desalting plant; the site of the WQIC);
- identify technologies and processes to advance the state of water treatment technology, and reduce the costs to treat impaired waters.

WQIC water sources include custom-mixed formulations, lower-stem Colorado River water and local brackish groundwater.

Water Research at the Water Quality Improvement Center

In-House Projects

(Authorized under Colorado River Basin Salinity Control Act, Title I)

Yuma Desalting Plant: Our Primary Focus

The Yuma Desalting Plant was constructed to salvage salty agricultural drainage water and return it to the Colorado River, saving water that would otherwise need to be released from Hoover Dam for delivery to Mexico. The water saved is used in communities like Los Angeles, San Diego, Phoenix, Tucson, and many small towns adjacent to the River.

Program Management & Development

Title I Salinity Control (TISC) Program Management and Water Quality Improvement Center (WQIC) Efficiency

The purpose of the TISC Program is to find ways to operate the Yuma Desalting Plant (YDP) at a lower cost. The WQIC supports that purpose by serving as the primary site for this research. The WQIC is a 14,000 square foot building housing membrane water treatment research equipment from bench-scale to full-scale. It is one of only two Reclamation-operated applied research facilities searching for desalination solutions. Research conducted at the WQIC is valuable outside Reclamation because results can be applied at other reverse-osmosis desalination plants in the U.S. and around the world. A Technical Assistance Team meets twice annually to provide technical guidance regarding best utilization of the WQIC for testing improvements to the YDP, developing new water treatment processes, evaluating improvements to existing processes, and troubleshooting problems with existing plants.

WQIC Technical Support & Program Development

The purpose of the WQIC is to support the Title I Salinity Control Research program and Reclamation's efforts to accomplish its mission by finding ways to stretch water supplies and develop new water supply technologies. The WQIC provides critical infrastructure not available at any other Reclamation office. Development and evolution of the WQIC presents new technical challenges, requiring support of process and equipment designs and modifications of these designs, preparation of test programs, review of potential CRADAs, chemical engineering analyses, experimental design recommendations, and data analyses.

FY06 YDP-Related Research Projects

Title I Salinity Control Management & WQIC Program Assistance	$58,000
Chlorine-Resistant Membranes	$60,000
High-Purity, High-Rejection Cellulose Acetate Membranes	$40,000
Development of Forward Osmosis Water Purification Process	$22,000
Upgrading YDP Pretreatment And Reverse Osmosis Processes	$120,000

Plant Technology Retrofits

YDP Aluminum-Bronze Life Analysis
High-pressure, low pH flows appear to be corroding YDP equipment fabricated from aluminum-bronze. This equipment includes process piping, pumps, and valves. YAO has contracted with CH2M Hill to evaluate the integrity of plant aluminum-bronze piping systems and recommend remedial measures. The company will prepare a report that will be used to support future budget requests to either repair or replace portions of plant piping, and/or as a basis for supporting changes to plant processes to prolong the life of aluminum-bronze plant features.

YDP Pretreatment and RO Technologies
When the YDP was designed in the 1970s, the design was based on the most reliable water treatment and desalting technologies available. YDP uses RO desalting and "conventional" pretreatment: partial-lime softening-clarification and gravity filtration. Over the past 20 years, an array of advances in RO pretreatment and RO systems has occurred These technologies need to be evaluated to determine how suitable they would be for use at the YDP. This research enables YAO not only to comply with legislation on finding ways to run the plant cost-efficiently, but in satisfying that legislation, YAO satisfies its responsibility to taxpayers to protect their investment in the plant.

Pioneering New Technology

Forward Osmosis Water Purification Process
Conceived by University of Arizona physicist John Kessler, unpressurized FO holds great potential for significantly reducing capital and energy costs of desalting. The proposed project builds on previous work funded by DARPA. The focus of the proposed project is to pursue a radical new strategy to achieve significant size, cost, and energy improvements through the development of innovative new FO membrane water purification processes. The proposed FO water purification processes will mimic the energy-efficient osmotic processes utilized by biological systems. The objective of this project is to develop and demonstrate unpressurized FO desalting processes as quantum improvements over existing pressurized RO desalting systems.

