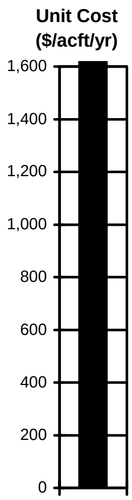
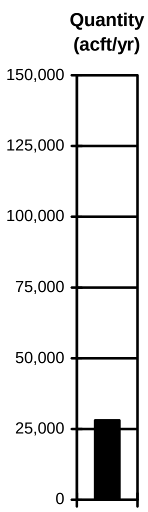
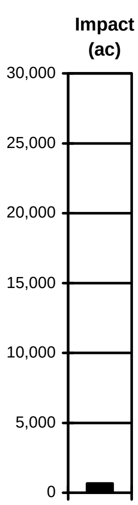
2006 South Central Texas Regional Water Plan
Water Management Strategy Summary Sheet







Name: Seawater Desalination – 25 MGD

Description: This strategy includes desalting seawater from San Antonio Bay and conveying water to the major municipal demand center of the South Central Region. Facilities include a raw water intake and water treatment plant near Seadrift, brine transmission and off-shore disposal system, 42-inch treated water transmission pipeline and associated pump stations for delivery of water a distance of approximately 126 miles to south Bexar County, and distribution system improvements for integration of the additional supply.

***Decade Needed*:** 2050 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**1,767**	**$/acft/yr**	**Treated Water Distributed**
Quantity of Water:	**28,004**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**673**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at the Aransas National Wildlife Refuge located across San Antonio Bay from the proposed intake site near Seadrift. Potential effects of diversions on bay salinity and estuarine habitat and species. Pipeline could traverse Attwater Prairie Chicken habitat.

Impacts on Water Resources:

Potential benefit to instream flows in the San Antonio River due to increased discharge of treated effluent.

Impacts on Agricultural & Natural Resources:

Temporary impacts due to construction of pipeline.

Other Relevant Factors per SCTRWPG:

Confirmation of technology and values used in developing costs prior to implementation. Perceived to have fewer associated environmental effects than typical fresh surface water supplies.

Comparison of Strategies to Meet Needs:

High unit cost, but potential for large drought-proof water supply. Unit cost is approximately 50 percent treatment and 50 percent conveyance. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Additional surface water supply without reductions in instream flows or freshwater inflows to the Guadalupe Estuary. Shared pipeline alignment with other recommended water management strategies.

Water Quality Considerations:

Integration of desalinated water with different corrosion chemistry may require conditioning of water to meet distribution system stability requirements. Operational treatment costs may be substantially reduced at source water salinities less than the assumed 25 ppt.

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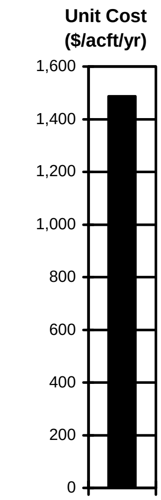

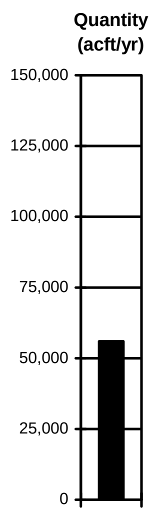

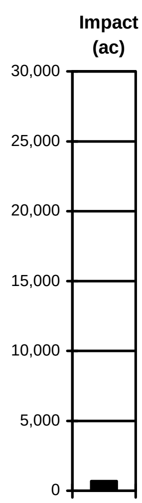

Name: Seawater Desalination – 50 MGD

Description: This strategy includes desalting seawater from San Antonio Bay and conveying water to the major municipal demand center of the South Central Region. Facilities include a raw water intake and water treatment plant near Seadrift, brine transmission and off-shore disposal system, 60-inch treated water transmission pipeline and associated pump stations for delivery of water a distance of approximately 126 miles to south Bexar County, and distribution system improvements for integration of the additional supply.

***Decade Needed*:** 2050 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**1,487**	**$/acft/yr**	**Treated Water Distributed**
Quantity of Water:	**56,008**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**693**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at the Aransas National Wildlife Refuge located across San Antonio Bay from the proposed intake site near Seadrift. Potential effects of diversions on bay salinity and estuarine habitat and species. Pipeline could traverse Attwater Prairie Chicken habitat.

Impacts on Water Resources:

Potential benefit to instream flows in the San Antonio River due to increased discharge of treated effluent.

Impacts on Agricultural & Natural Resources:

Temporary impacts due to construction of pipeline.

Other Relevant Factors per SCTRWPG:

Confirmation of technology and values used in developing costs prior to implementation. Perceived to have fewer associated environmental effects than typical fresh surface water supplies.

Comparison of Strategies to Meet Needs:

High unit cost, but potential for large drought-proof water supply. Unit cost is approximately 55 percent treatment and 45 percent conveyance. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Additional surface water supply without reductions in instream flows or freshwater inflows to the Guadalupe Estuary. Shared pipeline alignment with other recommended water management strategies.

Water Quality Considerations:

Integration of desalinated water with different corrosion chemistry may require conditioning of water to meet distribution system stability requirements. Operational treatment costs may be substantially reduced at source water salinities less than the assumed 25 ppt.

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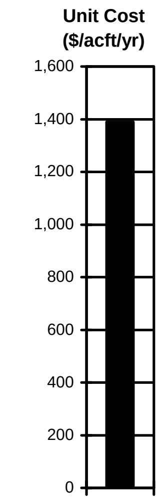

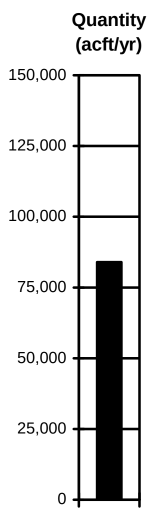

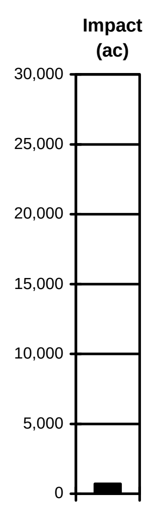

***Name: Seawater Desalination* – 75 MGD**

Description: This strategy includes desalting seawater from San Antonio Bay and conveying water to the major municipal demand center of the South Central Region. Facilities include a raw water intake and water treatment plant near Seadrift, brine transmission and off-shore disposal system, 72-inch treated water transmission pipeline and associated pump stations for delivery of water a distance of approximately 126 miles to south Bexar County, and distribution system improvements for integration of the additional supply.

***Decade Needed*:** 2050 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**1,390**	**$/acft/yr**	**Treated Water Distributed**
Quantity of Water:	**84,012**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**700**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at the Aransas National Wildlife Refuge located across San Antonio Bay from the proposed intake site near Seadrift. Potential effects of diversions on bay salinity and estuarine habitat and species. Pipeline could traverse Attwater Prairie Chicken habitat.

