Desalination of Brackish Groundwater in El Paso, Texas

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Population and Environment

El Paso is on the border of two nations – the United States and Mexico – and three states – Texas, New Mexico, and the Mexican state of Chihuahua. Its population of 594,000 makes it the sixth largest city in Texas and the 24th largest city in the United States. El Paso is in El Paso County and comprises most of the county's population, which is estimated at 717,000. Located in the Chihuahuan Desert, the city receives 302 days of sunshine annually and an average of 8.8 inches of rain per year.

El Paso Water Utilities (EPWU) has served the residents of the City of El Paso since 1910. However, in 1989 the Public Service Board, EPWU's board of trustees, made the decision to begin serving colonias and other areas of the county that needed services. The Texas legislature designated El Paso the regional planner for water and wastewater services within the county in 1995 and gave the Board priority for the public funding of regional water and wastewater projects.

Today, El Paso Water Utilities provides water to nearly 95 percent of El Paso County on a wholesale or retail basis. It draws water from the Rio Grande and two transboundary aquifers, the Hueco and Mesilla Bolson aquifers. These resources are shared with neighbors in the United States and Mexico. The Rio Grande provides water to users in Colorado, New Mexico, Texas, and Mexico, while the aquifers are pumped by users in Texas, New Mexico, and Mexico.

Growth in the region has been rapid. According to the 2000 Census, the population of El Paso County increased by 88,000, or 15 percent, between 1990 and 2000. Much of the growth was outside the city limits in communities such as Horizon City, San Elizario, Vinton and Fabens. The population increased 9.5 percent within the city limits, compared to 52 percent in the area outside the city limits.

El Paso and Juárez comprise one of the largest metropolitan areas on the U.S./Mexico border, and much of the growth resulted from maquiladoras that proliferated in the Juárez region as businesses capitalized on the North American Free Trade Agreement. The population in Juárez increased from 798,000 to 1.2 million between 1990 and 2000, bringing the combined population of this metropolitan area to nearly 1.9 million. The population of this area was estimated at more than 2 million in 2004, and it is expected to reach 3.4 million by 2020.

Water Resources

EPWU completed a 50-year Water Resource Management Plan in 1991 to ensure sufficient water for the rapidly growing service area. The plan outlines the means for prioritizing and augmenting water supply resources through increased conservation, additional surface water use,

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expansion of the reclaimed water system, desalination of brackish groundwater, and the importation of water into the El Paso area. This long-term plan was updated in 2001 and has been incorporated into the regional and state water plans.

El Paso is a leader in water conservation in the Southwest. The city's conservation ordinance, adopted in 1991, combined with education, enforcement, rate methodology, rebates, and other incentives, has made conservation a way of life for the city's residents. Per capita water use, once more than 200 gallons per day, had fallen to 149 gallons per day in 2003. However, based on surveys in which respondents indicate they can further reduce water use, EPWU has set a goal of reducing per capita consumption to 140 gallons per day by 2010.

Conservation is not sufficient to supply the area's growing population, so El Paso reclaims water from its four wastewater treatment plants. Pipelines carry reclaimed water to customers in all areas of the city for use in nonpotable applications such as turf irrigation or industrial use.

EPWU has also worked with El Paso County Water Improvement District No. 1 to increase its use of river water. In 1991, El Paso's downtown water treatment plant was treating 40 million gallons per day (mgd) of Rio Grande water. EPWU has since constructed and expanded an additional water treatment plant, bringing total treatment capacity to 100 mgd during years when there is a full supply. In 2002, the river supplied 50 percent of the water supply, but the percentage is greatly reduced during years of river drought. Additional resources, such as desalinated groundwater, are needed both to meet the needs of the growing population and to serve the city during drought conditions.

Project Background

EPWU has been analyzing the potential for desalination of brackish groundwater for several years. In the early 1990s, preliminary feasibility reports were prepared and pilot plant studies showed that brackish (salty) groundwater could be desalinated and used as an alternative resource. But many projects involving desalination were stalled because of the high capital and operating costs and the troublesome issue of how to deal with the concentrate.

With recent advances in membrane technology and private sector competition, the costs for reverse osmosis systems have been reduced. Competition has reduced the price of membranes and equipment and efficiencies have reduced the use of power, making it possible to produce desalinated water at a lower cost. When combined with the escalating cost of acquiring additional sources of fresh water, including the environmental costs and inherent roadblocks in development, desalination is emerging as a choice for cities such as El Paso.

In 1997, EPWU, the Juárez water utility and other agencies on both sides of the border commissioned the U.S. Geological Survey (USGS) to conduct a detailed analysis of the amount of fresh water remaining in the Hueco Bolson, the amount of brackish water available, plus a determination of the flow patterns. EPWU used data from the USGS groundwater model to determine where to site a desalination plant and source wells and obtain the initial information for deep well injections. Without these groundwater models and the technology associated with the information, it would have been very difficult to determine where best to locate these facilities.

