Technical Memorandum

Brackish Water Desalination for Public Water Supply in Las Cruces, New Mexico

Prepared for **City of Las Cruces, New Mexico**

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1. Introduction

Desalination is a process that is receiving increased attention in the southwestern United States as an alternative source of drinking water supply for municipalities. This technical memorandum provides a brief description of desalination processes, benefits, limitations, and regulatory considerations for the use of desalination as part of the City of Las Cruces public water supply.

Desalination is the process of physically removing dissolved solids—primarily salts and minerals—from water. There are two major classes of commercialized technologies for desalination: membrane desalination and thermal desalination. Membrane desalination, or reverse osmosis (RO), uses pressure to force brackish water through a membrane. This process produces clean water on one side of the membrane, leaving the remaining water concentrated with all the influent dissolved solids and other constituents on the other side (commonly referred to as "concentrate"). Thermal (evaporative) desalination heats water until it evaporates, leaving behind dissolved solids, then captures the pure water vapor and condenses it back into a liquid. Advanced treatment methods are capable of removing total dissolved solids (TDS) and other constituents to levels that comply with drinking water standards (CASS, 2006).

2. General Usage

As of 2013, more than 17,000 desalination plants were operating around the world; approximately 2,000 of these plants with capacity larger than 0.3 million gallons per day (mgd) were located in the United States (Carter, 2015). The most common water sources used for desalination are brackish groundwater (groundwater with high TDS concentrations), seawater, and treated wastewater. The majority of desalination facilities operating in the United States are located in coastal areas and use seawater as their source. Several inland desalination facilities currently operate in the southwestern United States, including Texas (Big Springs, Ft. Stockton, and El Paso), New Mexico (Cloudcroft), and Arizona (Goodyear and Scottsdale). The facilities in Big Springs, Texas and Cloudcroft, New Mexico both use reclaimed wastewater as their water source, while the others use brackish groundwater.

3. Source Water Availability

The City of Las Cruces is located in the Lower Rio Grande Basin; therefore, this technical memorandum focuses on the brackish groundwater reserves of the Lower Rio Grande Basin. The two principal groundwater aquifers in this basin, the Mesilla Basin and the Southern Jornada del Muerto Basin, represent the primary sources of drinking water for the City of Las Cruces. These two aquifers also contain brackish groundwater that could potentially be used as a potable water source.

The three shallowest water-bearing zones (which vary in thickness from 100 to 1,000 feet) are an important freshwater resource, with typical TDS concentrations below 1,000 ppm. The deepest water-bearing zone (the Lower Santa Fe unit) contains brackish water, with TDS concentrations greater than 3,000 ppm (Hawley and Lozinsky, 1992). Wilson et al. (1981) estimate that approximately 2.7 million acre-feet of brackish water is associated with the Lower Santa Fe unit of the Mesilla Basin.

The Southern Jornada del Muerto Basin also contains freshwater in the shallower aquifers and brackish water resources in the Lower Santa Fe unit, with TDS concentrations in the range of 2,500 to 9,000 ppm (Hawley and Lozinsky, 1992). Shomaker and Finch (1996) estimate the volume of brackish water in this basin to be up to 59 million acre-feet. These brackish water aquifers typically receive minimal, if any, natural recharge, and should be considered finite, non-renewable resources.

4. Benefits and Limitations

Because the Mesilla and Southern Jornada del Muerto Basins contain brackish water resources, there is potential for desalination to provide an alternative potable resource. The benefit of developing brackish water resources through desalination is that it provides an alternative water source when freshwater resources have been exhausted. A major limitation associated with the development of brackish water resources is cost. Capital expenditures and operation and maintenance costs for desalination are site-specific, and are dependent upon factors such as depth, location, and quality of source water, treatment plant size, pre- and post-treatment processes, regulatory issues, land costs, conveyance of water, and the concentrate disposal method (Arroyo and Shirazi, 2012).

A recent Texas Water Development Board study reviewed the implementation and long-term costs of brackish groundwater desalination in Texas (Arroyo and Shirazi, 2012). The operation and maintenance cost (including the debt for capital costs at construction) for a plant that installed RO and used evaporation ponds to dispose of concentrate was $3.27 per 1,000 gallons. The City of Las Cruces currently produces drinking water at a cost of $1.90 per 1,000 gallons, with costs primarily related to storage and distribution. Desalination and concentrate disposal costs would likely be added to the production costs, potentially increasing the cost to produce drinking water by three to five times.

