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RECYCLED WATER ★ FOR A THIRSTY WEST ★

U.S. DEPARTMENT OF THE INTERIOR · MARCH 3, 1849

WATER RESOURCES MANAGEMENT . . . . . . FOR THE FUTURE.

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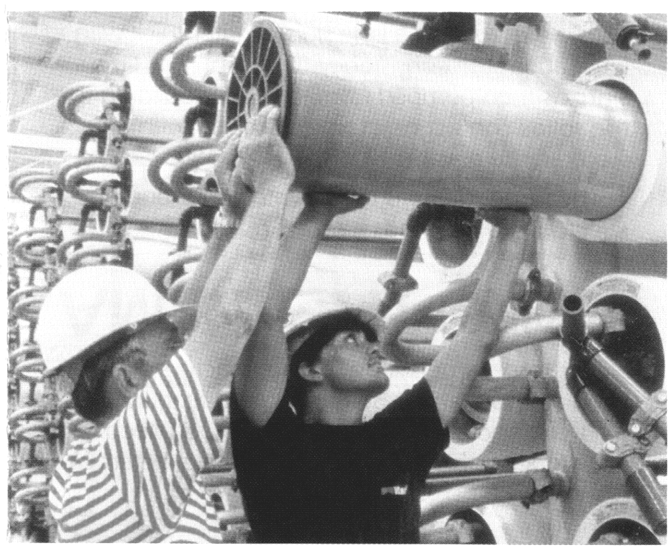
The Yuma Desalting Plant

Technology in Action



HISTORY

The Colorado River is a 2300-kilometer-long (1450-mile-long) ribbon of life for over 15 million people in the southwestern United States and Mexico.

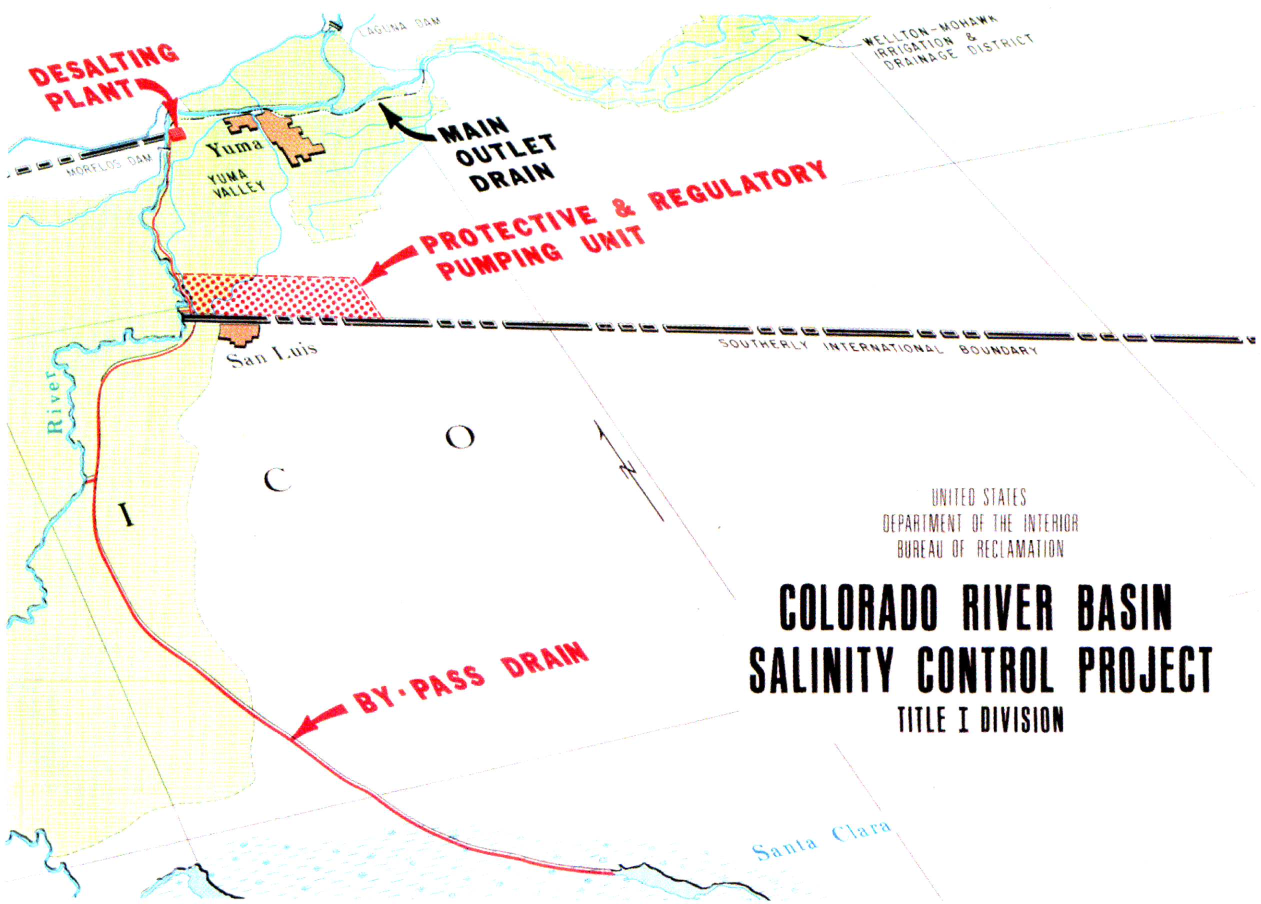
For years the Colorado was known as a river of too much or too little. Today it is one of the world's most regulated rivers; but regulation necessary to ensure a sufficient quantity of water for the users has also exacted a price in the quality of the water available.

As the Southwest was being developed during the early part of this century, the big question was, "Will there be enough water?" Today people also ask, "How good will the available water be?"

