Chapter 13

Status Report on Brackish Groundwater and Desalination in the Gulf Coast Aquifer of Texas

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Introduction

As the population of Texas grows and the demand for water increases, access to adequate supplies of fresh water will become a critical issue in many areas of the state. The 2002 State Water Plan projects that by the year 2050, the population of Texas will double and demand for fresh water will increase by about 20 percent (13 million acre-feet). The 2002 State Water Plan further suggests that by 2050 almost 900 water user groups will either need to reduce demand or develop additional water sources beyond those currently available to meet shortages during periods of drought (TWDB, 2002). One potential additional source that is available is brackish groundwater. Texas has a large reserve of brackish groundwater in its aquifers. A study funded by the Texas Water Development Board (TWDB) and completed by LBG-Guyton (2003) estimates that there is almost 2.7 billion acre-feet of brackish groundwater that may be available for use in the state. About one-fifth of this volume is present in the Gulf Coast aquifer (Table 13-1). However, to be usable, brackish groundwater needs to be desalinated.

Table 13-1. Volumetric estimates and characteristics summary of brackish groundwater in the Gulf Coast aquifer (Modified from LBG-Guyton, 2003; Kalaswad and others, 2004).

Region	Volume of Brackish Groundwater (acre-feet)		Availability (low to high)	Productivity (low to high)	Production Costs (low to high)
	1,000 - 3,000 mg/l TDS	3,000 - 10,000 mg/l TDS			
G	None Reported	None Reported	Not Applicable	Not Applicable	Not Applicable
H	60,814,000	25,018,000	High	High	Low to Moderate
I	26,203,000	13,487,000	High	High	Low to Moderate
K	11,574,000	20,543,000	Moderate to High	High	Low to Moderate
L	34,721,000	11,574,000	Moderate	High	Low
M	105,031,000	33,244,000	Moderate	Moderate	Low to Moderate
N	116,086,000	64,198,000	Moderate	Moderate to High	Low
P	None Reported	None Reported	Not Applicable	Not Applicable	Not Applicable

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Our paper is a status report on the characteristics of brackish groundwater in the Gulf Coast aquifer and the desalination facilities (existing and planned) that use, or plan to use, this source. Brackish groundwater is defined as water containing total dissolved solids (TDS) between 1,000 and 10,000 milligrams per liter (mg/l). This definition includes slightly saline (1,000 to 3,000 mg/l TDS) and moderately saline (3,000 to 10,000 mg/l TDS) water as defined by the Texas Water Development Board (Ashworth and Hopkins, 1995).