Impacts on Water Resources:

Potential benefit to instream flows in the San Antonio River due to increased discharge of treated effluent.

Impacts on Agricultural & Natural Resources:

Temporary impacts due to construction of pipeline.

Other Relevant Factors per SCTRWPG:

Confirmation of technology and values used in developing costs prior to implementation. Perceived to have fewer associated environmental effects than typical fresh surface water supplies.

Comparison of Strategies to Meet Needs:

High unit cost, but potential for large drought-proof water supply. Unit cost is approximately 56 percent treatment and 44 percent conveyance. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Additional surface water supply without reductions in instream flows or freshwater inflows to the Guadalupe Estuary. Shared pipeline alignment with other recommended water management strategies.

Water Quality Considerations:

Integration of desalinated water with different corrosion chemistry may require conditioning of water to meet distribution system stability requirements. Operational treatment costs may be substantially reduced at source water salinities less than the assumed 25 ppt.

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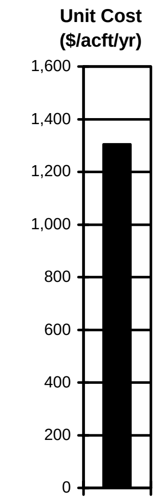

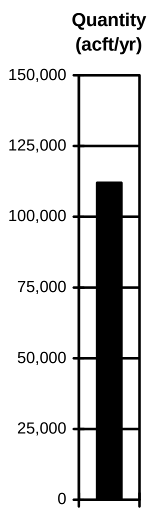

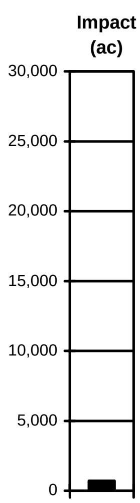

Name: Seawater Desalination – 100 MGD

Description: This strategy includes desalting seawater from San Antonio Bay and conveying water to the major municipal demand center of the South Central Region. Facilities include a raw water intake and water treatment plant near Seadrift, brine transmission and off-shore disposal system, 84-inch treated water transmission pipeline and associated pump stations for delivery of water a distance of approximately 126 miles to south Bexar County, and distribution system improvements for integration of the additional supply.

***Decade Needed*:** 2050 – 2060

Cost, Quantity of Water, and Land Impacted

Unit Cost of Water:	**1,305**	**$/acft/yr**	**Treated Water Distributed**
Quantity of Water:	**112,016**	**acft/yr**	**Reliability = Firm**
Land Impacted:	**706**	**acres**	

Additional Considerations per Regional Water Planning Guidelines

Environmental Factors:

Wintering population of endangered Whooping Cranes at the Aransas National Wildlife Refuge located across San Antonio Bay from the proposed intake site near Seadrift. Potential effects of diversions on bay salinity and estuarine habitat and species. Pipeline could traverse Attwater Prairie Chicken habitat.

Impacts on Water Resources:

Potential benefit to instream flows in the San Antonio River due to increased discharge of treated effluent.

Impacts on Agricultural & Natural Resources:

Temporary impacts due to construction of pipeline.

Other Relevant Factors per SCTRWPG:

Confirmation of technology and values used in developing costs prior to implementation. Perceived to have fewer associated environmental effects than typical fresh surface water supplies.

Comparison of Strategies to Meet Needs:

High unit cost, but potential for large drought-proof water supply. Unit cost is approximately 58 percent treatment and 42 percent conveyance. No conflicts with other recommended water management strategies.

Interbasin Transfer Issues:

Not applicable.

Third-Party Impacts of Voluntary Transfers:

Not applicable.

Regional Efficiency:

Additional surface water supply without reductions in instream flows or freshwater inflows to the Guadalupe Estuary. Shared pipeline alignment with other recommended water management strategies.

Water Quality Considerations:

Integration of desalinated water with different corrosion chemistry may require conditioning of water to meet distribution system stability requirements. Operational treatment costs may be substantially reduced at source water salinities less than the assumed 25 ppt.

4C.22 Seawater Desalination

4C.22.1 Description of Water Management Strategy

Desalting seawater from the Gulf of Mexico in the vicinity of San Antonio Bay is a potential source of freshwater supplies for municipal and industrial use. This section presents desalination information for a range of quantities so that a range of costs can be considered. The strategy will be a large-scale desalt plant with finished water capacity ranging from 25 to 100 MGD (28,004 to 112,016 acft/yr) drawing saline water from San Antonio Bay with a conveyance system for delivery of treated water to the major municipal water demand center of the South Central Texas Region.

The desalination treatment plant is located adjacent to San Antonio Bay near the City of Seadrift and the treated water delivery location is south Bexar County as shown in Figure 4C.22-1. The desalination process produces a concentrated brine that is conveyed out to the open Gulf of Mexico for diffusion in deep water. The treatment plant location and concentrate pipeline are shown in Figure 4C.22-2.

4C.22.1.1 General Desalination Background

The commercially available processes that are currently used to desalt seawater and brackish groundwater to produce potable water are:

- Distillation (thermal) Processes; and
- Membrane (non-thermal) Processes.

The following sections describe each of these processes and discuss a number of issues that should be considered before selecting a process for desalination of seawater.

4C.22.1.2 Distillation (Thermal) Processes

Distillation processes produce purified water by vaporizing a portion of the saline feedstock to form steam. Since the salts dissolved in the feedstock are nonvolatile, they remain unvaporized and the steam formed is captured as a pure condensate. Distillation processes are normally very energy-intensive, quite expensive, and are generally used for large-scale desalination of seawater. Heat is usually supplied by steam produced by boilers or from a turbine power cycle used for electric power generation. Distillation plants are commonly co-sited with power plants.