Salinity is a naturally occurring phenomenon in rivers. The salinity of Colorado River water at its source high in the Rocky Mountains is about 50 parts per million.

Where the river crossed the border into Mexico in the early 1900s, the salinity level was about 400 parts per million. In regulating the Colorado, developments since the beginning of this century have now more than doubled the salinity of the water arriving at the Mexican border. The reasons:

- Over 20 reservoirs constructed in this century created tremendous evaporative surfaces. When the water evaporates, the dissolved salts are left behind.
- Development of numerous irrigation and water user districts along the river has also increased salinity. Irrigation water from the Colorado River is routed to farmlands and applied to crops. Part of the water, not absorbed by crops, percolates through the mineral-rich soils predominant in the southwest United States. As water percolates, these minerals dissolve in the water, making it saline. These minerals include sodium chloride (table salt), sodium bicarbonate (baking soda), and calcium carbonate (calcite).



To keep the groundwater table low so it does not saturate the root zone of the plants and drown them, this saline groundwater is allowed to drain naturally into the aquifer, or sometimes it is pumped out of the ground and back into the river.

Saline pumped drainage from farmlands in the Wellton-Mohawk Irrigation and Drainage District in southwestern Arizona increased river salinities. In the 1960s, when drainage water from farmlands east of Yuma was channeled into the Colorado River above Morelos Dam near Yuma, river salinities sometimes exceeded 1200 parts per million.

On February 3, 1944, the United States and Mexico signed a treaty (TS994) wherein the United States agreed to annually deliver about 1.85 billion cubic meters (1.5 million acre-feet) of water to Mexico. This treaty did not address water quality. In 1961, Mexico expressed concerns that increased salinity was causing lower crop yields in Mexico's Mexicali Valley. During 12 years of negotiations with the Mexican Government, various interim agreements were reached.

A permanent solution was reached in 1973. The United States and Mexico signed Minute No. 242, an amendment to the 1944 treaty. Specifically, the United States agreed that the salinity level of water delivered to Mexico at Morelos Dam would not exceed 115 (plus or minus 30) parts per million over the salinity level at Imperial Dam, about 43 kilometers (27 miles) upstream.

The U.S. Government would meet this agreed-upon salinity level in part by constructing a desalting plant to treat the saline drainage water from farmlands east of Yuma. In June 1974 the U.S. Congress passed legislation authorizing the construction of the desalting plant; this legislation is titled the Colorado River Basin Salinity Control Act (PL 93-320).

DESALTING GOALS

In general, the Yuma Desalting Plant accomplishes two main goals:

- helps the United States meet salinity requirements and water quantity requirements for Colorado River water delivered to Mexico at Morelos Dam;
- desalts and salvages the drainage water that otherwise would be too saline to deliver to Mexico, thus saving the U.S. up to 97 million cubic meters (78,500 acre-feet) of Colorado River water per year.

The Yuma Desalting Plant has developed practical technologies for cleaning up impaired-quality waters and adding them to the available supply, and it conserves water by recycling unusable return flows from farmlands east of Yuma. Research and development efforts at the plant will be able to advance desalting technology and help develop or refine technologies for treatment of other saline waters.

BENEFITS OF DESALTING RESEARCH

What do kidney dialysis, low power bills, and better quality of life all have in common? They are results of desalting research.

Desalination is the separation of salt from water, whether it comes from oceans, inland seas, or the ground. The Department of the Interior's Office of Saline Water pioneered desalting research in the 1950's. Today we enjoy better and longer lives because of our improved quality of water; we pay lower prices for technology because desalted water lowers manufacturing costs; we pay less for power in our homes and businesses because desalted water lengthens equipment life and lowers operational costs, thus lowering bills.

And some people owe their lives to desalting research, which laid the groundwork for today's kidney dialysis process.

While the Yuma Desalting Plant is the world's largest reverse osmosis desalting plant, it isn't the only one. In the United States, communities in many states have built desalting plants to help supply water. Some nations depend on desalination as the primary method for meeting their water supply needs. Indeed, over 100 cities around the world desalt some water in some way, whether it's by reverse osmosis, electrodialysis, or flash distillation.

Desalted water today is relatively expensive compared to other types of clarified water. However, as water supplies diminish, desalted water may be considered reasonably priced compared to the alternate sources of water. The Yuma Desalting Plant desalts water at a total amortized capital and O&M cost of 60 cents per cubic meter ($700 per acre-foot), which is about .06 of a cent per liter (.2 of a cent per gallon).

Using the Yuma Desalting Test Plant as a development tool for desalting research is expected to cut desalting costs even further in the future. The Test Plant is being used to research three areas—membrane development, improved pretreatment, and improved operations.

- Companies that want to test new membrane technology in a working system can, by sharing costs with the federal government, install test equipment at the Test Plant and explore the new applications. Staffs at the Yuma Desalting Plant and Reclamation laboratories in Denver are already investigating different methods of preserving and storing membranes after they've been manufactured and after they've been used. Reclamation is also conducting research into alternate biocides for membrane storage and disinfection. Through this research, Reclamation hopes to increase the safety and environmental compatibility of desalting technology.
- Reclamation is looking at new ways of filtering water, cleaning it up as much as possible before desalting it, as another way to cut costs.
- And the third prong of Reclamation's effort involves improving operational procedures—finding a better way to desalt the water.

The use of desalination to meet the growing demands for water resources in the 21st century will be enhanced by the research conducted at the Test Plant.

Advances made at the Test Plant will mean improved processes and greater knowledge available not only to the Yuma Desalting Plant, but to the desalting industry around the world.

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REVERSE OSMOSIS AT THE YUMA DESALTING PLANT

A total of about 9,000 **membrane elements** desalt the water. The elements are inserted into about 1700 **fiberglass pressure vessels**. The length of the pressure vessels is about 7 meters (23 feet); the diameter of the larger pressure vessels is about 32 centimeters (12.75 inches), the diameter of the smaller pressure vessels is about 22 centimeters (8.5 inches.)