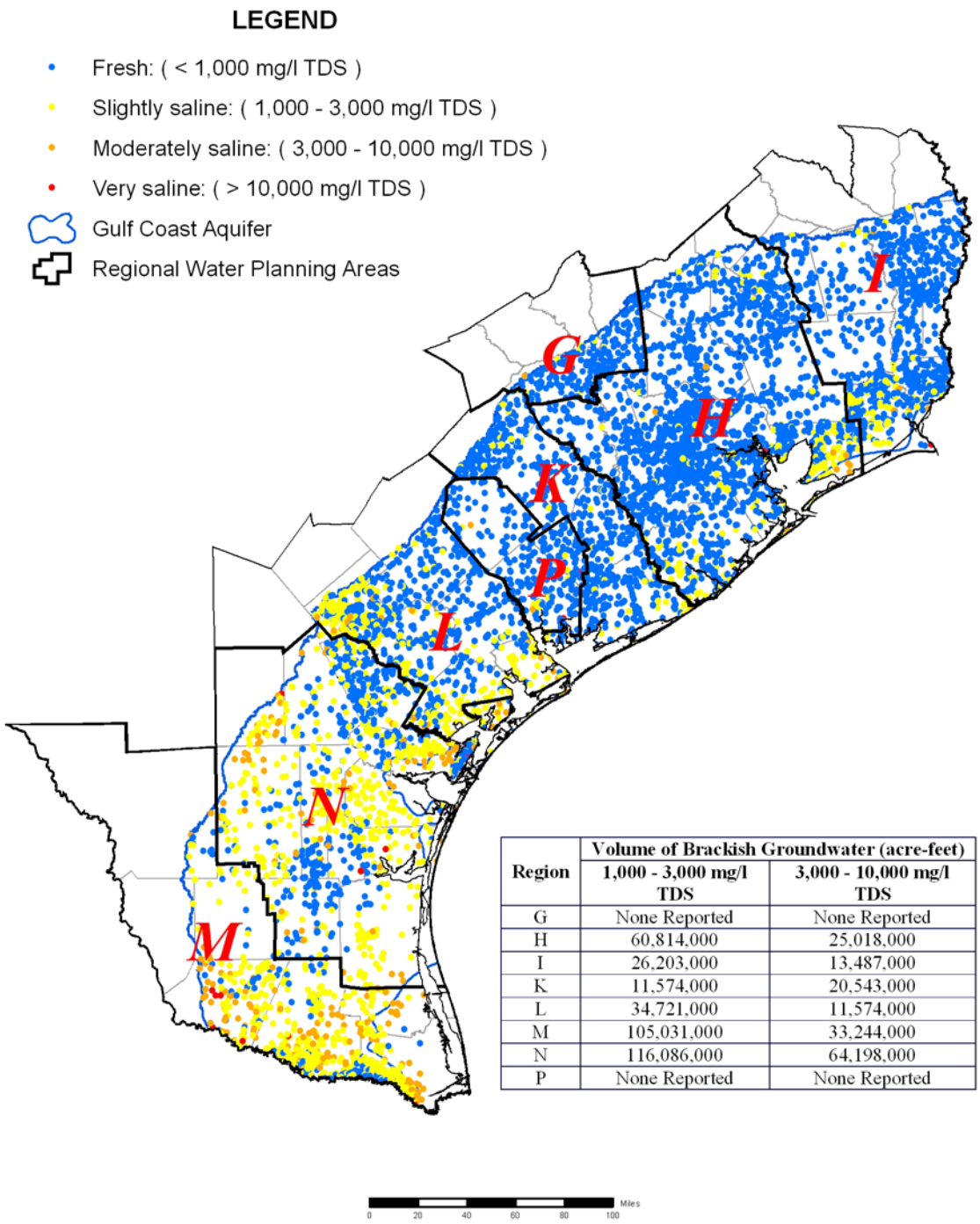
Brackish Groundwater in the Gulf Coast Aquifer

The approximately 100-mile-wide Gulf Coast aquifer in Texas extends along the Gulf of Mexico from the Rio Grande in the south to the Louisiana border in the north. The aquifer is made up of four connected, individual aquifers formed in Tertiary and Quaternary sediments with a collective maximum thickness ranging from 700 feet in the southern portion of the aquifer to 1,300 feet in the northern portion of the aquifer. The Gulf Coast aquifer provides water to all or parts of 54 counties, with municipal and irrigation use accounting for almost 90 percent of the total pumpage from the aquifer (Ashworth and Hopkins, 1995). Parts or all of eight regional water planning areas (G, H, I, K, L, M, N, and P) and three groundwater management areas (14, 15, and 16) overlie the Gulf Coast aquifer (Figures 13-1 and 13-2, respectively).

Water quality in the Gulf Coast aquifer varies with depth and location. It is generally fresh (containing less than 1,000 mg/l TDS) in the northern half of the aquifer and brackish (containing 1,000 to 10,000 mg/l TDS) in the southern half (Figure 13-1) and generally tends to deteriorate with depth throughout the extent of the aquifer. The Gulf Coast aquifer has a large volume of brackish water (about 522 million acre-feet)—the largest of any aquifer in Texas (LBG-Guyton, 2003). Of this volume, approximately 354 million acre-feet is water with a TDS concentration of between 1,000 and 3,000 mg/l and approximately 168 million acre-feet is water between 3,000 and 10,000 mg/l TDS (Kalaswad and others, 2004).

The volume of brackish groundwater that is available to the regional water planning areas that overlie the Gulf Coast aquifer varies. Regions G and P are not known to have brackish groundwater, but the other regions have fairly substantial volumes (Table 13-1 and Figure 13-1). The largest volume of water is present in Region N (Coastal Bend region), where approximately 180 million acre-feet of brackish groundwater in the 1,000 to 10,000 mg/l TDS range is estimated to be available. Region M (the Rio Grande Regional Water Planning Area) also has a fairly large volume of brackish groundwater, estimated at approximately 138 million acre-feet. Availability of brackish groundwater in the other regions ranges from approximately 32 million acre-feet in Region K to 85 million acre-feet in Region H (Table 13-1 and Figure 13-1).

