# Desalination in Texas

## RO technology key to additional water supply source.

By John Seifert and John Rogers

For the city of El Paso, the Fort Bliss Army Base, and surrounding communities, an additional water supply source is needed to keep pace with a rapid growth in population and accompanying economic expansion in the area. To provide this additional water source, work is under way on a $31-million desalination facility. The total project cost of $78 million includes source wells, blend wells, collector pipelines, distribution pipelines, concentrate pipeline, and surface injection facilities.

When completed in 2007, the project will produce 15.5 MG of high-quality desalinated water that will be blended with another 12 MG of moderately fresh groundwater from 16 new wells now being drilled, for a total of 27.5 MG of drinkable water daily. The El Paso-Fort Bliss Desalination Facility will be one of the largest inland facilities of its type in the world.

At the heart of the facility is a reverse osmosis (RO) filtration system that will remove minerals such as calcium, sulfate, chloride, nitrate, and iron from brackish groundwater that does not meet drinking water standards.

***Eleven monitoring wells were drilled to monitor any changes in both water levels and water quality as the Hueco Bolson aquifer yielded its brackish groundwater.***

### Permeate Production Facility

The RO plant is a permeate production facility that was designed by CDM, Inc. (www.cdm.com) to blend the permeate water with the natural groundwater. CDM performed the work under subcontract to Moreno Cardenas Inc. (www.morenocardenas.com), the prime consultant, which performed the civil and site design at the facility. LBG-Guyton Associates (www. lbgweb.com) provided consulting services to help identify a potential site for deep-well injection disposal of concentrate, design and test a pilot well, and assist the permitting of the underground injection.

Permeate water is aggressive water, because buffering minerals have been removed, and it is low on the pH scale. The permeate water is mixed in a blending chamber with slightly brackish groundwater to provide drinking-quality water.

The process wing of the RO plant is about 19,000 sq ft. The single-story, 30-ft high structure will contain five RO membrane (Hydranautics, www.hydranautics.com) modules from Advanced Environmental Water Technology (www.thinkh20 .com), five RO feed pumps, a clean-in-place system that cleans the membranes when they become fouled, three chemical feed rooms (two active, one for future use), an electrical room, control room, maintenance shop, membrane storage room, and a research laboratory. There is also space for an additional RO module, or a membrane unit for increasing the permeate recovery of the process. The administration wing is about 5,600 sq ft, including offices, reception area, conference room, toilets and lockers, communications room, instrument shop, library, and janitor room.

The RO modules consist of pressure vessels that contain membrane elements installed in series. Each pressure vessel contains seven membranes and each RO module contains 72 pressure vessels. Brackish water is pumped into the pressure vessels via a manifold system and the water flows through the vessels and the membranes in a parallel flow arrangement. The membranes separate dissolved solids, viruses, bacteria, spores, nitrate, etc. from the water to make it drinkable.

A multi-stage vertical turbine feed pump is utilized to pump the high TDS water into the pressure vessels for desalination, forcing the majority of the water across the membrane surface. The remaining portion of the water is concentrated with minerals and other contaminants and is rejected through the ends of the membranes and collected for disposal. Each RO unit uses eight-in. diameter low-pressure, high-rejection spiral-wound membranes that are constructed of thin film composites to reject 98.5 percent to 99 percent of the solids.

Before the desalination process begins, water will enter the RO plant site from two separate well fields, the existing Montana Well Field and the new wells installed on Fort Bliss property. The two streams will be metered and directed to either the process water units for treatment or bypassing the process for blending with the permeate water. The raw water flow stream passes through a mechanical sand strainer. The strained raw water is directed to preliminary treatment consisting of chemical pretreatment to lower the pH and inhibit scale formation and cartridge filtration to remove fine particles before introduction into the membranes.

Following pretreatment, the water is then pumped through individual three-mgd permeate, two-stage RO modules by high-pressure pumps. Each RO module will be served by a dedicated feed pump. The permeate from the RO modules is then directed to the permeate chamber in the clear well structure and eventually blended with raw well water in the mixing zone of the clear well structure.

The blended water is chemically treated to reduce its corrosiveness and to provide a chlorine residual to prevent bacterial growth in the distribution system. Finished water is pumped with high service pumps to the existing distribution system. A portion of the finished water will flow by gravity from the clear well to the Montana Ground Storage Reservoir to provide a different point of introduction. Concentrate from the RO modules is piped to a concentrate disposal pump station that will convey it about 18 miles to the disposal site.