DESALTED WATER

The separation of the salt from the product water is both a chemical process and a physical diffusion process. About three-fourths of the saline water is forced through the walls of the cellulose acetate membranes by pressure applied at about 2500 kilopascals (362 pounds per square inch). The pressure forces water toward the center tube of the desalting membrane. Only about three percent of the salts pass through the membranes along with the water, thus lowering the water salinity from about 3,000 parts per million to approximately 300 parts per million. The desalted water then flows out of the desalting building.

This process removes more than 90 percent of the salts from the water.

The desalted water (at about 300 parts per million) and untreated drainage water that has not been diverted into the desalting plant (at about 3,000 parts per million) will be blended to produce the desired salinity level. This **blending** has been found to be the most efficient way to produce water with the desired salinity level. It also reduces the costs of constructing the plant and the costs of desalting drainage water.

Blended water flows through a small canal for about 360 meters (.4 miles), then empties into the Colorado River to become part of the United States' treaty-required Colorado River water delivered to Mexico.

Reject Water

Part of the drainage water that enters the desalting plant does not pass through the desalting membranes and is left behind instead of being desalted. This "reject water" contains the concentrated salts left behind as the "product" water flows through the membranes. The reject water, or brine, with salinity levels at about 10,000 parts per million, jets into and drives the energy recovery turbines at the clearwell pumping plant, then flows into the bypass drain and to the Santa Clara Marsh (Cienega de Santa Clara) at the Gulf of California.

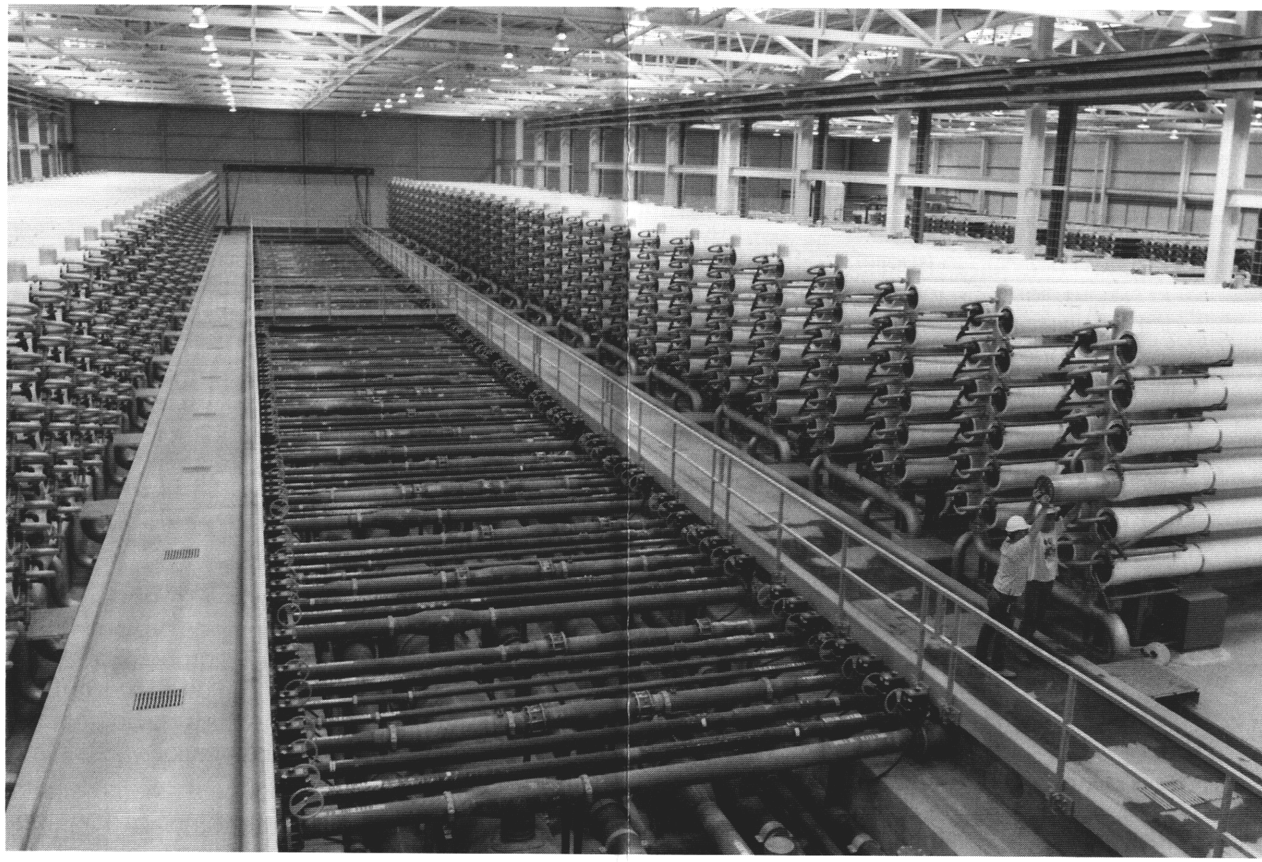
Bypassed Drainage Water

Untreated saline drainage water from farmlands east of Yuma can be bypassed around Mexico's diversion point at Morelos Dam and carried in a 95-kilometer-long (59-mile-long) concrete-lined drainage canal to the Santa Clara Marsh (Cienega de Santa Clara) at the Gulf of California. However, the United States receives no treaty credit for this untreated bypassed water because salinity levels exceed the limits of Minute No. 242. So, to deliver the entire quantity of water owed to Mexico under the 1944 Treaty, the United States replaces this bypassed untreated drainage water with water from upstream storage reservoirs; and this replacement water counts as part of the approximately 1.85 billion cubic meters (1.5 million acre-feet) of water allotted annually to Mexico under the terms of the 1944 Treaty.