LBG-Guyton (2003) assessed the characteristics of brackish aquifers in terms of the availability of brackish water in the aquifer, the productivity of the aquifer, and source water production costs. Availability is defined as a general measure of the volume of brackish groundwater in an aquifer, productivity as a measure of the ease of production from an aquifer based on the transmissivity of the aquifer, and production costs as an indication of the relative costs that would be incurred to produce the brackish groundwater (excluding treatment and disposal costs). An ideal aquifer would have the characteristics of high availability, high productivity, and low production costs. It is important to note that this methodology of scoring the merits of an aquifer



Region	Volume of Brackish Groundwater (acre-feet)	
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Figure 13-1. Distribution and volumetric estimates of brackish groundwater in the regional water planning areas overlying the Gulf Coast aquifer (modified from LBG-Guyton, 2003).

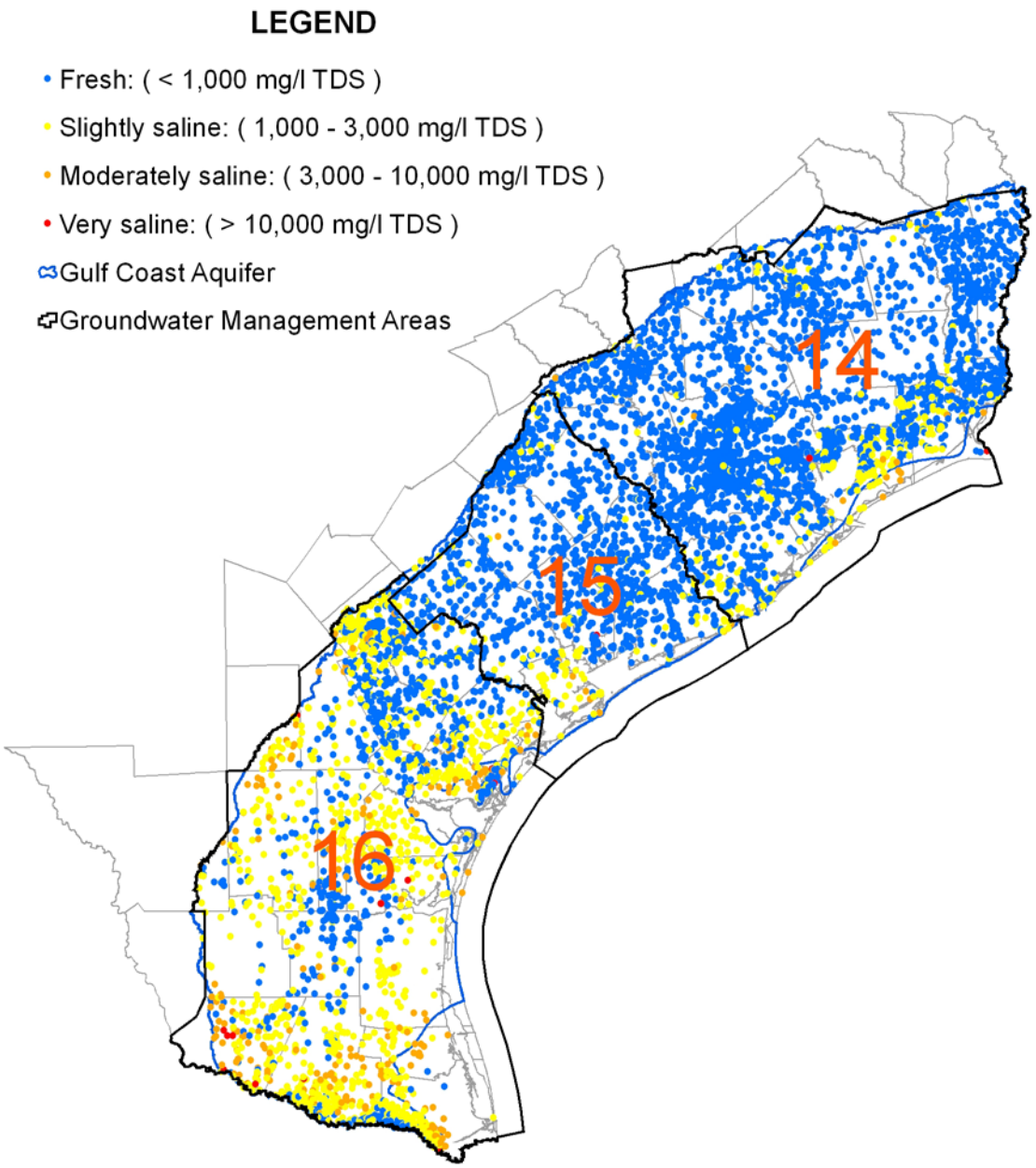

Figure 13-2. Distribution of brackish groundwater in the groundwater management areas overlying the Gulf Coast aquifer (modified from LBG-Guyton, 2003).

was developed only as a guide to regional water planning and was not intended to be used for siting facilities. Furthermore, the favorability of a brackish aquifer as a source of supply will depend to a large extent on the needs of a water user group and local conditions.

Generally, availability is estimated to be high to moderate in all regional water planning areas (except in Region P where it is estimated to be low), while productivity is estimated to be high

(except in Regions M and N in the southern part of the aquifer where it is moderate to high). Production costs throughout the aquifer are estimated to be generally low to moderate (Table 13-1).

Desalination Activities

To be usable, brackish groundwater needs to be treated (desalinated). Without treatment, brackish water can cause scaling and corrosion problems in water wells and piping and cannot be used in many industrial processes (Warner, 2001). The Texas Commission on Environmental Quality has established a secondary standard of 1,000 mg/l TDS for public water supply systems (TCEQ, 2004). Groundwater with TDS concentrations greater than 3,000 mg/l is not usable for irrigation without dilution or desalination and, although considered satisfactory for most poultry and livestock watering, can cause health problems at increasingly higher concentrations (Warner, 2001).