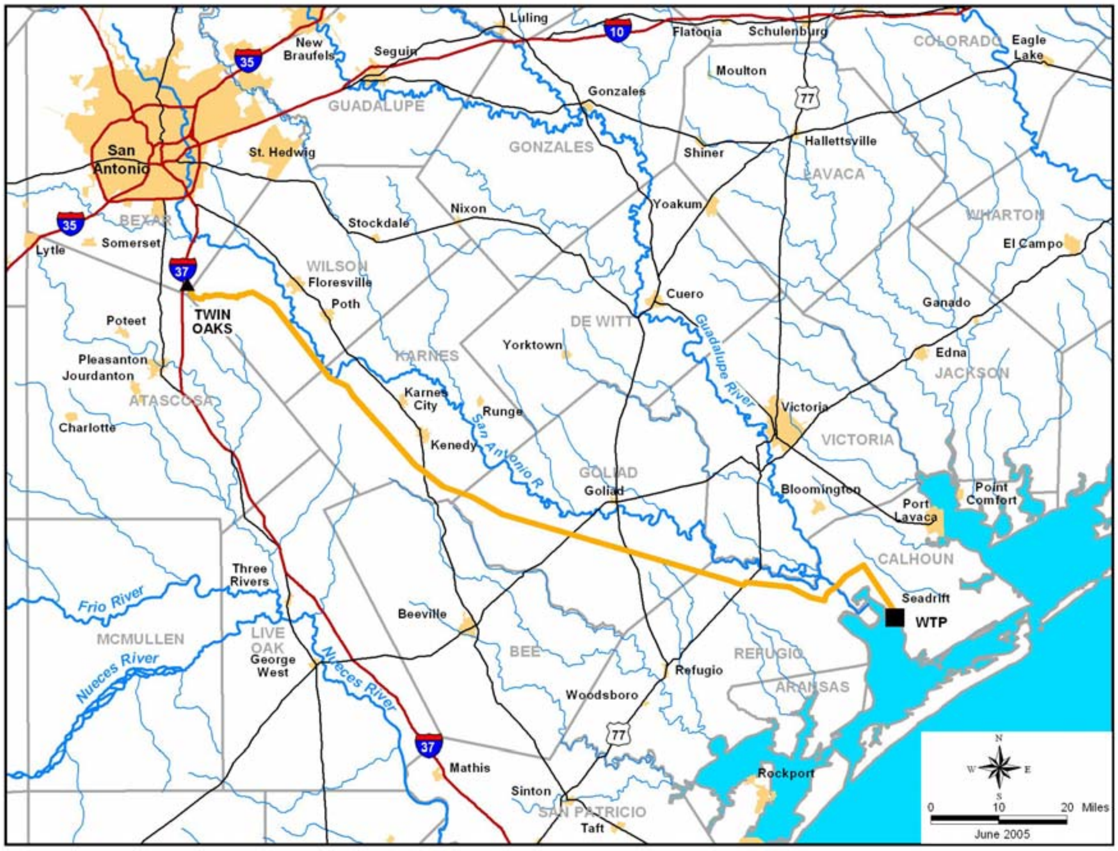

Figure 4C.22-1. Seawater Desalination Location Map

In general, for a specific plant capacity, the equipment in distillation plants tends to be much larger than membrane desalination equipment. However, distillation plants do not have the stringent feedwater quality requirements of membrane plants. Due to the relatively high temperatures required to evaporate water, distillation plants have high-energy requirements, making energy a large factor in their overall water cost. Their high operating temperatures can result in scaling (precipitation of minerals from the feedwater), which reduces the efficiency of the evaporator processes, because once an evaporator system is constructed, the size of the exchange area and the operating profile are fixed, leaving energy transfer as a function of only the heat transfer coefficient. Therefore, any scale that forms on heat exchanger surfaces reduces heat transfer coefficients. Under normal circumstances, scale can be controlled by chemical inhibitors, which inhibit but do not eliminate scale, and by operating at temperatures of less than 200°F.

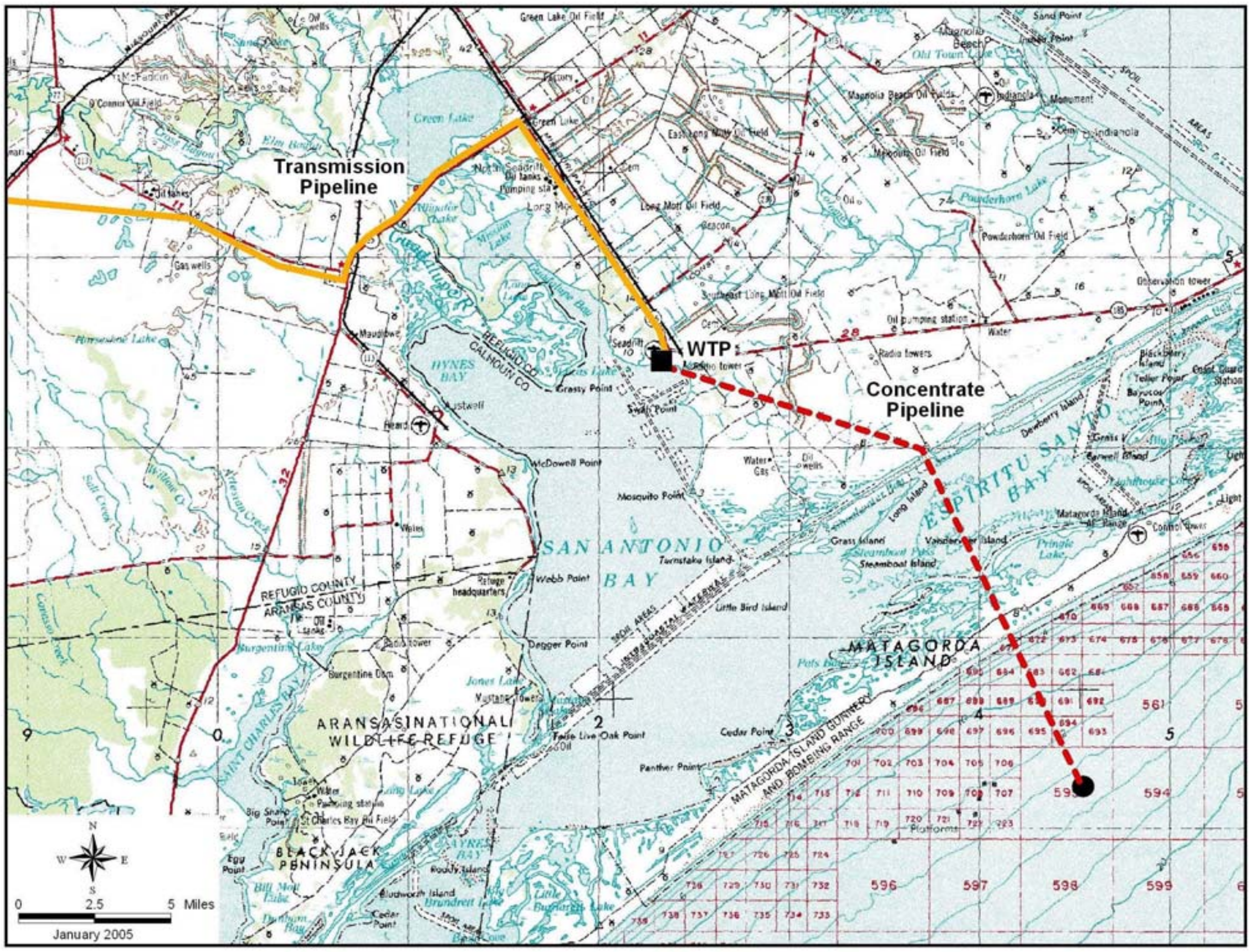

Figure 4C.22-2. Treatment Plant and Concentrate Pipeline Location

Distillation product water recoveries normally range from 15 to 45 percent, depending on the process. The product water from these processes is nearly mineral free, with very low TDS (less than 25 mg/L). However, this product water is extremely aggressive and is too corrosive to meet the Safe Drinking Water Act (SDWA) corrosivity standards without post-treatment. Product water can be stabilized by chemical treatment or by blending with other potable water.