Test Plant

Inside the Yuma Desalting Plant is another, smaller desalting plant, capable of desalting about 3300 cubic meters or 3.3 million liters (880,000 gallons) of water per day. It is called the **Test Plant** and serves several functions:

- train operators;
- test new types of reverse osmosis membranes;
- try out different chemical treatments of the water;
- develop and test new hardware and software; and
- experiment with changes to the desalting process before using those changes on a larger scale in the main plant.



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HOW THE YUMA DESALTING PLANT WORKS

The Yuma Desalting Plant is located on a 24-hectare (60-acre) tract of land about 8 kilometers (5 miles) west of Yuma. It is the world's largest reverse osmosis desalting plant. It can produce about 275,000 cubic meters or 275 million liters (72.4 million gallons) of desalted water per day from a total of up to approximately 390,000 cubic meters or 390 million liters (102.7 million gallons) of drainage water per day, the maximum capacity that can enter the plant. If the need later exists, the plant can be expanded to produce 363,000 cubic meters or about 363 million liters (96 million gallons) per day.

The saline drainage water from farmlands east of Yuma flows in a concrete-lined drainage canal to the desalting plant.

The drainage water enters the plant at an **intake system** where screens remove algae and large debris such as tree branches from the water. As the drainage water flows by gravity through underground pipes into the plant, the water is treated with chlorine. This chlorination kills micro-organisms and stops the growth of algae, which would plug or damage the plant's filters and membranes.

PRETREATMENT PROCESSES

Before being desalted, the water passes through several pretreatment steps to remove all solids, which would quickly clog the expensive desalting membranes. Pretreating the water extends the life of the membranes to 3 to 5 years. Without pretreatment, membranes would last approximately 1 hour.

1. Grit Sedimentation Basins

Once inside the plant, the water goes through **grit sedimentation basins**, the first pretreatment facility. There the rapidly flowing water slows down and spreads out, allowing gravity to pull the sediment to the bottom. At the bottom of the basins, automated rakes scrape the sediment buildup to the side.

- From the basins, the sediment is piped to a **sludge handling area**. There, most of the water is removed from the sediment; the sediment is discarded.
- The partially cleaned water near the top of the basins flows over the basin walls and into the **intake pumping plant**, which pumps the water to the next pretreatment process, the solids contact reactors.

2. Lime & Ferric Sulfate Process

Railroad cars and trucks transport most of the chemicals into the plant. Pebble-sized **quicklime** and **ferric sulfate** are stored in silos until used.

When needed, the **quicklime** is blown from the bottom of the silos to the square **lime slaker building**. There, the quicklime is mixed (or slaked) with water to form a lime slurry (water thick with lime, about the consistency of cream). The **lime slurry** is then pumped from the slaker building to the **solids contact reactors** and mixed with the water in the reactors.

The **ferric sulfate** is mixed with water and also injected into the **solids contact reactors**.

3. Solids Contact Reactors

The three large **solids contact reactors** (SCRs) each measure about 56 meters (185 feet) in diameter and about 8 meters (26.2 feet) deep. Each SCR can hold about 18,000 cubic meters or

18 million liters (4.71 million gallons) of water.

Inside these three giant structures, lime and ferric sulfate remove more suspended particles in the water and soften it by taking out most of the calcium. Lime and ferric sulfate are added to the water in the center of the reactors:

- As the **lime slurry** comes into contact with the calcium and suspended solids in the water, it bonds to the solids, primarily calcium. In addition to softening the water, this process removes part of the calcium that would have eventually plugged the desalting membranes if not removed.
- **Ferric sulfate** helps the lime form sludge and settle the suspended particles to the bottom of the solids contact reactors.

4. Sludge Thickener & Sludge Disposal Site

The sludge in the solids contact reactors is scraped to the center and transferred to the **sludge thickener** where the sludge can be concentrated further by settling. Pumps force concentrated sludge through an **underground pipeline** to a **disposal site** consisting of evaporation ponds. The site is located about 35 kilometers (22 miles) southeast of the desalting plant.

Each acre-sized **evaporation pond** will be filled with sludge. When the sludge dries, the ponds are covered over with soil to blend into the desert landscape. The buried sludge eventually becomes a limestone deposit. The sludge can also be used in scrubbers on air pollution control systems or can be recycled and used for soil treatment on farmlands.

5. Dual Media Gravity Filters & Sulfuric Acid Process

The water clarified by the **solids contact reactors** flows through pipes called launders, which are located near the top of the reactors, then flows to the **dual media gravity filters**.

Before the water reaches the dual media gravity filters, **sulfuric acid** is added to reduce the pH of the water from 10 to 7.5. (pH is an indicator of how acidic or alkaline water is.) Adding

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sulfuric acid prevents calcium carbonate plating, which would plug and cake the filters.

Very tiny suspended solids remaining in the water are removed as the water flows by gravity through the anthracite coal and sand filters. The dual media gravity filters consist of 28 filter cells. Each cell filters approximately 13,500 cubic meters or 13.5 million liters (3.6 million gallons) of water per day. The tiny solids that are filtered out of the water are left behind in the sand and anthracite coal; and these tiny solids are cleaned out periodically by "backwashing" the filters.

6. Clearwell & SHMP Silos

The filtered water flows from the dual media gravity filters into a large underground storage tank called a **clearwell**. As the water flows into the clearwell, additional chlorine can be added to stop the growth of micro-organisms and algae.

Also, from the **SHMP (sodium hexametaphosphate) silos**, the sodium hexametaphosphate is added to the water to help prevent scale buildup in the reverse osmosis desalting membranes, and the pH of the water is again lowered (to about 5.5) to prevent scaling of the desalting membranes if the pH is too high and to prevent damage if the pH is too low.