A recently completed desalination facility study by Nicot and others (2005) for the TWDB indicates that there are 38 public water systems with desalination facilities with design capacities of approximately about 0.025 million gallons per day (mgd) or more in the state. Although the study did not attempt to gather information on the source of brackish groundwater (that is, the aquifer), we tentatively identified ten facilities (Figure 13-3) that use brackish groundwater from the Gulf Coast aquifer based on the geographical location of the facility and the source of groundwater supply within the county as listed in the 2002 State Water Plan database. A list of the ten facilities and their characteristics is presented in Table 13-2.

The ten desalination facilities have a combined design capacity of 11.76 mgd, use reverse osmosis to desalinate the water for drinking water purposes, and all of them—with the exception of the DS Waters of America, LP desalination plant in Waller County—are located in the southern half of the Gulf Coast aquifer (Table 13-2). This is an area that LBG-Guyton (2003) has identified as having the most favorable characteristics for producing brackish groundwater.

Nicot and others (2005) also identified other public water systems with desalination capacities of less than 0.025 mgd and industrial and non-public water system facilities, but detailed information for these facilities was not easily available and is not listed in their report. Therefore, it is difficult to identify such facilities that are using brackish groundwater from the Gulf Coast aquifer and consequently these are not discussed in our paper.

In addition to the existing facilities mentioned above, there are other facilities that are being considered by the regional water planning groups to meet anticipated future shortages. Also, two TWDB-funded brackish groundwater desalination demonstration projects over the Gulf Coast aquifer are scheduled to be implemented in 2006. A brief description of these projects is presented below.

The 79th Texas Legislature, 2005, considered and approved a TWDB Legislative Appropriations Request that included $600,000 for implementing a proposed Brackish Groundwater Desalination Initiative. The goal of the initiative is to continue facilitating the development of brackish groundwater desalination supplies in Texas by assisting in the creation of engineering