The three main distillation processes in use today are Multistage Flash Evaporation (MSF), Multiple Effect Distillation (MED), and Vapor Compression (VC). All three of these processes utilize an evaporator vessel that vaporizes and condenses the feedstock. The three processes differ in the design of the heat exchangers in the vessels and in the method of heat introduction into the process. Since there are no distillation processes in Texas that can be shown as comparable installations, distillation will not be further considered herein. However, there are membrane desalination operations in Texas, so the following discussion and analyses are based upon information from the use of membrane technology for desalination.

4C.22.1.3 Membrane (Non-thermal) Processes

The two types of membrane processes use either pressure, as in reverse osmosis, or electrical charge, as in electrodialysis reversal, to reduce the mineral content of water. Both processes use semi-permeable membranes that allow selected ions to pass through while other ions are blocked. Electrodialysis reversal (EDR) uses direct electrical current applied across a vessel to attract the dissolved salt ions to their opposite electrical charges. EDR can desalinate brackish water with TDS up to several thousand mg/L, but energy requirements make it economically uncompetitive for seawater, which typically contains approximately 35,000 mg/L TDS. As a result, only reverse osmosis (RO) is used for seawater desalination.

RO utilizes a semi-permeable membrane that limits the passage of salts from the saltwater side to the freshwater side of the membrane. Electric motor driven pumps or steam turbines (in dual-purpose installations) provide the 800 to 1,200 psi pressure to overcome the osmotic pressure and drive the freshwater through the membrane, leaving a waste stream of brine/concentrate. The basic components of an RO plant include pre-treatment, high-pressure pumps, membrane assemblies, and post-treatment. Pretreatment is essential because feedwater must pass through very narrow membrane passages during the process and suspended materials, biological growth, and some minerals can foul the membrane. As a result, virtually all suspended solids must be removed and the feedwater must be pre-treated so precipitation of minerals or growth of microorganisms does not occur on the membranes. This is normally accomplished by various levels of filtration and the addition of various chemical additives and inhibitors. Post-treatment of product water is usually required prior to distribution to reduce its corrosivity and to improve its aesthetic qualities. Specific treatment is dependent on product water composition.

A "single pass/stage" seawater RO plant will produce water with a TDS of 300 to 500 mg/L, most of which is sodium and chloride. The product water will be corrosive, but this may be acceptable, if a source of blending water is available. If not, and if post-treatment is required, the various post-treatment additives may cause the product water to exceed the desired TDS levels. In such cases, or when better water quality is desired, a "two pass/stage" RO system is used to produce water typically in the 200 mg/L TDS range. In a two pass RO system, the product water from the first RO pass/stage is further desalted in a second RO pass/stage, and the water from the second pass is blended with water from the first pass.

Recovery rates up to 45 percent are common for a two-pass/stage seawater RO facility. RO plants, which comprise about 47 percent of the world's desalting capacity, range from a few gallons per day to 35 MGD. The largest RO seawater plant in the United States is the 25-MGD plant in Tampa Bay, Florida. The current domestic and worldwide trend is for the adoption of RO when a single purpose seawater desalting plant is to be constructed. RO membranes have been improved significantly over the past two decades (i.e., the membranes have been improved with respect to efficiency, longer life, and lower prices).

Table 4C.22-1.
Municipal Use Desalt Plants in Texas
(>25,000 gpd and as of June 2004)

Location	***Source***	***Total Capacity (MGD)***	***Desalt Capacity (MGD)***	***Membrane Type***[1]
Abilene, City of	Surface Water	5	3	RO
Bardwell, City of	Groundwater	0.12	0.12	RO
Bayside, City of	Groundwater	0.15	0.15	RO
Brownsville, City of	Groundwater	7.5	7.5	RO
Burleson County MUD 1	Groundwater	0.43	0.43	RO
Country View Estates	Groundwater	0.18	0.18	RO
Dell City, City of	Groundwater	0.11	0.11	EDR
Electra, City of	Groundwater	2.23	2.23	RO
El Paso County Water Auth.	Groundwater	2.29	2.29	RO
Ft. Stockton, City of	Groundwater	6.5	3.67	RO
Granbury, City of	Surface Water	0.35	0.35	EDR
Haciendas del Norte (El Paso)	Groundwater	0.12	0.12	RO
Homestead MUD (El Paso)	Groundwater	0.1	0.1	RO
Kenedy, City of	Groundwater	2.86	0.72	RO
Lake Granbury	Surface Water	10	10	RO
Lake Granbury	Surface Water	5	5	EDR
Los Ybanez, City of	Groundwater	0.11	0.11	RO
Oak Trail Shores	Lake Water	0.72	0.72	EDR
Robinson, City of	Surface Water	2.38	2.38	RO
Seadrift, City of	Groundwater	0.24	0.17	RO
Sherman, City of	Surface Water	5.6	5.6	EDR
Sportsman’s World	Surface Water	0.17	0.17	RO
Tatum, City of	Groundwater	1.14	1.14	RO
Texas Resort Co.	Surface Water	0.144	0.144	EDR

[1] RO = Reverse Osmosis EDR = Electrodialysis Reversal

4C.22.1.4 Examples of Relevant Existing Desalt Projects

Tampa, Florida: The water utility, Tampa Bay Water, has selected a 30-year design, build, operate, and own (DBOO) proposal to construct a nominal 25 MGD seawater desalt plant. The plant will use RO as the desalt process. The proposal included total capitalization and operations costs for producing high quality drinking water (chlorides less than 100 mg/L). The total cost to Tampa Bay Water in the original proposal was to be $2.08 per 1,000 gallons ($678 per acft) on a 30-year average, with first year cost being $1.71 per 1,000 gallons ($557 per acft). However, subsequent issues with the original design including significant problems in obtaining adequate pretreatment have increased the projected total cost to Tampa Bay Water by $0.72 per 1,000 gallons for a total projected cost of $2.80 per 1,000 gallons ($912 per acft) on a 30-year average.[1] The results of Tampa Bay's competition has attracted international interest in the current cost profile of desalting seawater for drinking water supply, since these costs are only about one-half the levels experienced in previous desalination projects.

