Cost of Water Desalination in Texas

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Purpose of paper

To provide sample water production costs of brackish groundwater and seawater desalination in Texas.

Results

Water desalination is not new to Texas. In fact, in 1961 one of the first seawater desalination demonstration plants to be built in the United States was located at the Dow Chemical Complex in Freeport, Texas (The Dow Chemical Company, 1960; The Dow Chemical Company, 1961; Lomax, 2008). Twenty years later, a desalination production facility was installed at a public water system in Texas.[1] Since then, installed design desalination capacity has increased to over 80 million gallons per day produced by 39 facilities ranging in size from the small 25,000 gallons-per-day plants to the 27.5 million-gallons-per-day El Paso and Fort Bliss Kay Bailey Hutchison facility (TWDB, 2005; El Paso Water Utilities, 2007).

Approximately 80 percent of the current installed capacity in Texas is achieved by reverse-osmosis, a technology that has experienced remarkable improvements in the last 20 years and is now the leading technology for desalinating water around the globe.

In spite of the history of desalination in Texas and the recognized reliability of the technology, desalination is relatively new when compared to other better-known water management strategies, and this lack of familiarity prompts questions and concerns about its comparative costs. This is especially true for seawater desalination and, given the limited direct experience in the state with implementing seawater desalination projects, it is reasonable to seek reliable cost references. Unfortunately, in the words of a recognized industry expert, "seawater desalination projects are arguably the most multifaceted water projects undertaken and variations in project scope, size, location and accounting methods make true comparisons notoriously difficult" (Pankratz, 2007).

Nevertheless, for this paper we assembled a representative sample of projects consisting of recently completed brackish groundwater desalination projects and planning-level cost projections for proposed seawater desalination plants in Texas.

[1] Haciendas Del Norte in El Paso County.

Cost of water

The total production cost of water includes the cost of capital or debt service and operation and maintenance costs. Debt service costs are a function of the total capital cost of the project, the interest on the capital, and the loan payback period. The operation and maintenance costs are a function of chemical, power, equipment replacement, and labor costs.

The total unit cost of desalinated water may be calculated as follows:

$$\textit{Total unit cost of water} = \frac{\textit{annual debt service}}{\textit{365 X design capacity}} + \frac{\textit{operation and maintenance}}{\textit{production volume}}$$

The cost of desalinated water also could be calculated by assigning the debt service cost to the actual production volume (Wilf, 2007). Although desalination facilities are typically designed to operate close to their design capacity, in cases where the demand is substantially less than projected, this approach results in a higher cost of water. Another alternative is to calculate the debt service load on the basis of a life-cycle analysis and use an efficiency factor to estimate actual production volume instead of the design production capacity (Sturdivant, et al., 2009).

Many factors affect the capital and operational costs of desalination facilities (See Figure 1); a list of key factors includes the following (Graves & Choeffel, 2004; Younos, 2005):

Capital Costs	Operation and maintenance
Project location	Energy requirements
Quality and variability of the source water	Cost of power
Co-location with existing facilities	Equipment replacement
Concentrate management strategy	Chemicals
Environmental mitigation	Labor

In 2003, the U.S. Bureau of Reclamation (Reclamation) published planning-level estimating procedures for seawater and surface brackish desalination facilities delivered by conventional procurement methods.[2] The estimating procedures include monographs to calculate the impact of selected variables, such as cost of power, in the cost of desalination projects (USBOC, 2003). Another of Reclamation's products is WTCost©, a database and computer program with cost algorithms for different types of desalination pre-treatment and treatment technologies.

[2] Separate contract awards for design, specifications, and procurement documents and for construction and equipment.