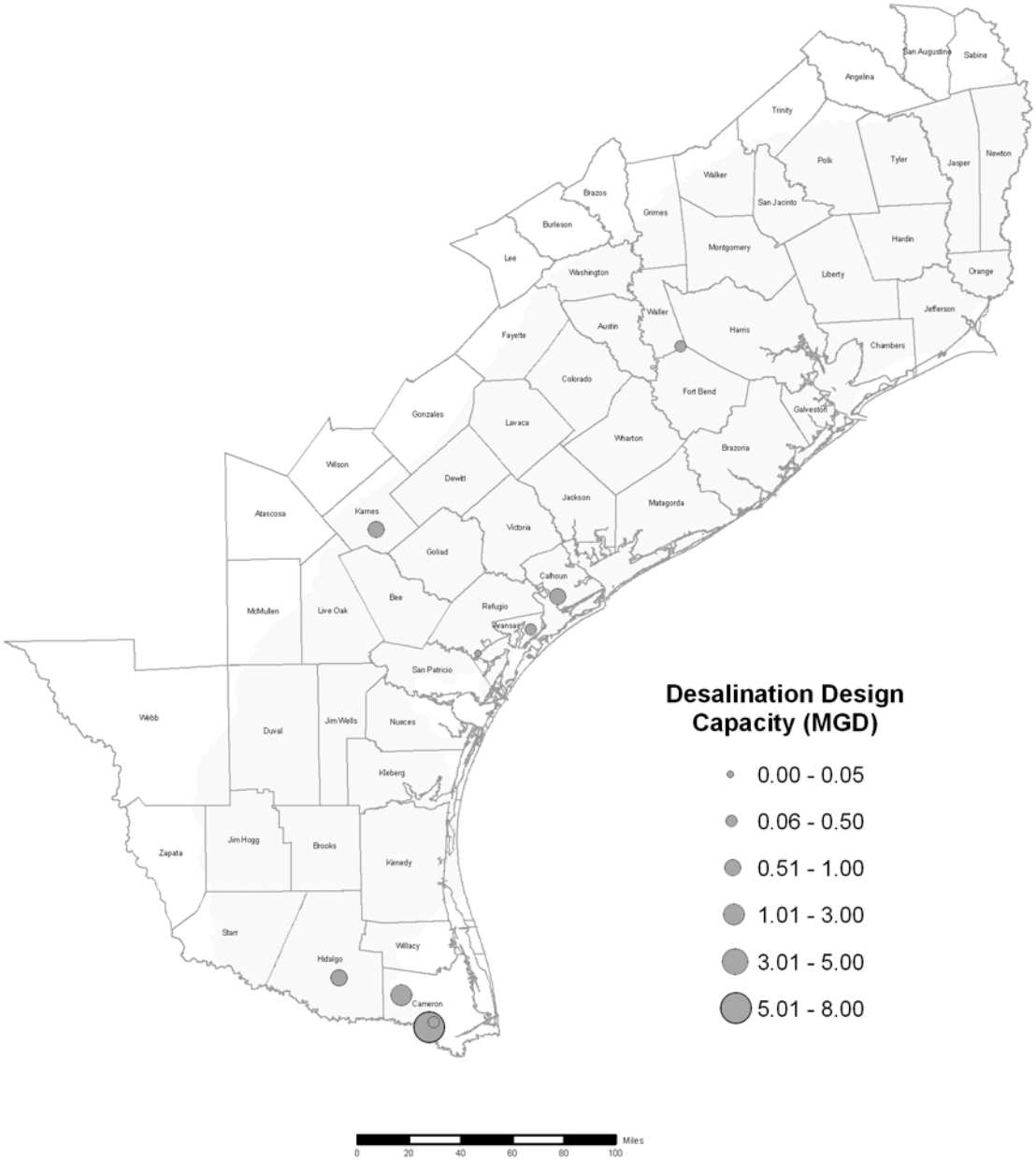

Figure 13-3. Location of brackish groundwater desalination facilities over the Gulf Coast aquifer (modified from Nicot and others, 2005). See Table 13-2 for characteristics of the facilities.

facility roadmaps for characterizing source waters, using desalination technologies, and managing desalination concentrate. The primary focus of the initiative is on small-to-medium sized communities located in water-scarce areas of the state.

In November 2005, the TWDB selected the top three proposals from a pool of ten responses to serve as demonstration projects for the use of brackish groundwater desalination. Two of these

Table 13-2. Characteristic summary of Texas desalination facilities with capacity ≥0.025 mgd (Modified from Nicot and others, 2005).