In 2001, EPWU began to plan the construction of a 20 mgd desalination plant to be located near the El Paso International Airport. The plant, as planned, would serve customers in a recently annexed area on the east side of the city, the East Montana area outside the city limits, portions of the city's east side, and Northeast El Paso.

The U.S. Army installation, Fort Bliss, which is located in El Paso, was concurrently considering the construction of a desalination facility. Most of Fort Bliss' water comes from its wells that draw from the Hueco Bolson, and the military installation was looking for additional resources to meet future water requirements. The Army was in the early stages of planning a 7.5 mgd plant.

The two entities began to discuss the concept of building a single, larger desalination plant to supply both El Paso and Fort Bliss. Such a plant would be more economical for both, while providing for better management of the aquifer. A public-public partnership was formed to construct what would be the world's largest inland desalination plant. EPWU would deliver sufficient water to Fort Bliss to meet current and future demand, and Fort Bliss would be positioned to use its existing wells as backup or as an emergency supply.

The Army proposed to lease the land for constructing and operating the plant and its infrastructure. It also underwrote the cost of investigating the deep-well injection of the residual concentrate formed during the desalination process and provided brackish wells for blending. EPWU agreed to design, build, operate and maintain the plant and supporting facilities, as well as conduct any related engineering studies. Fort Bliss consultants conducted the environmental impact study that will be used to determine the best site for the plant and process used.

The project includes the rehabilitation of 15 existing wells plus three new source wells, 16 blend wells, a 27.5-mgd plant, concentrate disposal facilities, and pipelines for collection, transmission, and concentrate disposal. Wells will be located along Loop 375 to protect El Paso's and Fort Bliss' fresh wells from brackish water intrusion, which has been a significant problem in managing the Hueco Bolson.

The U.S.G.S. model shows that brackish groundwater is flowing toward the city's fresh water wells. However, the water pumped for the desalination plant will reduce brackish water intrusion, thereby protecting fresh groundwater for El Paso and Fort Bliss.

The total project cost is estimated at $72 million, and EPWU has received $21 in federal funding to offset the costs. The State of Texas authorized a $1 million zero-interest loan which was used for design purposes. Furthermore, the Department of Defense (Army) provided $3.3 million to do the test hole drilling for concentrate disposal and to pay for the Environmental Impact Statement (EIS).

Process

The desalination plant will use reverse osmosis to obtain potable water from brackish water drawn from the Hueco Bolson. In this process, raw water passes through a fine membrane that salts cannot pass through. The collection of membranes and associated inlet and outlet piping is referred to as a module. Modules are typically eight inches in diameter and 40 feet long. They are usually arranged horizontally in stacks of six or more modules high, with common distribution and collection header pipes for a number of stacks.

Reverse osmosis produces purified water called permeate. Raw water from new and existing well fields will be pumped to the plant and flow into the process building through a static mixer and cartridge filters. Mixers prevent or remove chemical scaling or biological growth; filters remove turbidity and suspended solids from the raw water before it is pumped to the reverse osmosis membrane modules. Plans call for 18.5 mgd of water from existing wells to pass through five reverse osmosis membrane modules, where approximately 83 percent of the water will be recovered. Each module will produce approximately 3.1 mgd of permeate. The process will yield a total of 15.5 mgd of permeate and 3 mgd of water will be output as concentrate.

At the conclusion of the reverse osmosis process, the permeate is routed to an underground storage tank called a clearwell, and the concentrate is routed to a disposal facility. In the clearwell, the permeate is combined with an additional 12 mgd of untreated water from new wells to yield a total of 27.5 mgd of potable water. The estimated proportion is 1.3 parts permeate to one part blend water, which will produce water containing less than 270 milligrams per liter (mg/l) of chlorides and less than 800 mg/l of total dissolved solids.

Chemicals are added to the blended water to adjust the pH and act as a disinfectant before a five-pump system drives the finished water to the distribution system and a ground storage tank.

Concentrate Disposal

Coastal plants that desalinate ocean water return the concentrated brine to the ocean, but this option is not available to El Paso. A study was conducted to evaluate several alternatives for concentrate disposal, including injection wells, enhanced evaporation, solar ponds and simple evaporation ponds. The study analyzed the regulatory, siting, technical, and economic aspects of each. Based on the results, two methods were selected for additional study – evaporation ponds and deep-well injection. The preferred method of disposal is deep-well injection, which is significantly less expensive than using evaporation ponds; however, either method would require a permit from the Texas Commission on Environmental Quality (TCEQ).

With deep-well injection, concentrate from the desalination plant would be pumped through underground pipes to the injection site. The concentrate would be placed in porous, underground rock via wells, and the site would confine the concentrate to prevent migration to fresh water, provide storage volume sufficient for 50 years of operation, and meet all underground injection control permitting standards adopted by the TCEQ. Based on test results, the concentrate water quality will be better than that of the receiving brackish water.