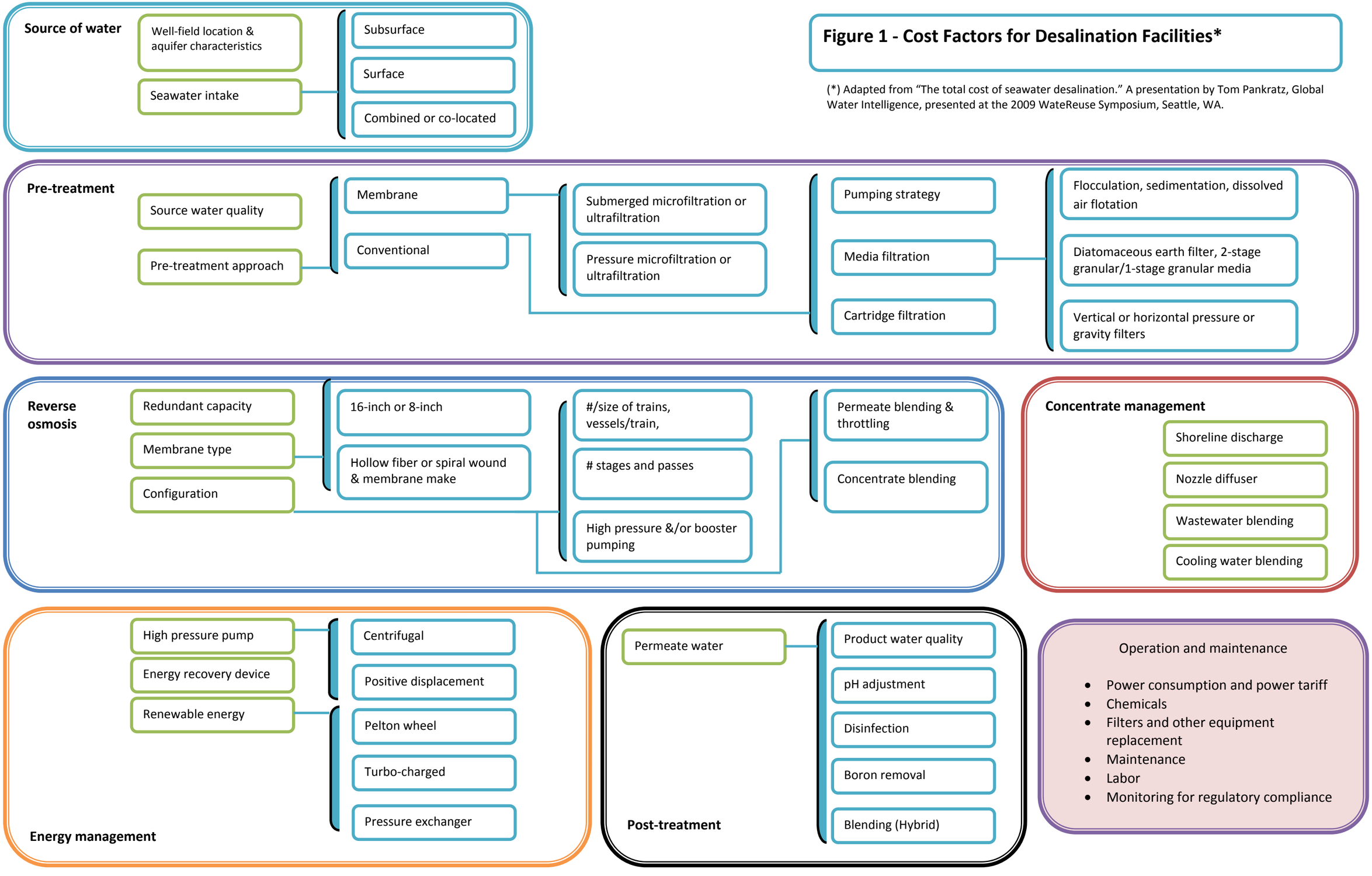

Figure 1 - Cost Factors for Desalination Facilities*

(*) Adapted from "The total cost of seawater desalination." A presentation by Tom Pankratz, Global Water Intelligence, presented at the 2009 WateReuse Symposium, Seattle, WA.

Methodology

We considered a sample of recently completed brackish groundwater desalination projects and recent planning proposals for seawater desalination projects in Texas.

The sample of brackish groundwater desalination plants consists of projects developed by the North Alamo Water Supply Corporation, the Southmost Regional Water Authority, and the El Paso Water Utilities. The North Alamo Water Supply Corporation has completed three facilities[3] since 2005 and participated as a lead partner in developing the North Cameron Regional Water Supply Corporation facility completed in 2007. The Southmost Regional Water Authority completed its 7.5 million-gallon-per-day plant in 2004, and El Paso Water Utilities' Kay Bailey Hutchison Brackish Groundwater Desalination Plant (27.5 million gallons per day) began operating in 2007. This sample, thus, includes small, medium, and large-scale facilities completed within the last five years.