Plant Name	County	Design Capacity (mgd)	Use	Source	Startup Year	Process	Blending?	Disposal Method
SWRA	Cameron	6.75	DW	GW	2004	RO	Yes	SWD
City of Primera	Cameron	2	DW	GW	2005	RO	Yes	SWD
City of Raymondville	Hidalgo	1	DW	GW	2004	RO	No	SWD
City of Kenedy	Karnes	0.72	DW	GW	1995	RO	Yes	SWD
City of Seadrift	Calhoun	0.52	DW	GW	1998	RO	Yes	SWD
Valley MUD #2	Cameron	0.5	DW	GW	2000	RO	Yes	SWD/LA
Holiday Beach WSC	Aransas	0.15	DW	GW	1998	RO	Yes	SWD
DS Waters of America, LP	Waller	0.09	DW	GW	1997	RO	No	SWR
City of Bayside	Refugio	0.029	DW	GW	1990	RO	No	EP
North Cameron /Hidalgo WA	Hidalgo	NA	DW	GW	2005	RO	Yes	SWD
Total Design Capacity (mgd)		**11.76**						

Notes: DW = drinking water; GW = groundwater; RO = reverse osmosis; SWD = discharge to surface water body; LA = land application; SWR = discharge to sewer; EP = discharge to evaporation pond; NA = information not available.

projects (North Cameron Regional Water Supply Corporation and City of Kenedy) will be located over the Gulf Coast aquifer. The North Cameron Regional Water Supply Corporation is constructing a brackish groundwater desalination plant that is scheduled to be completed by May 2006. The facility will treat 3.2 mgd of brackish groundwater from the Gulf Coast aquifer and produce a blended output of 5 mgd. The project proponents offer to develop a comprehensive engineering facility roadmap to track the development of the project from start to finish. The City of Kenedy is in the process of retrofitting and modernizing an existing reverse-osmosis groundwater desalination facility and proposes to conduct a feasibility study to add another such facility to meet the city's projected water needs. The project will allow for a factual comparison of the performance of a new system with the older reverse-osmosis filtration system currently in place. This will result in useful information (cost-benefit) for assessing replacement of similar facilities in other areas of the state.

In anticipation of expected future shortages, four regional water planning groups (regions K, L, M, and N) are recommending brackish groundwater desalination from the Gulf Coast aquifer as a water management strategy to meet these shortages. A short description of these projects follows. All information for the desalination projects within a regional water planning group was obtained from the region's initially prepared plan submitted to the TWDB for review. The reference to these is cited at the end of the description for each region. It is important to note that these initially prepared plans are still under review by the TWDB and have not yet been approved for inclusion in the 2007 State Water Plan.

Region K: The Lower Colorado Regional Water Planning Group (Region K) is recommending a brackish groundwater desalination facility for the STP Nuclear Operating Company in Matagorda County to meet expected shortages in steam electric usage starting in decade 2030. Region K has determined that the Gulf Coast aquifer has a significant volume of brackish water at the STP Nuclear Operating Company location with a TDS concentration of approximately 2,500 mg/l. The brackish groundwater desalination strategy would require the drilling of wells capable of supplying between 40 and 50 mgd (44,800 and 56,000 acre-feet) of brackish groundwater. A plant that is sized to provide 26.4 mgd (29,568 acre-feet) annually will be required. Region K estimates that water from this strategy can be produced for about $430 per acre foot. This is slightly less than one half of the cost of water from a seawater desalination facility (LCRWPG, 2005).

Region L: The South Texas Regional Water Planning Group (Region L) recommends Gulf Coast aquifer brackish groundwater desalination as a water management strategy in Refugio County to provide up to 9.07 mgd (10,160 acre-feet) of additional water annually to the Lower Guadalupe Water Supply Project. The desalination facilities will be located adjacent to the well field and will treat half the brackish water to produce a finished blended water supply that meets all potable water regulatory requirements. After desalination treatment and blending, the finished water from the brackish well field will be delivered to the Lower Guadalupe Water Supply Project transmission system for blending with surface water and other non-brackish groundwater from the Gulf Coast aquifer for delivery to Bexar County. The estimated incremental unit cost to add this supply to the Lower Guadalupe Water Supply Project is $796 acre-feet per year (STRWPG, 2005).