The clearwell holds about 13,500 cubic meters or 13.5 million liters (3.6 million gallons) of water. Concrete that covers the top of the clearwell keeps dust from blowing into the cleaned water.

7. High-Pressure Pumps

Fourteen high-pressure pumps at the clearwell force water from the underground tank into the processing area and into the reverse osmosis membranes. The water enters the membranes at an average pressure of about 2500 kilopascals (362 pounds per square inch).

After going through the desalting process, a stream of pressurized reject water is sent first through energy recovery units on three of the high pressure pumps. The stream of fast moving water turns the turbines of these energy recovery units and powers the pumps. This helps reduce overall energy consumption and costs.

Also, ammonia is added into the pump discharge pipe to convert the remaining chlorine to a less aggressive biocide called chloramine. This chloramine does not harm the membranes and prevents mold and bacteria from growing in the spiral-wound membranes.

8. Desalting Process Area

The heart of the desalting plant is the reverse osmosis desalting equipment. Reverse osmosis is the process whereby one component of a solution is separated from another—in this case, the salt is separated from the water—by the pressure exerted on semi-permeable membranes.

The salty water is forced through the membrane walls. The walls of cellulose acetate do not allow the salt to pass through but do allow pure water to pass. The desalting equipment can produce about 3.2 cubic meters or 3200 liters (837 gallons) of desalted water per second.

It takes 4 1/2 hours for a unit of water to travel through the plant from the intake where it enters as untreated drainage water to the discharge canal, where it leaves the plant as desalted water.

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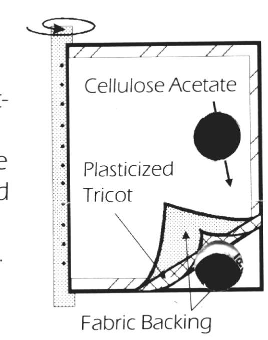
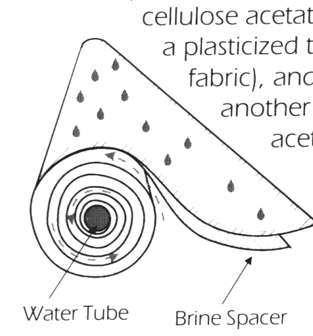
How Does Reverse Osmosis Work?

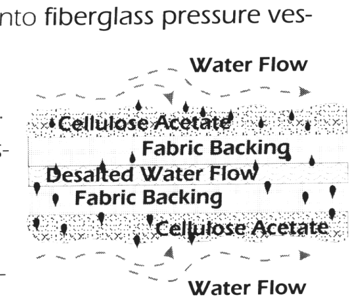


Multi-leaved **reverse osmosis membranes** used at the Yuma Desalting Plant are like an **envelope**—sealed on three sides, with the open end wrapped around a hollow pipe, or water tube.

Each **membrane** has three layers. The top layer is fabric (dacron sailcloth or pellon) coated with a material called cellulose acetate; the middle layer is a plasticized tricot (or knitted fabric), and the bottom layer is another sheet of cellulose acetate-coated fabric.

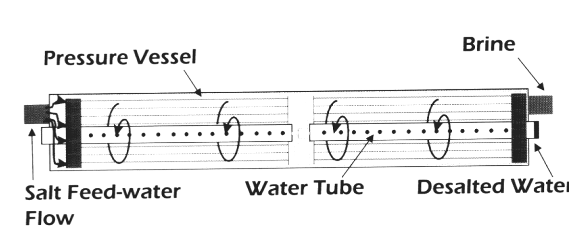


Membranes are wound around the perforated hollow tube with a loose mesh called a brine spacer inserted between the **envelopes**. The rolled-up membranes are called membrane elements, and these elements are loaded into **fiberglass pressure vessels**, large cylinders that are capped at the end.



In the reverse osmosis process, pressurized salt water flows across the membrane surface of the cellulose acetate. The pressurized water causes water molecules to diffuse through the membrane, leaving the larger salt ions, and some salt-laden water molecules, behind.

Once through the membrane, the desalted water is trapped within the cellulose acetate **envelope**, and it travels along minuscule grooves in the plasticized tricot toward the center of the element. There, it empties into the water tube through evenly-spaced holes.



remote terminal units (RTUs) located at various sites on plant grounds. Information collected using the RTUs is stored in the YDP's database. The database contains as many as 50,000 data points and is continually modified to reflect second-by-second data updates, which allows custom analysis. Operator interface with the PMSC occurs via an operator console or the mimic board–a graphical representation of plant processes. Using the PMSC, an operator can run the plant in three modes, ranging from local to full automatic.

Successful Tests

Autopsying membranes. YDP had initial problems with membranes that were failing prior to manufacturer estimates. Autopsies tipped engineers off to the causes of membrane failure and helped determine which processes to modify to extend membrane service life.

Optimizing recovery. Design specifications told YDP engineers to expect only about 70% recovery from reverse osmosis elements. Testing proved they could push recovery–without shortening element life–up to 80%, which reduces bottom line production costs.

Trihalomethane removal. THM levels in water desalted at YDP exceeded EPA drinking water standards. YDP staff experimented with various operating conditions for air stripping out the THMs and found a way to remove them at a reasonable cost.

Membrane drying. When the YDP is kept in ready reserve, membrane elements must be stored to prevent them from deterioration. Elements stored in liquid last from 3-5 years, but drying membranes can extend their lives almost indefinitely. YDP engineers investigated membrane drying to develop a standard process for drying and storing the plant's $18 million dollars of elements. While membrane companies have tried to experimentally dry membrane, YDP is the first to dry new and used elements.

Instrumentation development & evaluation. YDP engineers continually search for accurate indicators of plant performance. (For example, plugging factor as a measure of membrane fouling) Finding the instrument that will provide these measurements often means designing, building, and debugging on-site.