For each of the facilities, the capital cost was converted to 2009 dollar equivalents by using Construction Cost Indexes and the debt service calculated on the basis of a 20-year amortization period at 6 percent interest. Jesús Leal of NRS Engineers provided the original capital cost information for all facilities except the El Paso-Ft. Bliss plant. Charles Browning, general manager of North Alamo Water Supply Corporation, provided recent operation and maintenance cost data for the North Cameron Regional Water Supply Corporation plant[4] and recommended using the operation and maintenance costs of the Lasara facility as representative for the all three North Alamo Water Supply Corporation facilities.[5] Judy Adams, manager of the Southmost Regional Brackish Groundwater Desalination Plant, and Mike Cortés of the Finance and Accounting Department of the El Paso Water Utilities provided operation, maintenance, and power costs for their respective facilities via e-mail.

Currently, Texas does not have a full-scale operating seawater desalination plant. However, planning-level costs for the proposed Lower Rio Grande Valley Seawater Desalination Plant (Brownsville Ship Channel) were developed on the basis of a comprehensive pilot study conducted by the Brownsville Public Utilities Board and reported in the 2008 Biennial Report on Seawater Desalination (TWDB, 2008). Additionally, in May 2009 the South Central Texas Regional Water Planning Group evaluated seawater desalination as one of the water management strategies to deliver water to south Bexar County; Sam Vaugh of HDR Inc., a consultant for the South Central Texas Regional Water Planning Group, provided the information via e-mail. In all cases,

[3] Charles Browning, general manager of North Alamo Water Supply Corporation, informed Innovative Water Technology staff that plans are underway to add another brackish groundwater desalination facility (North Donna), with an approximate design capacity of 2 million gallons per day.
[4] Facsimile from Charles Browning to Jorge Arroyo, September 30, 2009.
[5] Telephone conversation with Jorge Arroyo, September 18, 2009.

the cost of conveyance is noted as a reference and excluded from the production cost of water.

Results

The total production cost of desalinated brackish groundwater for a sample of recently completed projects in Texas ranges from $410 per acre-foot (North Alamo Water Supply Corporation plant at Lasara) to $847 per acre-foot (Southmost Regional Water Authority's plant) (Table 1). The projected cost of producing desalinated water from seawater ranges from $1,168 per acre-foot (treatment cost of a proposed 100 million-gallons-per-day facility to deliver water to southern Bexar County) to $1,881 per acre-foot (proposed 2.5 million-gallon-per-day facility in the Lower Rio Grande Valley) (Table 2).

Table 1-Total production cost of sample operational brackish groundwater desalination facilities in Texas

Facility	Plant start date	Construction cost ($)		Design capacity (MGD)	Power cost (¢/Kw-hr)	Production cost ($) per 1,000 Gallons			Total cost ($ per acre-foot)
		Original	2009-dollar equivalent			O&M	Debt	Total cost	
La Sara[6]	2005	2,000,000	2,297,400	1.2	8.0	0.80	0.46	1.26	410
Owassa[6]	2008	8,000,000	8,231,200	3.3	8.0	0.80	0.60	1.40	455
Doolittle[6]	2008	8,000,000	9,656,000	3.3	8.0	0.80	0.70	1.50	488
NCRWSC[7]	2007	6,500,000	6,955,000	2.2	8.0	1.17	0.76	1.93	629
KBH[8]	2007	87,000,000	93,090,000	27.5[9]	8.35	1.75	0.81	2.56	834
SRWA[10]	2004	26,190,993	33,760,190	7.5	7.49[11]	1.52	1.08	2.60	847

Although the above information provides a useful reference of the production cost of brackish It is important to note that the costs reported in Table 1 are estimates of what the production cost of water would be if the plants were to be built this year, the capital cost were amortized on a 20-year 6-percent interest basis, and if the unit operation and maintenance costs observed on the basis of actual operation to-date were maintained.

The value of this cost reference for brackish groundwater desalination could be enhanced by introducing data about the water source (salinity, distance and depth to the source), pre-treatment and concentrate management strategy used by the system.

