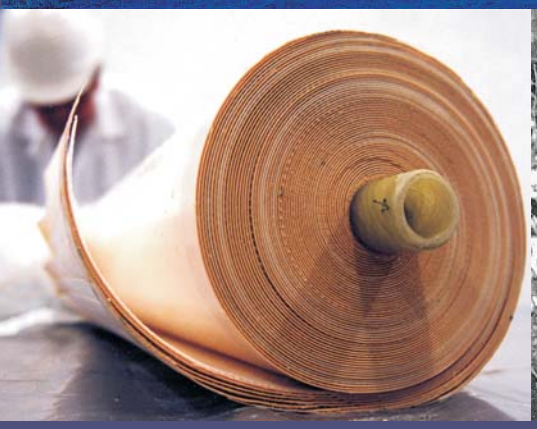
RECLAMATION

*Managing Water in the West*

## *Water Quality Improvement Center*

# Advanced Water Treatment Research 2005



***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, 2004.***

**U.S. Department of the Interior**
**Bureau of Reclamation**

## Our Mission:

# Improve Water Quality to Increase Water Availability

### New Technologies to Stretch Water Supplies


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

***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 is used to grow our nation's crops, supply our cities, and serve our industries.

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 (such as sewage effluent or plant wastewater), it typically is not re-usable for potable purposes unless it's treated. Once treated, it could be re-used, and this would increase the amount of water 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.

Research develops technologies and methods to economically improve water quality. These improvements make 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.

Waters the WQIC uses in tests include custom-mixed formulations, but primarily consist of lower-stem Colorado River water and 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

### FY05 YDP-Related Research Projects

- **Title I Salinity Control Management & WQIC Program Assistance**
- **Membrane Storage Study**
- **Chlorine-Resistant Membranes**
- **High-Purity, High-Rejection Cellulose Acetate Membranes**
- **Investigate CA/PA Membrane Replacement for YDP**
- **Well Analysis to Investigate Desalting Yuma Mesa Conduit**
- **Development of Forward Osmosis Water Purification Process**
- **Non-Toxic Storage of Cellulose Acetate Membranes**
- **Upgrading YDP Pretreatment And Reverse Osmosis Processes**

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.

## 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. This project evaluates the ability of various high-carbide stainless steels, high-nickel alloys, and aluminum-bronze to stand up to conditions that occur at the YDP and other brackish water desalting plants. The findings from this study will be used to calculate the expected life of aluminum-bronze fluid-handling equipment at YDP, and will provide information about suitable replacement materials.

**Nontoxic Storage of YDP RO Elements**
RO membranes stored for use at the YDP are subject to damage by microbiological agents such as bacteria, fungi, and chemicals, cutting short their useful life and increasing plant operating costs. One method of arresting this damage is to store membranes in a biocide; however, this method of storage has problems at all stages from prep for storage to post-storage handling. This project evaluates the effectiveness of gamma irradiation in providing non-damaging sterilization of Fluid Systems 12-inch membranes. Results have been promising enough that staff are planning to patent the process. **(PATENT)**

**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.

**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.

**Identification of Replacement Elements for YDP**
In the early 90s, Reclamation purchased elements to use in YDP. These membranes have been in cold storage since their purchase, except for a portion of them that were successfully dried and are now stored in ambient conditions at the YDP. The formula used to create the original membranes has been modified over the years, and no cellulose acetate element on the market currently matches the elements originally specified for use at the YDP. New elements must be tested and evaluated for use at the YDP to ensure the lowest-cost operations. This project involves identifying, describing, and testing cellulose acetate and polyamide elements for possible use at the YDP. The final outcome will be a list of elements that are optimal for use at the plant.

**Fluid Systems 12-Inch Membrane Drying**
Previous research efforts resulted in iden-tification of a process to "dry" part of the membranes to be used at YDP; those membranes are currently stored on-site. YAO currently keeps the remainder of YDP membranes in cold storage off-site at the cost of

### 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 an interaction of iron and chlorine caused the membranes to lose integrity. The process changed and now ammonia is added to form chloramines. This has slowed the degradation to a pace that doesn't affect the life of the membranes.

approximately $150,000 per year. This project will identify a method to dry the remaining membranes so they can be stored at the YDP, eliminating the need to keep them in cold storage. This will also eliminate the need to pay for storage off-site, saving about $150,000 per year or up to $1,500,000 over a 10-year period.