Membrane life studies. The life of a membrane can be seriously affected by what may seem minor differences in feed water composition and operating conditions. Engineers have successfully identified solutions for conditions that threatened to considerably shorten the life of membranes.

Membrane performance studies. As new membranes become commercially available, such as thin film membranes, the facilities at YDP have been used to determine the strength and weaknesses of these new membranes and their potential for future use.

Information gathered from these tests is made available as widely as possible, via technology transfer, feedback to the manufacturers, seminars, published reports, or one on one discussions with designers and engineers in the industry.

Research Center Capabilities

On-site staff includes researchers, engineers, operators, and maintenance workers familiar with desalting technology and relevant permitting processes. The plant is required to maintain up-to-date permits for operations and disposal of products and byproducts.

Infrastructure necessary for pilot and full scale testing of additional industrial equipment and desalting processes is already in place at the YDP.

Besides traditional infrastructure features (intake/discharge systems, conveyance systems), service infrastructure also exists at the YDP, including welding and machine shops.

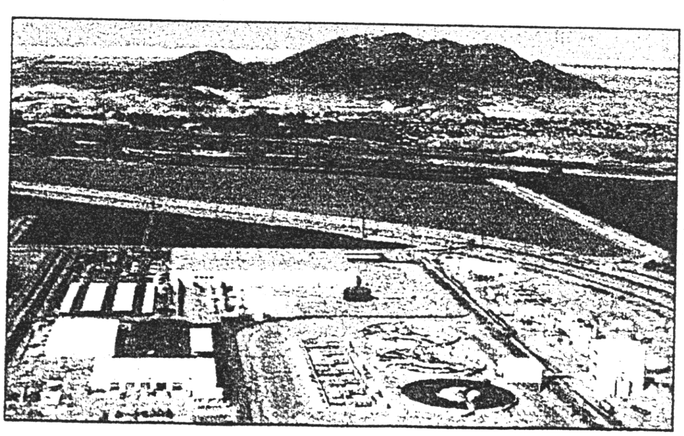
The Yuma Desalting Plant and related Test Plant are owned by the federal government and as such are available for joint research and development projects to further desalination and water quality technology and commercialization of related products.

For more information about the Yuma Desalting Plant or testing at YDP, contact Ed Lohman at (602) 343-8448, or at U.S. Bureau of Reclamation, P.O. Box D, Yuma, Arizona 85366.

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Researching Desalination

AT THE YUMA DESALTING PLANT



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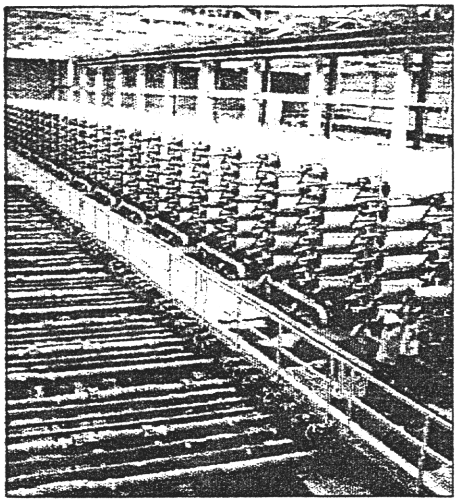
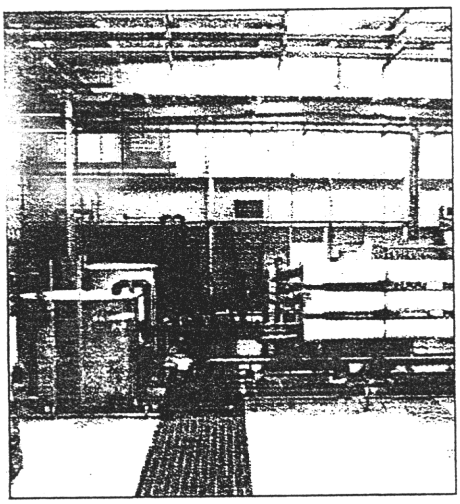


Production Plant

- Brackish-water facility–up to 73 million gallons of desalted water per day, or 81,000 acre-feet per year of blended flow.
- Canal Intake System–up to 100 million gallons per day; large trash removal screens.
- 4 Grit Sedimentation Basins–33 million gallons per day per basin.
- 3 Solids Contact Reactors–185 feet in diameter, 26 feet deep, 5-million to 34 million gallons per day per reactor.
- 28 Dual Media Gravity Filters–4-million gallons per day per filter; sand/anthracite media.
- Clearwell–covered 4-million-gallon tank.
- 14 High Pressure Pumps–average pressure of 400 pounds per square inch.
- 5000 Reverse Osmosis elements installed; maximum capacity 10,000 elements. Can produce 50,000 gallons of desalted water per minute.
- Pressure Vessels both 12-inch and 8.5-inch internal diameter, by 20 feet long.
- Outflow System–73 million gallons per day permeate, with brine rejected to the sea.
- Chemical Feed & Storage Systems–feed systems for liquid, powder, and gaseous chemicals. Storage systems for powder and liquid.
- Sludge Thickener and Disposal System–700,000-gallon capacity tank that reduces water content of sludge then releases it into the disposal pipeline. Eight-inch pipeline carries sludge to lined 1-acre evaporation ponds



Test Plant

- Brackish-water facility; can desalt up to 1 million gallons per day, or 1,000 acre-feet per year.
- Intake System–up to 1.2 million gallons per day.
- Solids Contact Reactor–up to 1.3 million gallons per day.
- Dual Media Gravity Filters–up to approximately 1.3 million gallons per day.
- Clearwell–60,000 gallons storage.
- 2 High Pressure Pumps–up to 450 psi.
- Reverse Osmosis Elements–varying numbers of elements in use, depending on the tests being run.
- 7,000 square feet of enclosed test area, as well as additional outside pad areas.
- Element Check Apparatus–a reverse osmosis system for individual testing of full-sized 8.5- and 12-inch RO elements.
- Small Scale Test Units–3 small-scale units using low cost 2.5-inch elements provide a quick and economical means for membrane performance testing under realistic field conditions.