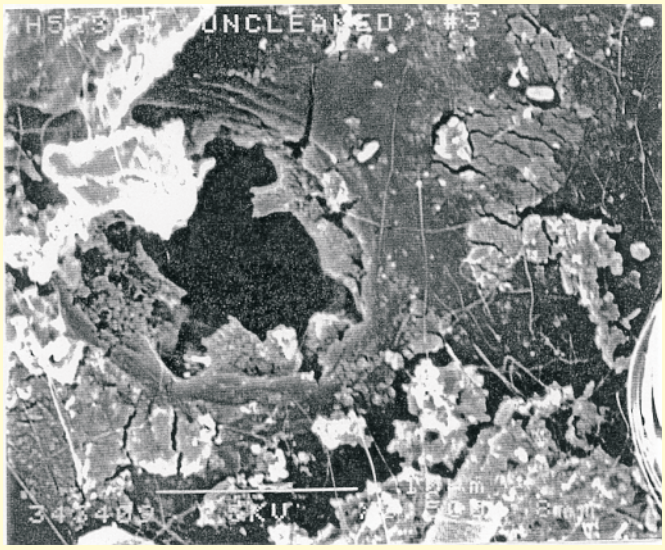
Cutting Costs by Increasing Product Water Recovery, Reducing Chemical Use

Engineers designing the YDP in 70s-80s planned for the YDP to recover 73% of the water it processed. They also planned to use a chemical anti-scalant in the process. While the plant was being constructed, Reclamation began exploring new ways to operate at higher recovery levels and with fewer chemicals. Using our demonstration scale test unit, Pilot System 1, our engineers perfected a new operating process that increased our product water recoveries to 80%, without antiscalants. There is also the potential to get to 85% recovery, though at that level, anti scalants would be required.

Chlorine-Resistant Low-Pressure Membrane Study
A primary limiting factor in the spread of RO is that the process is energy-intensive, which makes the process relatively expensive. One way to reduce the cost of RO is to create low-pressure membranes, which require less energy to operate. Low pressure membranes do exist, but they are degraded by one of the most common and low-cost disinfectants in water treatment - chlorine. Industry describes the "holy grail" of membranes as a low-pressure membrane that will work with chlorine. This project seeks to perfect the formulation for such a membrane. Upon successful, replicable formulation, the membrane will be patented and mass marketed. **(PATENT)**

High-Purity High-Rejection Cellulose Acetate Membranes
While industry seeks a low-pressure, chlorine-resistant membrane, cellulose-acetate membranes continue to hold promise, if certain shortcomings can be overcome. One such shortcoming is that, while the intrinsictransport properties of CA

Solving the Mystery of Membrane Degradation



In the early 90s, engineers noticed that YDP membranes made from cellulose acetate were inexplicably degrading. They conducted testing and determined that iron and chlorine interacted, causing the membranes to lose integrity. Reclamation changed the operating process, adding ammonia to form chloramines. This has slowed the degradation to a pace that doesn't affect the life of the membranes.

membranes can exceed 99.5% salt rejection, in actual practice CA membranes operate at about 95% salt rejection. Modifying CA membranes to achieve 99.5% salt rejection would require only relatively minor modifications in the production process of cellulose to CA in the final membrane. This project focuses on finalizing these modifications and beginning the process of applying for a patent on the process. **(PATENT)**

Partnered Research Projects

(authorized under Technology Transfer Act of 1986)