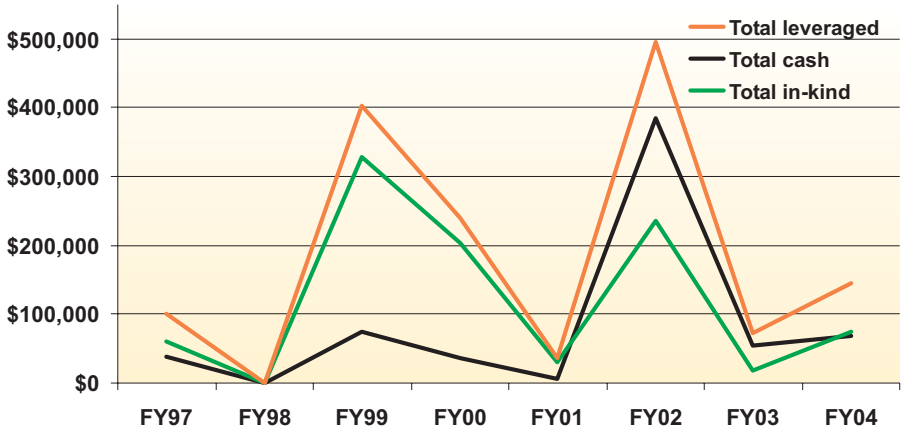
## Pioneering New Technologies

**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.

**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 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

### Partnered Research Contributions FY97-04



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**

MWD'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 MWD. A planning goal at MWD 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.

MWD is conducting research associated withvarious aspects of membrane water treatment. These aspects consist of: 1. Evaluation of new, high-performance reverse osmosis (RO) membranes; 2. Investigation of hybrid-membrane processes (i.e., combining RO and nanofiltration (NF) membranes) to achieve 90 percent total water recovery; 3. Evaluation of high-voltage, capacitor-based technology to prevent colloidal, biological, and precipitative fouling; 4. Develop a pilot-scale, membrane crystallizer to minimize brine residuals. The research project is expected to last for one year. MWD will also be supplying supplemental equipment. Burns & Roe Services Corporation will provide operations and maintenance services.
*Partner: Metropolitan Water District of SouthernCalifornia in Los Angeles, CA.*

**Somerton 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 is planning to blend Colorado River water with Somerton 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.*

**Proof-Testing a Hot Water Engine for Use in Desalination**

Arizona company Deluge, Inc has developed an engine that is powered by hot water. The engine

**Supporting Rural Communities in Water Resources Management**

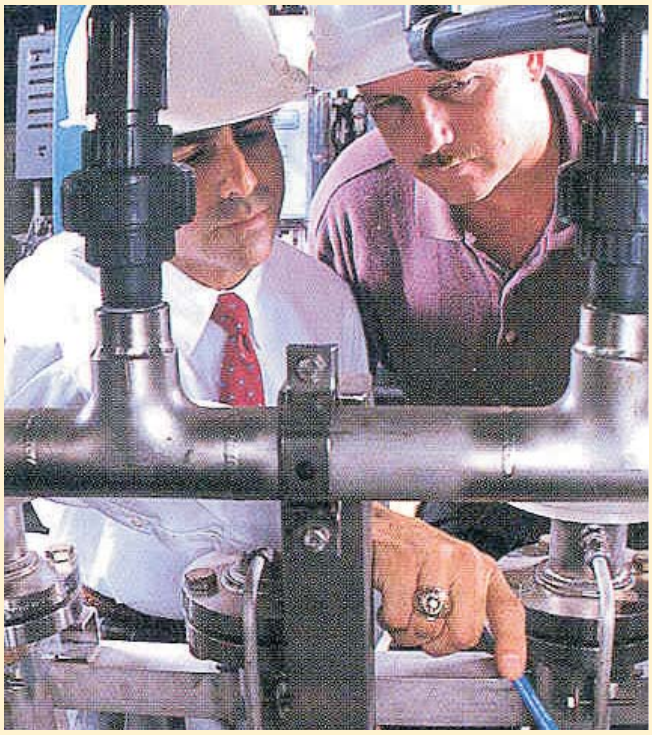
The City of Somerton, AZ, approached Reclamation for assistance planning for an upcoming change in the mix of water they deliver to their residents. WQIC staff helped the City conduct a taste test and are now working with the city to evaluate how different metals will respond to their expected new type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

was originally developed through a CRADA with the Department of Energy and has recently been selected to power crude oil pumps in Missouri. Deluge managment wants to apply the technology to desalting and is proof-testing the engine's ability to power desalting pumps using equipment from the WQIC. After tests demonstrate the engine can effectively power pumps used in the desalting process, Deluge plans to construct a larger test system and test it using geothermal energy.
*Partner: Deluge, Inc., Phoenix, AZ*

**Computer Modeling to Predict Membrane Performance**
University of California is developing a computer model to predict how various membranes perform under various operating conditions. This is a component test. The data produced will be combined with that from other tests to help scientists create a multi-functional piece of equipment that engineers can use to assist them in planning and designing membrane water treatment plants. The equipment will rely on software to model various treatment processes, diagnose operational problems, and generate treatment solutions. If successful, the project will enable more accurate testing of treatment processes at a smaller scale, decreasing the cost of designing a membrane water treatment plant.
*Partner: University of California - Riverside, CA*

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

## Info about the WQIC



**For more information about the Title I Salinity Control Research Program or the Water Quality Improvement Center, contact Daniel Hsu at 928-343-8229.**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