Production

Using reverse osmosis technology, the Yuma Desalting Plant can desalt up to 73 million gallons of brackish water per day. The plant takes in water from a drainage canal called the MODE, and pretreats the water by grit removal, sedimentation, softening and clarification, filtration and pH reduction. Fourteen high pressure pumps then force the water (which is under about 400 pounds per square inch) into the desalting process area. There, reverse osmosis membrane elements remove the salt from the water. Desalted water is discharged into a small canal that carries it to the Colorado River. Brine, or reject water, is discharged into the Bypass Drain and flows to the Santa Clara Marsh (Cienega de Santa Clara) in Mexico along with any untreated feed water.

A smaller version of the YDP exists in the form of the Test Plant. Fully functional, the Test Plant can desalt up to one million gallons of water per day. It contains the same components as the production plant; however, the Test Plant is a research and development tool, with extra instrumentation and the ability to change processes and quipment as various tests occur.

State-of-the-Art Water Lab

Automation and an experienced staff enable YAO's Water Lab to process as many as 10,000 samples annually and to perform tests on a variety of water types–from fresh to salt water. Typically the lab has scored in the top 20% of U.S. labs, as rated by the U.S. Geological Survey's Proficiency Evaluation. The lab is licensed by the state of Arizona to test for major inorganics; it also tests for most trace metals. The lab follows EPA quality control procedures.

The lab provides full support to field analysis. Typical water quality equipment is included in the lab, such as inductively coupled plasma, automated analyzers, and auto diluters.

Full Process Automation

YDP operations and data collection are performed by a central computer system called the Programmable Master Supervisory Control (PMSC) system. The system consists of two MODCOMP 9250 computers with 29

History of the A-22 Disposal Facility

As early as the concept for developing the Desalting Plant, the problem of disposing of waste sludge material had to be considered. The waste sludge consists primarily of water with the concentrated total dissolved solids (TDS) and a large quantity of lime (calcium oxide) which is used in the desalinization process.

Disposal sites were initially considered in California, directly across the river from the Desalting Complex, and in areas closer to Yuma on the Arizona side. The site currently in use was determined to be the best alternative and a "master plan" was developed to provide a series of disposal cells (evaporation ponds) capable of holding the waste sludge material. An estimate was made that 8 sets of 64 cells would be sufficient for approximately 50 years of sludge disposal.

The following question has been asked repeatedly, "What is the significance of 'A-22' in the name of the site?" Nothing magic! It's not another acronym! Yuma County is in a grid system with roads at one mile intervals along the section lines. Numbered streets are east-west, alphabetized avenues are north-south. The A-22 Disposal Facility is bordered on the east by Avenue A and subdivided by 22nd Street. Hence, the name was selected to also identify the site by its grid location.

The following is a brief list of the phases of work that have been completed to date:

1) Special purchase of tanker trucks for transportation of sludge material from the Desalting Plant to the proposed disposal site.

2) Sol. No. 6-SI-30-04540, A-22 Waste Disposal Facility - Cells AA-9 through AA-12

3) Miscellaneous test wells, monitoring wells, and pilot holes at various locations on the A-22 Waste Disposal Facility Site.

4) Sol. No. 7-SP-30-05700, A-22 Waste Disposal Facility - Construction Stage 1A

5) Construction of steel pipeline from the Desalting Plant to the A-22 Waste Disposal Facility.

6) Sol. No. 0-SP-30-08300, A-22 Waste Disposal Facility - Construction Stage 1B

7) Sol. No. 1425-2-SI-30-09270, A-22 Waste Disposal Facility - Water Supply Well No. 2

Of the four designs and specifications prepared by the LC Region, Design Branch, each design has been prepared with continuing improvements to construct a better and more cost efficient facility.

The first solicitation (-04540) consisted of four disposal cells that were constructed with differing criteria. Side slopes varied from 4 to 1 to 2 to 1 on the various cells to determine the stability of the cells. Sludge was transported via tanker truck and was discharged into the cells by drain hoses and the chutes into the cells were constructed from 2 x 12 redwood planks.

Certain criteria, such as maximum depth of 13', 40 mil thick PVC lining, periodic monitoring using observation wells, etc., had been agreed to by USBR representatives and Arizona Department of Environmental Quality. Each phase of the work must have their approval (permits) before issuance and award of the next contract.

Information from these cells alerted the designer that the 2 to 1 side slopes would be sufficient and would provide the maximum storage capacity. Furthermore, the chutes may be sufficient but a change to 1/2 round sections of 6-inch diameter PVC pipe may be cheaper and have better integrity. The next contract (-05700) made these changes, while leaving the overall dimensions of the cells the same. In addition, the 8-inch diameter steel pipeline from the Desalting Plant to the A-22 Waste Disposal Facility was completed (separate contract) and sludge was now being delivered to the cells using an intricate piping system.

The third solicitation (-08300) was designed with other subtle changes. The width of interior berms was increased from 8 ft. to 10 ft. This was at the request of the project office to allow easier constructability and safer use of the roads between the cells. Certain warning signs ("Do Not Enter") that had been purchased and installed on the previous phases of work were determined to be unnecessary and they were deleted from this contract. The discharge chutes were modified to 3/4 round sections of 8-inch diameter PVC pipe. In addition the discharge pipeline was changed from 45 degree angles to 22.5 degree angles. These changes greatly reduced splashing and erosion of the side slopes.