Region M: Based on the success of previous pilot studies and implementation of several projects, the Rio Grande Regional Water Planning Group (Region M) is recommending brackish groundwater desalination as a water management strategy for domestic, municipal, and industrial users in several areas of the region. The proposed desalination projects are expected to have design capacities of between 0.25 and 0.75 mgd (280 and 840 acre-feet). The volume of brackish groundwater required for these projects is expected to total approximately 62,000 acre-feet annually. The annual cost per acre-feet to implement this strategy is estimated to be $506 (RGRWPG, 2005).

Region N: Brackish groundwater desalination is one of 18 water management strategies recommended by the Coastal Bend Regional Water Planning Group (Region N) to meet anticipated shortages in municipal use. The region is recommending this strategy for several cities in Duval County (the cities of Benavides, Freer, and San Diego) and for other water user groups in Live Oak, Jim Wells, Kleberg, and San Patricio counties where brackish groundwater from the Gulf Coast aquifer is readily available. The recommended desalination facilities are relatively small, ranging from 0.6 to 1.2 mgd (672 to 1,344 acre-feet; CBRWPG, 2005).

Conclusions

There is an abundance of brackish groundwater in the Gulf Coast aquifer of Texas that is available for desalination. There are, however, difficulties associated with implementing such projects that can be particularly challenging for smaller communities. Chief among them are

managing the desalination waste and predicting the long-term performance of brackish groundwater aquifers. Progress is being made on these fronts (for example, work presently being pursued to ease the regulatory burden of desalination waste permitting and modeling the performance of brackish aquifers under pumping conditions) and we are optimistic that, with greater efficiencies offered by modern desalination technologies and continued support from the State, brackish groundwater desalination will play an important role as a source of water supply in the future.

References

Ashworth, J. B., and Hopkins, J., 1995, Aquifers of Texas: Texas Water Development Board Report 345, 69 p.

CBRWPG, 2005, Initially prepared regional water plan: Coastal Bend Regional Water Planning Group, Available at (http://www.twdb.state.tx.us/rwpg/2005_1PP/Region%20N/Volume%20I/Section%204B.pdf).

Kalaswad, S., Christian, B., and Petrossian, R., 2004, Brackish groundwater in Texas, *in* Arroyo, J., editor, The Future of Desalination in Texas, Volume II: Texas Water Development Board Report 363, p. 9–21.

LBG-Guyton Associates, 2003, Brackish groundwater manual for Texas regional water planning groups: Contract report prepared for the Texas Water Development Board, Austin, Texas, 188 p. Available at (http://www.twdb.state.tx.us/RWPG/rpgm_rpts/2001483395.pdf).

LCRWPG, 2005, Initially prepared Region "K" water plan for the Lower Colorado Water Planning Group: Lower Colorado Regional Water Planning Group. Available at (http://www.twdb.state.tx.us/rwpg/2005_1PP/Region%20K/Chapter%204.pdf).

Nicot, J.-P., Walden, S., Greenlee, L., and Els, J., 2005, A desalination database for Texas: Report prepared for the Texas Water Development Board, Austin, Texas, 35 p. Available at (http://www.twdb.state.tx.us/RWPG/rpgm_rpts/2004483021_Desal_Database_Texas.pdf).

RGRWPG, 2005, Initially prepared plan: Rio Grande Regional Water Planning Group Available at (http://www.twdb.state.tx.us/rwpg/2005_1PP/Region%20M/Chapter%204%20IPP.pdf).

SCTRWPG, 2005, Initially prepared 2006 regional water plan: South Central Texas Regional Water Planning Group Available at (http://www.twdb.state.tx.us/rwpg/2005_1PP/Region%20L/Volume%20II/Summary%20Sheets/Summary%20Sheet%204C.21%20Gulf%20Coast.pdf).

TCEQ, 2004, Drinking water standards governing drinking water quality and reporting requirements for public water systems: Texas Commission on Environmental Quality, 30 TAC Chapter 290, Subchapter F: TCEQ RG-346, 99 p.

TWDB, 2002, Water for Texas—2002 State Water Plan: Texas Water Development Board, v. 1, 155 p. Available at (http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2002/FinalWaterPlan2002.asp).

Warner, D. L., 2001, Technical and economic evaluations of the protection of saline ground water under the safe drinking water act and the UIC Regulations: Report submitted to the

Ground Water Protection Research Foundation, 44 p. Available at (http://www.gwpc.org/uic/State_App3.pdf).