## Process Area Floor Plan

In designing the RO facility, the process area floor plan was developed around the membrane modules. The RO modules are arranged in a line, which results in a long membrane room. Cartridge filters are arranged in a line adjacent to the RO modules and parallel to the long building dimension. Three major piping trenches were designed for the various piping to and from the cartridge filters and membrane modules. This facilitates access to each module, places piping below grade, and provides efficient foundation design with trenches oriented parallel to the long axis of the building.

The area south of the modules will be open to the south exterior wall to allow removal of a pressure vessel if necessary, and more importantly, to provide access for a boom vehicle, which will be used to remove and reinstall RO feed pumps, actuated valves, and fittings on the membrane module assemblies, as needed as part of maintenance operations.

The membrane selection process proved challenging. RO membranes are generally defined by construction materials, construction configuration, productivity (gpd), operating pressures, and salt rejection characteristics. Membrane elements supplied for recent large scale brackish water desalination projects have been overwhelmingly made of thin film composite/polyamides (TFC/PA) construction in a spiral-wound configuration. These TFC/PA membranes are distinctly different from the previous generation of cellulose acetate (CA) membranes. TFC/PA membranes typically operate at lower pressures, have higher capacities, and improved scale rejection over CA membranes. As a result, membrane selection was limited to the TFC/PA membrane class for this project.

To help evaluate membranes for this project, RO membrane manufacturers provided computer programs that project membrane performance based upon feedwater characteristics. The programs perform hydraulic and physi-chemical calculations that allow the program user to compare various membrane configurations and various membrane operating characteristics such as flux rate and degradation of performance with time.

Program output provided projections of critical water quality parameters of the solubility of sparingly soluble salts such as calcium carbonate, calcium sulfate, barium sulfate, and silica; and saturation index (Langelier, Stiff and Davis). Thus the projection programs allowed the consideration of many variables to narrow down an optimal design. The designs derived from these projections were then tested in a direct pilot program over a period of nine months.

## Determining Subsurface Conditions

The new water supply wells are the result of study and drilling to identify optimal locations for them. LBG-Guyton was involved in the drilling and testing of 11 monitoring wells that will be used to detect changes in water levels and water quality as brackish groundwater is withdrawn from the Hueco Bolson aquifer.

A major component of the project is the disposal of the liquid concentrate generated from the RO process. LBG-Guyton was charged with helping identify a potential area for deep-well injection disposal of the concentrate, designing a test well and injection wells, and assisting with obtaining authorization for the underground injection of the concentrate.

After identifying a potential disposal site on Fort Bliss property about 18 miles northeast of the desalination facility, four test holes and a test well were drilled to determine subsurface geohydrologic characteristics, fault trends, and permeable zones capable of receiving an injected concentrate of desalinated water byproducts with as much as 8,000 mg/L of dissolved solids. The Silurian-age Fusselman Dolomite, encountered from 2,200 to 2,800 ft, and potentially deeper formations, appears to have the best reservoir characteristics.

Usually, conventional mud rotary drilling equipment is used to drill these types of wells. In this case, the use of air rotary equipment allowed the contractor to maintain a clean drilling hole, enabling clean water samples to be obtained as the drilling progressed. After the test well was constructed, down-hole pressure transducers were employed to measure formation pressure changes and the aquifer response to water pumping and injection.

The air rotary equipment could be operated at high pressure, which allowed the pilot injection well to be drilled to about 3,800 ft, while simultaneously removing drill cuttings and pumping water from the hole. Water samples were taken from depths of 1,300 ft to 3,800 ft to check water quality and water temperature, which reached 120 degrees Fahrenheit. The testing procedure for the pilot injection well (test well) included conducting a pumping test at a rate of 500 gpm, capturing water from the test, and using the water after filtration for an injection test.

## Streamlined Permitting Process

Getting the pilot well and four additional injection well sites authorized through the Texas Commission on Environmental Quality required LBG-Guyton to demonstrate that concentrate flowing out of the facility would basically be brackish water and not a toxic hazardous waste. Before this effort, Texas did not have a well-defined process for the permitting of desalination byproducts disposal.

A permitting procedure was created with a Class V injection well authorization and strict well construction standards instead of a Class I injection well permit. The less stringent regulatory standard enabled the project to be permitted in an expedited manner and at a considerably lower cost. GE

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