Tampa Bay Water selected the winning proposal from four DBOO proposals submitted, which ranged from $2.08 to $2.53 per 1,000 gallons. The factors listed below may be all or partially responsible for these seemingly low costs:

1. Salinity at the Tampa Bay sites ranges from 25,000 to 30,000 mg/L, lower than the more common 35,000 mg/L for seawater. RO cost is sensitive to salinity.
2. The power cost, which is interruptible, is below $0.04 per kilowatt-hour (kWh).
3. Construction cost savings through using existing power plant canals for intake and concentrate discharge.
4. Economy of scale at 25 MGD.
5. Amortizing over 30 years.
6. Use of tax-exempt bonds for financing.

The Tampa bids contrast with another current large-scale desalination project in which distillation is proposed. The current desalt project of the Singapore Public Utility Board, which proposes a 36 MGD multi-stage flash distillation plant, will cost an estimated $5.76 per 1,000 gallons ($1,877 per acft) for the first year operation in 1998 dollars.[2]

Large-Scale Demonstration Seawater Desalination in Texas: The Texas Water Development Board (TWDB) funded several studies to evaluate the feasibility of large-scale desalination in Texas. As part of this initiative, the City of Corpus Christi, Freeport, and the

[1] Associated Press, "Tampa Bay Water to Hire Group to Fix Desalination Plant," September 21, 2004.
[2] Desalination & Water Reuse Quarterly, vol. 7/4, Feb/Mar 1998.

Lower Rio Grande Valley-Brownsville were selected as potential locations for large-scale seawater desalination and feasibility studies were conducted for each of these locations. The draft feasibility reports were submitted to TWDB in August 2004 and indicated that the demonstration seawater desalination projects for the three locations are technically feasible. However, all three draft reports indicate that the estimated total costs for capital and O&M of the proposed projects will exceed the cost of alternative sources of drinking water at these locations[3].

The study evaluated several potential strategies and the assumptions utilized in the cost estimates were selected by the individual study participants. Table 4C.22-2 shows a summary of the cost estimates with the costs for each study modified using the Regional Planning assumptions (power cost = $0.06 / kWh, Debt Service = 6 percent, 30 years). The Total Project Cost and Total O&M Cost in Report were reported in the summary evaluation prepared by the TWDB.

Table 4C.22-2.
Cost Summary for TWDB Large-Scale Seawater Demonstration in Texas
(Costs Adjusted to Regional Planning Format)
(2004 Prices)

Item	***Brownsville (25 MGD)***	***Corpus Christi (25 MGD)***	***Freeport - BRA (10 MGD)***
Total Project Cost	**$151,388,000**	**$196,600,000**	**$93,183,000**
Debt Service (6 percent, 30 years)	$10,998,173	$14,282,776	$6,769,644
Power Usage (kWh)	127,400,000	112,391,661	NA
Power Cost (@$0.06/kWh)	7,644,000	6,743,500	NA
Power Cost in Report (@$0.0545, @$0.065, NA)	6,943,000	7,305,458	3,162,200
Total O&M Cost in Report	11,776,000	17,515,000	7,364,100
Adjusted Total O&M Cost	**$12,477,000**	**$16,953,042**	**$6,803,900**
Total Annual Cost	**$23,475,173**	**$31,235,818**	**$14,133,744**
Available Project Yield (acft/yr)	**28,004**	**28,004**	**11,201**
Annual Cost of Water ($ per acft)	**$838**	**$1,115**	**$1,262**
Annual Cost of Water ($ per 1,000 gallons)	**$2.57**	**$3.42**	**$3.87**
Source: Texas Water Development Board, “The Future of Desalination in Texas, Volume I, Biennial Report on Seawater Desalination,” December 2004.			

[3] Texas Water Development Board, “The Future of Desalination in Texas Volume I, Biennial Report on Seawater Desalination”, December 2004.

4C.22.2 Available Yield

Seawater from San Antonio Bay and the Gulf of Mexico is an unlimited quantity within the context of a supply for the South Central Texas Region. For the purpose of developing this strategy in which seawater from the bay is desalted to develop a significant drinking water supply for the major urban area in the region, it is assumed that the availability of water is unlimited and that its cost is zero prior to extraction from the source.

4C.22.3 Environmental Issues

4C.22.3.1 Seawater Desalination

The proposed location of the desalination facilities is near Seadrift on San Antonio Bay, which is part of the estuary of the San Antonio and Guadalupe Rivers (Figure 4C.22-2). This location would take advantage of the lower energy requirement of the desalination process at the lower salinity levels of the upper estuary, although the variable salinity can adversely affect operations. Estuaries, which serve as critical habitat and spawning grounds for many marine species and migratory birds, are marine environments maintained in a brackish state by the inflow of freshwater from rivers and streams. The high productivity characteristic of estuaries arises from the abundance of terrigenous nutrient input, shallow water, and the ability of a few marine species to exploit environments continually stressed by low, variable salinities, temperature extremes, and, on occasion, low dissolved oxygen concentrations.

The potential environmental effects resulting from the construction of a desalination plant in the vicinity of San Antonio Bay will be sensitive to the siting of the plant and its intake and locations. Construction of either will temporarily disrupt shoreline and benthic habitats in the immediate vicinity, including wetlands and other sensitive areas and operation of the intake will result in some impingment and entrainment of aquatic organisms. Impingement takes place when organisms are trapped against intake screens by the force of the water passing into the intake structure. Entrainment occurs when organisms are drawn through the water intake structure into the pump and transport system. Organisms that become impinged or entrained are normally relatively small organisms, including early life stages of fish and shellfish. Impingement can result in descaling or other physical damage, and starvation, exhaustion or asphyxiation when the organism cannot escape the intake structure. Entrained organisms are subject to mechanical, thermal, or toxic stress (e.g., biocides or low dissolved oxygen concentrations) as they pass through the system. In the case of either impingement or entrainment, a substantial proportion of the affected individuals will be killed or subjected to significant harm. Minimization of impingement and entrainment by appropriate site selection and through the use of appropriate screening technology must be considered during system design as part of the overall effort to avoid or minimize potential impacts to the esturine environment.

Since the brine concentrate discharge point is planned to be located about 13 miles offshore, impacts of this feature on the estuary would be limited to the impacts of pipeline construction on bay bottom habitats. Of particular concern will be potential impacts to *Spartina* marshes and to seagrass beds. Discharge structure sites should be selected to avoid areas where organisms tend to concentrate. These include rock outcrops, man-made structures, the vicinities of tidal passes and the surf zone. It can be assumed that the permit process will at sometime require a (modeling) demonstration showing that the design of the discharge structure will be adequate to rapidly disperse the brine plume to ambient salinities within a relatively small mixing zone.