The fourth solicitation (-09270) was for construction of a large capacity well conveniently located at the center of the facilities. Prior to this, water for construction purposes had been provided to the Contractor at the 242 Well Field (approximately 3 miles to the south. Water was either transported using tanker trucks or by construction of temporary water supply lines. It was determined that installation of a water supply well at the site would greatly reduce the construction costs of future phases of the work. A separate contract for installation of the pump, motor, and discharge line is being prepared and should be complete prior to start of the next construction phase.

The present design, Construction Stage 2A, was completed through the ConceptC portion of the design. For various reasons, completion of the design was delayed for approximately 15 months. At the ConceptC meeting, drawings showing two alternative options for the configuration and dimensions of the disposal cells were presented to the Yuma Projects Office. After several months, a memorandum from YPO agreed that the new cell configuration with the long narrow cells would increase the volume and reduce the overall cost.

A-22 Waste Disposal Facility

The following information outlines the present cell configuration for the A-22 Waste Disposal Facility and two options which would increase the capacity while decreasing the overall cost. The information includes approximate quantities and the advantages and disadvantages for each option.

The first set of information is based on the Stage 1B cells (300' by 175') which are currently under construction.

At the CONCEPTC meeting at Yuma, it was discussed that changing from 32 small cells to 16 larger cells would reduce the earthwork quantities and cost of the next phase of the work. This seemed reasonable. So upon consulting with representatives from Burns & Roe, it was agreed to eliminate the earth berm between 2 cells, thus making 1 large cell (610' by 175'). This is shown as Stage 2A, Option 1.

Mr. Curt Cloud, Chief Inspector at the Yuma Projects Office, telephoned to discuss the existing arrangement of cells for the ongoing construction of Stage 1B cells. In the discussion, he noted that the slope of the original ground and the stair-stepping elevations of the cells created some difficulties in the slope of the embankments between the cells.

As the designer/specification writer for the next phase of the work, this concerned me. If the contractor was having difficulty with the stair-stepping of cells that are 300' by 175', then how would cells that are 610' by 175' effect the next phase of the work? The design was revisited and another option was studied. The CONCEPTC determination to reduce the cells from 32 small to 16 large cells remained, however the dimensions were changed to a more symmetrical 300' by 360'. This is shown as Stage 2A, Option 2.

A-22 Waste Disposal Facility, Stage 1B

32 cells at 300' by 175' (13 foot deep w/ 6" earth cover, 6" gravel cover)

Requires:
1) 7' excavation below original grade (300,000 cy)
2) 6' embankment around cells (174,000 cy)
3) 40 mil PVC lining material (200,000 sq yd)
4) 6" earth cover over PVC lining (33,500 cy)
5) 6" pit run gravel cover (33,500 cy)
6) 128 discharge chutes
7) 1200 lin. ft of 4-inch PVC pipe with 128 4-inch pinch valves
8) 7200 lin. ft of 6-inch PVC pipe with 13 6-inch pinch valves
9) 6" gravel surfacing on embankments (5,000 cy)
10) 32 sludge depth measurement poles.

Advantages: 1) Consistent with Stage 1A work which is already complete and operational.
2) Guarantees even distribution of sludge.

Disadvantages: 1) Requires more construction of embankments.
2) Requires more discharge chutes (4 per cell).
3) Requires more PVC pipe and pinch valves.

A-22 Waste Disposal Facility, Stage 2A - Option 1

16 cells at 610' by 175' (13 foot deep w/ 1' earth cover)

Requires: 1) 6.5' excavation below original grade (295,000 cy)
2) 6.5' embankment around cells (150,000 cy)
3) 40 mil PVC lining material (200,000 sq yd)
4) 1' earth cover over PVC lining (67,000 cy)
5) 64 discharge chutes
6) 650 lin. ft of 4-inch PVC pipe with 64 4-inch pinch valves
7) 6900 lin. ft of 6-inch PVC pipe with 10 6-inch pinch valves
8) 6" gravel surfacing on embankments (4,500 cy)
9) 16 sludge depth measurement poles.

Advantages: 1) Overall volume for sludge disposal increases by 8 percent compared to Stage 1B (an additional 38,000 cy of sludge).
2) Guarantees even distribution of sludge.
3) Reduction in quantity in materials and earthwork.
4) Reduction in overall cost.

Disadvantages: 1) Stair-stepping of cells is difficult because of 610' length of cell. Will result in a 1.5' elevation change over 20' in the embankment.
2) Increased possibility of wave action damage to the cells due to north/south winds.

A-22 Waste Disposal Facility, Stage 2A - Option 2

16 cells at 300′ by 360′ (13 foot deep w/ 1′ earth cover)

Requires:
1) 6′ excavation below original grade (295,000 cy)
2) 6.5′ embankment around cells (125,000 cy)
3) 40 mil PVC lining material (200,000 sq yd)
4) 1′ earth cover over PVC lining (65,000 cy)
5) 64 discharge chutes
6) 650 lin. ft of 4-inch PVC pipe with 64 4-inch pinch valves
7) 4200 lin. ft of 6-inch PVC pipe with 10 6-inch pinch valves
8) 6" gravel surfacing on embankments (4,500 cy)
9) 16 sludge depth measurement poles.

Advantages:
1) Overall volume for sludge disposal increases by 15 percent compared to Stage 1B (an additional 69,000 cy of sludge).
2) Reduction in quantity in materials and earthwork.
3) Reduction in overall cost.
4) Easier to construct symmetrical cells.
5) Stair-stepping of cells is easier because of 300′ length of cell.
6) Increased surface area to expedite evaporation and drying process.

Disadvantages:
1) Possible uneven settlement of dissolved solids over the 360′ width of the cell. Should verify w/ Burns & Roe that this will not occur.
2) Increased possibility of wave action damage to the cells due to winds predominantly from the west.