The principal site-specific issues that would require consideration include the source location and quality, treatment plant siting and infrastructure, specific pre-treatment process, energy costs, method of concentrate management, and regulatory requirements. Depending upon local conditions, brackish groundwater may need to be treated for a range of constituents other than TDS to meet federal, state, and local regulations. RO desalination costs are directly related to the salinity and location of the source water; therefore, the cost of treating water with a TDS concentration of 6,000 ppm will be substantially higher than the cost of treating water with a TDS concentration of 3,000 ppm. This difference is due to the energy/pressure required to force water through a membrane, as well as a corresponding decrease in membrane life expectancy. Likewise, use of a source that is located at a depth of 2,400 feet below ground surface (bgs) will be substantially more expensive than use of source that is located at a depth of 1,200 feet bgs due to the costs associated with well drilling and pumping processes. A detailed study for Las Cruces would be required to more accurately estimate the cost of desalinating brackish water sources, which is beyond the scope of this memorandum; however, the following comparisons can be made that would affect the costs:

- Brackish water sources are generally two to three times deeper than existing freshwater resources, which may require larger pumps and more power to extract water from deeper wells. Deeper wells in high TDS water require more intensive long-term maintenance than typical drinking water wells.

- Desalination would require disposal of the concentrate, which represents a significant additional cost.

- Naturally occurring arsenic and uranium are known to exist is some portions of the aquifers used in Las Cruces. If these constituents occurred in the brackish water used, they would have to be removed as part of the treatment process, potentially adding to the treatment cost.

The choice of pre-treatment process is another important component that can have a significant impact on costs. The cost of chemicals used during this step to prepare the water for filtration can represent in the range of 20 percent of the total treatment costs (Foldager, 2003). Electrical expenses can account for one-third to one-half of the operating costs (Carter, 2015; NRC, 2004).

Choice of method of concentrate management for an inland desalination facility has received attention due to its significant costs and because it is often a limiting factor (Keyes et al., 2012) to desalination plant production. Current desalination efficiencies range from 60 to 85 percent; therefore, 15 to 40 percent of the available water is not used and must be disposed of properly (Hightower, 2004). The preferred methods of concentrate management are deep well injection, evaporation ponds, discharge to sanitary sewers, and land application.

Each method has pros and cons based on site-specific conditions and costs. Deep well injection is costly, but is sometimes the most viable option. The Kay Bailey Hutchinson desalination plant, which serves El Paso, Texas and is the largest inland desalination plant in the world, uses three deep water injection wells at a capital cost of around $19 million, which represents around 20 percent of the total project costs, including ongoing operation and maintenance (Keyes et al., 2012). Evaporation ponds are an alternative where land is available; however, there are still substantial costs associated with permitting and pond construction and maintenance. Discharging the concentrate into the public sewer system has the potential to harm the conveyance infrastructure or the wastewater treatment plant itself depending upon the volume and concentration of the waste stream.

5. Regulatory Issues

Several regulatory requirements must be addressed prior to the implementation of a desalination strategy. The following subsections discuss these requirements relative to method of concentrate management.

5.1 Deep Well Injection

In New Mexico, deep well injection requires permits, monitor wells, and completions in deep, contained aquifers to ensure that freshwater supplies are not compromised (Hightower, 2004). The New Mexico Environment Department (NMED) Ground Water Quality Bureau (GWQB) regulates discharges that have the potential to cause groundwater contamination by enforcing the New Mexico Water Quality Act and the Water Quality Control Commission regulations that apply to sources with a TDS concentration less than 10,000 ppm. The NMED provides Class I and Class V discharge permits, which are relative to the depth, location, and quality of the water in the formation that will receive the concentrate. Discharge permits require four main components (Menetrey, 2004): (1) an operational plan that includes construction and operating requirements designed to ensure that the facility is properly constructed, (2) a monitoring plan that includes sampling, analysis, and the submittal of monitoring reports, (3) a contingency plan that outlines measures to be taken in the event of a system failure or groundwater contamination, and (4) a closure plan that outlines the steps to be followed to ensure that waste is not left on-site.