[6] Facilities developed and/or operated by the North Alamo Water Supply Corporation
[7] North Cameron Regional Water Supply Corporation
[8] Kay Bailey Hutchison Brackish Groundwater Desalination Plant, El Paso
[9] This facility is currently operating at approximately 25 percent capacity (Jorge Arroyo, personal notes)
[10] Southmost Regional Water Authority
[11] Power to well field rated at 11.57 ¢/Kw-hr

Table 2 - Planning-level production costs for proposed seawater desalination facilities in Texas

Facility	Projected plant start date	Construction cost ($)		Design capacity (MGD)	Power cost (¢/Kw-hr)	Production cost ($ per 1,000 Gallons) (excludes conveyance)			Total cost ($ per acre-foot)*
						O&M	Debt service	Total cost	
Region L	N/A	Plant	657,691,244	100	9	2.01	1.57	3.59	1,168
		Conveyance	959,361,756						
Region L	N/A	Plant	513,748,496	75	9	2.05	1.64	3.69	1,201
		Conveyance	780,078,504						
Lower RGV**	2050	Plant	170,229,000	25	8	2.25	1.63	3.88	1,264
		Conveyance	12,180,000						
Region L	N/A	Plant	369,142,461	50	9	2.13	1.76	3.89	1,269
		Conveyance	646,226,539						
Region L	N/A	Plant	211,867,298	25	9	2.17	2.02	4.19	1,367
		Conveyance	400,664,702						
Lower RGV **	2012	Plant	31,748,566	2.5	6	2.74	3.03	5.77	1,881
		Conveyance	4,885,434						

(*) Excludes conveyance costs

(**) Final Pilot Plant Study Report (Brownsville Public Utilities Board, 2008)

Additional considerations

Several of the methodologies researched for this paper provide a valuable reference for a systematic planning-level water production cost estimating for desalination facilities (US Bureau of Reclamation, 2003; Wilf, 2007; Sturdivant, et al., 2009).

A greater effort than what has been invested in producing this paper is needed to provide a comprehensive and transferable life-cycle cost analysis of the costs of producing water at any operating reverse osmosis desalination facility.

A systematic water cost estimating tool for desalination facilities would be of benefit to planners and project developers. The usefulness of such a tool would be greater if it incorporates more of the cost factors described in this paper. Key factors include source water chemistry and location, reverse-osmosis recovery rate, blending ratio, energy recovery strategy, power tariff, concentrate management strategy and projected plant availability.

Works Cited

Brownsville Public Utilities Board. (2008). *Pilot study report, Texas Seawater Desalination Demonstration Project.* Brownsville Public Utilities Board.

El Paso Water Utilities. (2007). *Water*. Retrieved September 2009, from El Paso Water Utilities: http://www.epwu.org/water/desal_info.html

Graves, M., & Choeffel, K. (2004). Economic siting factors for seawater desalination projects using reverse-osmosis processes. In TWDB, *Report 363, Technical Papers, Case Studies and Desalination Technology Resources* (pp. 203-220). Texas Water Development Board.

Lomax, I. (2008). Experiences of Dow in the field of seawater reverse osmosis. *Desalination, Volume 224* , 111-118.

Pankratz, T. (2007, February 26). SWRO project estimating. *Water Desalination Report* .

Sturdivant, A. W., Rister, M. E., Rogers, C. S., Lacewell, R. D., Norris, J. W., Leal, J., et al. (2009). *An analysis of the economic and financial life-cycle costs of reverse-osmosis desalination in south Texas: A case study of the Southmost Facility.* Texas Water Resources Institute.

The Dow Chemical Company. (1961, July 5). Beutel terms phone call a shocker. *The Dow Texan* .

The Dow Chemical Company. (1960, August 31). Seawater conversion plant will make history. *Dow Texan* , p. 1960.

TWDB. (2008). *2008 Biennial report on seawater desalination.* Texas Water Development Board.

TWDB. (2005). *A desalination database for Texas.* Texas Water Development Board.

US Bureau of Reclamation. (2003). *Desalting handbbok for planners.* Denver: Bureau of Reclamation.

Wilf, M. (2007). *The guidebook to membrane desalination.* L'Aquila, Italy: Balaban Desalination Publications.

Younos, T. (2005). The economics of desalination (Issue 132). *Journal of Contemporary Water Research and Education* , 39-45.