A desalination facility using 50 MGD of feedwater would process about 154 acft of bay water per day, or up to 4,800 acft/month. This is a small amount (2.5 percent) compared to historical San Antonio Bay (Guadalupe Estuary) average inflows (195,000 acft/month). Four percent of median inflows (119,000 acft/month), and 1.3 percent of bay volume (360,000 acft). Only during low flow periods would the water withdrawal from desalination be substantial relative to inflows. For example, the 4,800 acft/month would be about 12 percent of monthly inflows during months so dry that they occur only 10 percent of the time, and is roughly equivalent to the lowest monthly inflow recorded for the estuary. Bay volumes, inflows, and tidal exchanges with the Gulf of Mexico are so large relative to this alternative that substantial impacts to overall salinity gradients, or to the delivery of nutrients and sediment are not realistic.

Many migratory birds are dependent on the quality of estuarine environments in order to complete the foraging and nesting of their migration. One of the most well known of the migratory birds is the Whooping Crane (*Grus Americana),* which is listed as endangered by both USFWS and TPWD. A growing population of whooping cranes winter in and near the Aransas National Wildlife Refuge located adjacent to the Mesquite Bay and the southern and western portions of San Antonio Bay. This wintering population has grown from a low of only 16 birds in 1941 to a high of 216 birds in 2004. Detailed research studies by Texas A&M University are underway at this time to identify and better understand factors affecting whooping crane population. Two other migratory birds known to the San Antonio Bay area are listed as threatened by TPWD: the Reddish Egret (*Egretta rufescens*), and the Piping Plover (*Charadrius melodus*). The Piping Plover is also listed as threatened by USFWS.

The water transmission pipeline between San Antonio Bay and Bexar County would be approximately 126 miles long. A construction right-of-way of approximately 140-feet wide would affect a total area of approximately 2,138 acres. The construction of the pipeline would include the clearing and removal of woody vegetation. A 40-foot wide right-of-way corridor, free of woody vegetation and maintained for the life of the project, would total 611 acres. The proposed pipeline route would traverse three of Omernik's[4] ecoregions: the Western Gulf Coastal Plain, the East Central Texas Plains, and the westernmost reaches of the Texas Blackland Prairie. In addition, the Guadalupe River is listed by TPWD as a Ecologically Significant River and Stream Segment. Surveys for protected species should be conducted within the proposed construction corridors where preliminary evidence indicates their existence. Many of these species, such as the Texas Tortoise, the Texas Horned Lizard, and the Indigo Snake, are dependent on shrubland or riparian habitat. The Texas Garter Snake may be present in wetland habitat, and the Timber Rattlesnake, a threatened species, may be found in the riparian woody vegetation of the area.

Destruction of potential habitat can be avoided by selecting a corridor through previously disturbed areas, such as croplands. Selection of a pipeline right-of-way alongside the existing habitat could also be beneficial to some wildlife by providing edge habitat; however, the majority of these areas are small and fragmented, so care should be taken to ensure minimum impacts.

The Wildlife Science Research and Diversity maps, which are maintained by TPWD, do report the occurrence of endangered, threatened, or rare species near the potential pipeline right-of-way. One endangered species known to exist near the pipeline corridor is the Attwater's Greater Prairie Chicken in Goliad and Refugio Counties. The Attwater's Greater Prairie Chicken prefers the coastal prairies grassland in area 0 to 24 inches in vegetation height. Big red sage (Salvia penstemonoides), Coastal Gay Feather (*Liatris bracteata*), Plains Gumweed (*Grindelia oolepsis*), Elmendorf's Onion (*Allium elmendorfii*), Parks' Jointweed (*Polygonella parksii*), Threeflower Broomweed (*Thurovia triflora*) and Welder Machaeranthera (Psilactis heterocarpa) are all rare plants found in this corridor. In addition, the Texas Diamondback Terrapin, a species

[4] Omernik, J.M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77:118-125, 1987.

of concern, has been documented within 1 mile of the proposed project route. Plant and animal species in the project area listed by the USFWS, and TPWD as endangered or threatened are presented in Table 4C.22-3. All species listed have habitat requirements or preferences that suggest they could be present within the project area.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Based on the review of available records housed at the Texas Archeological Research Laboratory in Austin, six cultural resource sites appear to occur within the proposed project area. Table 4C.22-4 lists archeological sites within a one-mile corridor of the Seawater Desalination project area. Considering that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the Texas Historical Commission regarding if the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to cultural resources.

4C.22.4 Engineering and Costing

4C.22.4.1 Seawater Desalination at San Antonio Bay

This water management strategy provides for a major desalination water treatment plant on the Texas coast and the infrastructure for transferring potable water from the coast to the major municipal demand center of the South Central Texas Region. The entire strategy consists of the intake, water treatment plant, storage tanks, pumping stations and a 126-mile pipeline. The water treatment plant component includes pretreatment necessary to ensure normal life and efficiency of the reverse osmosis membranes. This water management strategy is presented in terms of four firm capacities that demonstrate the potential economy of scale over a range from 25 MGD to 100 MGD.

Desalination treatment cost estimates are based on recent similar desalination treatment plant construction experience and feasibility studies. This approach takes advantage of the development of membrane technology and the resulting reduction in capital and operating costs in comparison to previously available technology. During the past 15 years, the price and

Table 4C.22-3. Important Species Having Habitat or Known to Occur in Counties Potentially Affected by Desalination of Seawater*

Common Name	Scientific Name	Impact Value	Multiplier Based on Status	Adjusted Impact	Summary of Habitat Preference	Listing Entity USFWS[1]	Listing Entity TPWD[1]	Potential Occurrence in County
American Eel	*Anguilla rostrata*	1	1	1	Moist aquatic habitats.			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	0	3	0	Open country; cliffs	DL	E	Nesting/ Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	0	2	0	Open country; cliffs	DL	T	Nesting/Migrant
Atlantic Hawksbill Sea turtle	*Eretmochelys imbricata*	1	3	3	Gulf and bay system.	LE	E	Migrant
Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	2	3	6	Coastal Prairies of Gulf Coastal Plain	LE	E	Nesting
Bald Eagle	*Haliaeetus leucocephalus*	2	2	4	Large Bodies of water with nearby resting sites	LT-PDL	T	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	2	1	2	Moist Creek and stream bed edges; historic; introduced in native plant nursery trade			Resident
Black Bear	*Usus americanus*	0	2	0	Mountains, broken country, woods, brushlands, forests	T/SA; NL	T	Resident
Black Lace Cactus	*Echinocereus reichenbachii var. albertii*	1	3	3	Grasslands, thorn shrublands, mesquite woodlands on sandy, somewhat saline soils on coastal prairie	LE	E	Resident
Black-Spotted Newt	*Notophthalmus meridionalis*	1	2	2	Ponds and resacas in south Texas		T	Resident
Brown Pelican	*Pelecanus occidentalis*	0	3	0	Coastal inlands for nesting, shallow gulf and bays for foraging	LE	E	Nesting/Migrant
Cave Myotis Bat	*Myotis velifer*	0	1	0	Roosts colonially in caves.			Resident
Coastal Gay Feather	*Liatris bracteata*	2	1	2	Black clay soils of midgrass grasslands on coastal prairie remnants.			Resident
Corkwood	*Leitneria floridana*	1	1	1	Small shrub, found in narrow zone between brackish marsh and freshwater areas.			Resident
Elmendorf's Onion	*Allium elmendorfii*	1	1	1	Endemic; deep sands derived from Queen City and similar Eocene formations			Resident