Desalination Research with Metropolitan Water District of Southern California

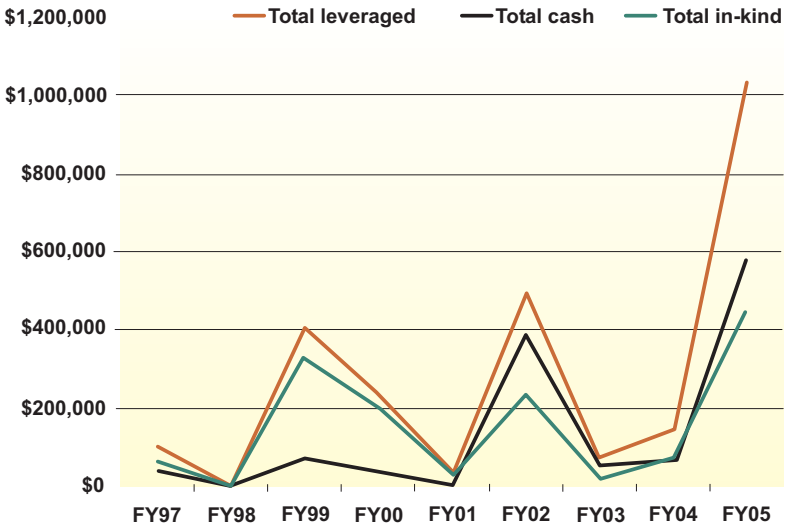
Metropolitan's mission is to provide its service area (17+ million consumers in Southern California) with adequate and reliable supplies of high quality water to meet present and future needs in an environmentally and economically responsible way. The Colorado River is a major source of water for Metropolitan. A planning goal at Metropolitan is to meet or exceed the 500 mg/L total dissolved solids secondary USEPA non-health standard. One way to accomplish this goal is through desalination. Since the district is planning to use desalination equipment similar to that used at the Yuma Desalting Plant, Reclamation benefits by partnering with them.

Reclamation and Metropolitan are conducting three water desalination demonstration-scale projects. The first project tested replacing microfiltration pretreatment with a reverse osmosis pretreatment using ozone and biofiltration processes. The test examined whether this pretreatment can cost effectively maximize feed water quality and minimize membrane fouling.

The second project is studying the performance of large-diameter (18-inch) reverse osmosis membranes, the largest currently available in the world. This is the first demonstration for membranes of this size as part of a complete water treatment system. The test examines membrane performance at 85 percent or greater water recovery following conventional pretreatment.

The third project calls for a new concentrate recovery technology to be fed by the reject stream

WQIC Partnered Research Funding FY97-05



Supporting Rural Communities in Water Resources Management

The City of Somerton, AZ, approached Reclamation for assistance planning for an upcoming change in the mix of water they deliver to their residents. WQIC staff helped the City conduct a taste test and are now working with the city to evaluate how different metals will respond to their expected new type of water. Small rural communities like Somerton can access the WQIC for help with water resources management questions like this one.

of a large-diameter reverse osmosis unit. The project hopes to confirm previous pilot-scale research, which produced a 95 percent water recovery - which is a 10 percent increase over more traditional reverse osmosis recovery.
Partner: Metropolitan Water District of Southern California, Beach Global, Burns & Roe Services Corporation.

Somerton, AZ Surface and Ground Water Blending Study
In some locations such as Tucson and the Yuma County Foothills area, corrosion problems have been reported when Colorado River water has been blended with existing well water sources. The City of Somerton, AZ, is planning to blend Colorado River water with local well water in the near future. This study investigates corrosion issues of the blended water in order to anticipate possible problem areas. The corrosion properties of various materials of construction in the water treatment, distribution, and customer piping areas will be studied. City of Somerton well water, Colorado River water, and blended water will be used to investigate corrosion rates under static & dynamic conditions.

The goal of this project is to evaluate the corrosion characteristics of typical materials of construction with City of Somerton water supplies and blends. The effectiveness of water treatment with the addition of corrosion inhibitors and other chemicals will be determined.
Partner: City of Somerton, AZ, Nicklaus Engineering, Burns & Roe Services Corporation.

(PATENT) = means patent either is being or will be applied for.

Water Quality Improvement Center
Yuma Desalting Plant
Yuma, Arizona
Yuma Area Office
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U.S. Department of the Interior
Website: www.usbr.gov/yuma