5.2 Evaporation Ponds

Discharge to evaporation ponds also requires an NMED permit, with the following requirements: (1) an operational management and construction plan that includes a double synthetic liner and leak detection system, (2) monitoring requirements that include flow metering, effluent sampling, groundwater monitoring, routine inspection of the leak detection system, and routine inspection of the liner and berms around the pond, (3) contingency requirements including liner repair, spill reporting and corrective action, and abatement of groundwater contamination, and (4) closure requirements that include the removal or plugging of the conveyance system, perforating or removing the liner, the filling of the pond and grading for positive drainage, and two years of post-closure groundwater monitoring (Menetrey, 2004).

Evaporation ponds also hold the potential for recovery of the chemical constituents of the concentrate that have commercial value (NRC, 2004). Although gypsum, sodium chloride, and magnesium sulfate are three minerals that have commercial value, further research is required to quantify the cost-effectiveness of this method (NRC, 2004).

5.3 Discharge to Sanitary Sewers

Discharge of concentrate into sanitary sewers does not require involvement by the NMED GWQB, other than to ensure that the municipal infrastructure could meet regulatory requirements for effluent disposal (Menetrey, 2004). While this allows the concentrate to be diluted with other wastewater streams, the City of Las Cruces' wastewater treatment process does not remove TDS, so the dissolved solids would be discharged into the Rio Grande.

5.4 Land Application

Land applications are not currently permitted by the NMED due to concerns regarding impacts to shallow groundwater and salt accumulation on the ground surface.

6. Conclusion

There are potential benefits and limitations from the treatment of brackish groundwater through the process of desalination. Given the ready availability and high quality of the freshwater currently available to the City of Las Cruces, desalination of brackish water is not needed at this time. Use of brackish water as a potable water supply comes with a much higher cost due to the required treatment system, concentrate management, permitting, pumping, and other factors. The current 40-year water plan for the City of Las Cruces combines conservation and fresh water source development to continue to provide a reliable water source to the city's residents without the use of desalination. The economic viability of desalination should continue to be evaluated as an alternative in both local and regional long-term water planning.

References

Arroyo, J. and S. Shirazi. 2012. *Cost of brackish groundwater desalination in Texas*. Innovative Water Technologies, Texas Water Development Board.

Carter, N.T. 2015. *Desalination and membrane technologies: Federal research and adoption issues*. Congressional Research Service, 7-5700.

Central Arizona Salinity Study (CASS). 2006. *Phase II – Concentrate management*. Available at <https://www.phoenix.gov/waterservicessite/Documents/d_046551.pdf>

Hawley, J.W. and R.P. Lozinsky. 1992. *Hydrogeologic framework of the Mesilla Basin in New Mexico and western Texas*. New Mexico Bureau of Mines and Mineral Resources Open-File Report 323.

Hightower, M. 2004. Desalination technology development and potential applications in New Mexico. pp. 225-233 in *Proceedings: Identifying technologies to improve regional water stewardship: A conference series featuring intersections of technology and water management, North–Middle Rio Grande corridor.* Hosted by the University of New Mexico, April 21-22, 2004. Available at <http://www.unm.edu/~cstp/Reports/H2O_Session_4/4-6_Hightower.pdf> Accessed March 11, 2015.

Keyes, C.G. Jr., M.P. Fahy, and B. Tansel (Eds.). 2012. *Concentrate management in desalination: Case studies*. American Society of Civil Engineers.

Menetrey, K. 2004. Regulation of brine discharges for protection of groundwater quality in New Mexico [transcript of presentation]. p. 69-72 in *Water desalination and reuse strategies for New Mexico, New Mexico Water Resources Research Institute*. September 2004.

National Research Council (NRC). 2004. *Review of the desalination and water purification technology roadmap*.

Shomaker, J.W. and S.T. Finch Jr. 1996. *Multilayer groundwater flow model of Southern Jornada Del Muerto Basin, Dona Ana County, New Mexico, and predicted effects of pumping wells LRG-430-S29 and -S30, City of Las Cruces, New Mexico*.

Wilson C.A., R.R. White, B.R. Orr, and R.G. Roybal. 1981. *Water resources of the Rincon and Mesilla Valleys and adjacent areas, New Mexico*. New Mexico State Engineer Office Technical Report 43.