Table 4C.22-3 continued

Eskimo Curlew	*Numenius borealis*	1	3	3	Grasslands, pastures.	LE	E	Nonbreeding Resident
Green Sea Turtle	*Chelonia mydat*	1	2	2	Gulf and bay system.	LT	T	Migrant
Guadalupe Bass	*Micropterus treculi*	2	1	2	Clear flowing streams			Resident
Gulf Saltmarsh Snake	*Nerodia clarkii*	0	1	0	Brackish to saline coastal waters			Resident
Henslow's Sparrow	*Ammodramus henslowii*	1	1	1	Weedy fields, cut over areas; bare ground for running and walking			Nesting/Migrant
Indigo Snake	*Drymarchon corais erebennus*	1	2	2	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	Resident
Interior Least Tern	*Sterna antillarum athalassos*	1	3	3	Inland river sandbars for nesting and shallow water for foraging	LE	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroundi*	0	3	0	South Texas thick brushlands, favors areas near water	LE	E	Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	1	3	3	Gulf and bay system.	LE	E	Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	1	1	1	Coastal dunes, Barrier islands and sandy areas			Resident
Leatherback Sea Turtle	*Dermochelys coriacea*	1	3	3	Gulf and bay system.	LE	E	Migrant
Loggerhead Sea Turtle	*Caretta caretta*	1	2	2	Gulf and bay system.	LT	T	Migrant
Louisiana Black Bear	*Ursus americanus luteolus*	0	2	0	Within historical range.	LT	T	
Maculated Manfreda Skipper	*Stallingsia maculosus*	1	1	1	Fast erratic flight, larvae feed inside a leaf shelter, pupate in cocoon made of leaves & silk			Resident
Mexican Treefrog	*Smilisca baudinii*	1	2	2	Subtropical woodlands, resacas.		T	Resident
Mountain Plover	*Charadrius montanus*	1	1	1	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts			Nesting/Migrant
Ocelot	*Felis pardalis*	1	3	3	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	LE	E	Resident
Opossum Pipefish	*Microphis brachyurus*	1	2	2	Brooding adults found in fresh or low salinity waters.		T	Resident
Parks' Jointweed	*Polygonella parksii*	2	1	2	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			Resident
Piping Plover	*Charadrius melodus*	0	2	0	Beaches and flats of Coastal Texas	LT	T	Migrant
Plains Gumweed	*Grindelia oolepsis*				Early successional patches in coastal prairie on heavy clay soils, sometimes in disturbed habitats in urban areas			Resident

Table 4C.22-3 continued

Plains Spotted Skunk	*Spilogale putorius interrupta*	1	1	1	Prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, forest edges			Resident
Red Wolf	*Canis rufus*	0	3	0	Extirpated.	LE	E	
Reddish Egret	*Egretta rufescens*	0	2	0	Coastal inlands for nesting, coastal marshes for foraging		T	Migrant
Runyon's Water Willow	*Justicia runyonii*	1	1	1	Openings in subtropical woodlands.			Resident
Scarlet Snake	*Cemophora coccinea*	1	2	2	Sandy soils of East Texas, central and south Gulf Coast		T	Resident
Sennett's Hooded Oriole	*Icterus cucullatus sennetti*	1	1	1	Often builds nest of Spanish moss.			
Sheep Frog	*Hypopachus variolosus*	1	2	2	Deep sandy soils of Southeast Texas		T	Resident
Snowy Plover	*Charadrius alexandrinus*	0	1	0	Wintering Migrant on mud flats.			Migrant
Sooty Tern	*Sterna fuscata*	1	2	2	Catches small fish.			Resident
South Texas Siren (Lg. Form)	*Siren sp. 1*	1	2	2	Moist soils		T	Resident
Southern Yellow Bat	*Lasiurus ega*	0	2	0	Associated with trees.		T	Resident
Spot-Tailed Earless Lizard	*Holbrookia lacerata*	1	1	1	central & southern Texas; oak-juniper woodlands and mesquite-prickly pear			Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	1	1	1	Found near slow-moving water, eggs laid on objects near water; larvae are aquatic, adults prefer shady areas; feed on nectar and pollen			Resident
Texas Botteri's Sparrow	*Aimophila botterii texana*	1	2	2	Coastal lowlands and prairies.		T	Resident
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	0	1	0	Bays, coastal marshes of the upper two-thirds of Texas Coast			Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	1	1	1	Varied, especially wet areas; bottomlands and pastures			Resident
Texas Horned Lizard	*Phrynosoma cornutum*	1	2	2	Varied, sparsely vegetated uplands, grass, cactus, brush		T	Resident
Texas Tortoise	*Gopherus berlandieri*	1	2	2	Open brush w/ grass understory; open grass/bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	Resident
Tharp's rhododon	*Rhododon angulatus*	0	1	0	Deep, sandy soils in dunes.			Resident
Threeflower broomweed	*Thurovia triflora*	1	1	1	Endemic, black clay soils.			Resident

Table 4C.22-3 continued

Timber Rattlesnake	*Crotalus horridus*	1	2	2	Floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	Resident
Welder Machaeranthera	*Psilactis heterocarpa*	2	1	2	Coastal prairie; Shrub-infested grasslands and open mesquite-huisache woodlands			Resident
White-faced Ibis	*Plegadis chihi*	0	2	0	Prefers freshwater marshes.		T	Resident
White-tailed Hawk	*Buteo albicaudatus*	1	2	2	Coastal prairies, savannahs and marshes in Gulf coastal plain		T	Nesting/Migrant
Whooping Crane	*Grus americana*	0	3	0	Potential migrant	LE	E	Migrant
Wood Stork	*Mycteria americana*	0	2	0	Forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	Migrant

[1] Texas Parks and Wildlife Department (TPWD), Unpublished 2005, March 2005, Data and Map Files of the Wildlife Science Research and Diversity Division maintained by TPWD, Austin, Texas.