TCEQ requires that local geologic and hydrologic conditions must be investigated, which includes compiling data on previously drilled wells, conducting geophysical and seismic work, drilling test holes, taking water samples and cores, and testing pilot wells. Three potential injection sites were identified and evaluated, and it was determined that the most technically suitable and least expensive site to permit was approximately 20 miles northeast of the plant site at the Texas-New Mexico border near McGregor Range.

The Army, through its contractor, drilled four test holes at the site to find a good geological formation that could be used for injecting the concentrate. Based on those tests, the University of Texas at El Paso conducted the geophysics study that EPWU used to create a geologic model and obtain a portion of the data needed for permitting. EPWU subsequently drilled a pilot well within the dolomite formation to obtain the additional data needed. EPWU is seeking TCEQ approval for three wells with a total capacity of 5 mgd. Once approved, the additional wells will be drilled, which will dictate the pipeline route.

If the injection wells are not approved, the concentrate from the desalination plant will be pumped through underground pipes to ponds at the Fred Hervey Water Reclamation Plant in northeast El Paso. The water in the concentrate would be removed through natural evaporation. The solid residue remaining after evaporation of the water would be transported to a landfill. Evaporation ponds must use liners to confine the concentrate so it does not migrate to fresh water or soil and provide sufficient storage volume and surface area to ensure the continuous operation of the plant.

Three options were considered – conventional evaporation ponds, an evaporation system using misting equipment, and a system that uses a concentrator step to condense the solution.

Conventional evaporation ponds, the simplest option, are easiest to construct, have minimal mechanical equipment requirements and are relatively inexpensive to operate and maintain. However, a conventional pond would measure 772 acres, which would necessitate a large capital investment. The construction cost for conventional evaporation ponds is estimated at $41 million, and operation and maintenance costs would be $1 million per year.

Misting equipment, used in the second option, propels the concentrate into the air in a mist to increase the evaporation rate. This system needs only 294 acres of pond area, which requires a smaller capital investment than conventional evaporation ponds, but the savings are offset by increased operation and maintenance costs. Furthermore, misters cannot be used during periods of high winds. This option was eliminated

The third option, using a concentrator step, would require only a 77-acre pond. An added advantage is the additional water recovered by the concentrator system, which reduces the volume of concentrate discharged to the ponds. This method requires considerably higher operation and maintenance costs than the other options, and is not a proven method in large applications.

Engineering Studies and Pilot Plant Work

A number of additional studies were undertaken in association with the design and potential environmental effects of the project. They include an analysis of existing production facilities, which characterized the wells that would supply water to the facility for treatment, and a well-testing program that produced data used to predict the quality of blend water. A reverse osmosis pilot plant was constructed to test the lubricants, cleaners and membranes used in the reverse osmosis process and determine which worked best with local water. The U.S. Bureau of Reclamation funded a study that explored an alternative approach toward concentrate disposal, and EPWU conducted preliminary investigations to determine of the feasibility of using the concentrate in recreational venues, such as in the irrigation of turf areas. Also, as required by the National Environmental Policy Act, Fort Bliss is completing an Environmental Impact Statement.

Environmental Impact Statement

In July 2004, the Army published and distributed copies of the Draft Environmental Impact Statement for the proposed leasing of lands, siting, construction, and operation of the desalination plant and associated infrastructure. The Army is considering three alternative sites for the desalination plant and two alternative disposal methods for the concentrate. The Draft EIS compares the environmental effects of six action alternatives, which combine each site with either deep-well injection or evaporation ponds as the method of concentrate disposal. The study analyzes the effects on geology and soils, water resources, utilities and services, hazardous materials and waste, air quality, biological resources, land use and aesthetics, transportation, cultural resources, and socioeconomic and environmental justice.

The seventh alternative would be to take no action. With this alternative, the desalination facilities would not be constructed on Fort Bliss land.

The Department of the Army, through the Commanding General at Fort Bliss, will use the Desalination EIS and public input on the findings in deciding whether to grant an easement to EPWU for the construction and operation of the plant and supporting facilities and, if so, which site EPWU will be permitted to use for the facilities. No decision will be made until the Army reviews the environmental impacts, considers the public comments, and determines that implementation of the proposed action is compatible with the installation's mission. The preferred alternative will be identified in the Final EIS.

The design of the facilities is nearly complete and the Record of Decision on the EIS is expected in early December 2005. Construction of the plant would begin after that time, most probably in early spring 2005, with completion in mid- to late-2006.

Summary

El Paso began pilot planting brackish groundwater treatment in El Paso more than 10 years ago. It was not pursued at that time because of the much higher cost of desalination compared to other alternatives and the difficult issue of dealing with concentrate disposal in the desert.

In recent years, the advances in membrane costs and the capital and operating costs for reverse osmosis systems have been reduced. During the same time, the cost of acquiring additional water resources has increased. Desalination, now recognized as a drought-proof alternative water resource, has become a viable option for arid cities such as El Paso. The challenge for all U.S. desert cities in the future is to develop the more economical concentrate disposal alternatives.

The Fort Bliss/El Paso Desalination Facilities project is a great example of how a public-public partnership can work beneficially for both parties.