* LE/LT=Federally Listed Endangered/Threatened E/SA, T/SA=Federally Listed Endangered/Threatened by Similarity of Appearance
C1=Federal Candidate for Listing DL, PDL=Federally Delisted/Proposed for Delisting NL=not Federally Listed E, T=State Listed Endangered/Threatened
PE, PT=Federally Proposed Endangered/ Threatened Blank = Rare, but no regulatory listing status

Table 4C.22-4.
Previously Recorded Sites within 1-mile Corridor of the Proposed Seawater Desalination Project Area

Sites	41CL1
	41CL10
	41CL13
	41CL70
	41CL73
	41WN66

operating costs of membranes have declined due to improvements in materials and manufacturing. This contrasts with recent experience with conventional water treatment technology (i.e., costs for conventional water treatment technologies have not been influenced greatly by equipment innovations).

The basic assumptions made to determine the size and characteristics of the components of this seawater desalination strategy are listed in Table 4C.22-5. A 126-mile pipeline route from the desalination plant adjacent to San Antonio Bay near Seadrift to south Bexar County was assumed. The pumping capacities are equal to the nominal plant capacities, except for the raw water intake, which includes the full raw water quantity that is separated into desalinated finished water and concentrated brine in the plant. A conveyance line to carry the concentrated brine offshore is also included in the costs. A concentrate pump station is not included because it

Table 4C.22-5.
Engineering Assumptions for Seawater Desalination

Parameter	Assumption	Description
Raw water salinity	25,000 mg/L	Intake located near Seadrift
Finished water chlorides	100 mg/L	
Treatment capacities	25, 50, 75, 100 MGD	
Concentrate Pipeline Length	23 miles total (10 miles on land, 13 miles submerged)	Diffused in open Gulf
RO Recovery Rate	60 percent	
Power cost	$0.06 per kWh	Assume interruptible power
Pipeline diameter	42”, 60”, 72”, 84”	
Booster storage	5 percent of flow	More than 1 hour storage to avoid in-line pumps
Number of booster stations	2	

is assumed that the residual pressure from the desalination process is utilized to convey the concentrate offshore.

The treatment and delivery components and respective sizes and capacities are summarized in Table 4C.22-6. The brine concentrate capacities for each nominal plant capacity are based on a recovery rate of 60 percent. This means that of the 100 percent of flow taken from San Antonio Bay at the plant intake, 60 percent is desalted and 40 percent is returned to the Gulf as concentrated brine *via* a route approximately 23 miles long from the plant location through the barrier island.

Table 4C.22-6.
Capacities for Seawater Desalination Plant

Item/Facility	Nominal Water Treatment Plant Capacity			
	25 MGD	50 MGD	75 MGD	100 MGD
Intake Pump Station (MGD)	42	83	125	167
Intake Pipeline Diameter (inches)	48	72	84	102
Desalination Water Treatment Plants				
Plant Intake (seawater) (MGD)	42	83	125	167
Desalted Product Water (drinking water) (MGD)	25	50	75	100
Brine Discharge (MGD)	17	33	50	67
Brine Discharge Pipeline Diameter (inches)	30	42	54	66
Desalted Product Water (MGD)	25	50	75	100
Pump Station at Plant and Each Booster Station (gpm)	17,361	34,722	52,083	69,444
Finished Water Pipeline Diameter (inches)	42	60	72	84
Storage at Booster Pump Stations (MG, each)	1.25	2.5	3.75	5.0

The estimated costs to desalt seawater range from $889 per acft for the 25 MGD size plant to $760 per acft for the 100 MGD size plant (Table 4C.22-7). The treatment costs include the water treatment plant (pretreatment and RO desalination), raw water intake, and concentrate discharge to the open Gulf. The pretreatment portion of the plant is essentially a full conventional surface water plant to remove solids from the raw water prior to the RO desalination process. There is some economy of scale in the treatment process with larger processes in the pretreatment and RO desalination components. Also, there are greater economies of scale for components such as the intake and concentrate pump stations and pipelines.

There are some economies of scale with increasing capacity to convey the treated water to the municipal demand center. Over the range from 25 MGD to 100 MGD the conveyance unit costs decrease from about $878 per acft for the 25 MGD size project to $546 per acft for the 100 MGD size project (Table 4C.22-7). The estimated total desalination treatment and conveyance cost from San Antonio Bay to the major municipal demand center of the South Central Texas Region decreases from $1,767 per acft ($5.42 per 1,000 gallons) for the 25 MGD size project to $1,305 per acft ($4.01 per 1,000 gallons) for the 100 MGD size project (Table 4C.22-7).

For a conservative cost estimating purposes the salinity of the raw water drawn from San Antonio Bay near Seadrift was assumed to consistently be 25,000 mg/L of total dissolved solids, which is on the upper end of historically observed salinity in this area of the bay. One study of salinity during the period 1968 to 1987 reported mean salinity of 5,640 mg/L in San Antonio Bay near Seadrift[5]. To provide firm yield of desalinated bay water, the desalination facilities should be constructed for the maximum anticipated salinity of 24,000 mg/L. Therefore, the capital costs would not decrease with lower mean salinity. However, if the mean salinity of the raw water delivered to the desalination plant is much less than the maximum, then the operations and maintenance costs may be significantly less than the costs shown in Table 4C.22-7. The primary cost savings for desalinating lower salinity water is the decrease in electrical power required due to an increase in the RO recovery rate and a decrease in the required pumping pressure to pass the desalinated water through the RO membranes. The decrease in cost to desalinate bay water

[5] Longley, W.L., ed. "Freshwater inflows to Texas bays and estuaries: ecological relationships and methods for determination of needs", TWDB and TPWD, 1994.

with mean salinity of 5,640 mg/L versus the costs shown in Table 4C.22-7 would be approximately $132 per acft ($0.41 per 1,000 gallons).

4C.22.5 Implementation Issues

4C.22.5.1 Seawater Desalination

Implementation of this water management strategy requires overcoming several financial, environmental, and technological impediments. The capital cost is likely to be a somewhat serious limitation. The cost estimate shows that while the treatment cost, based on recent Tampa experience and other feasibility studies for a planned 25 MGD desalination facility may be competitive, transferring water from the coast makes the total cost quite high in relation to other water management strategies.

There are several environmental issues that must be considered. The first is the location of the intake in San Antonio Bay. It will be an advantage to take slightly lower salinity water, similar to Tampa, rather than Gulf water. However, to accomplish this means that dilution with freshwater from the San Antonio and Guadalupe Rivers is necessary. Studies will need to be performed to ensure that the removal of the somewhat diluted bay water causes no harmful effects on plant and animal life in San Antonio Bay. Another issue with the desalt plant is the disposal of the concentrated brine created from the desalination process. Disposal would have to occur at a location and in a manner that also did not disrupt plant or animal life in the Bay or in the Gulf. A further complication is the permitting of a 126-mile pipeline across rivers, highways, and private rural and urban property.

Technological issues include: (1) confirming that desalination as proposed with membranes is the appropriate technology; (2) confirming that blending desalted seawater with the other water sources in the municipal demand distribution system can be successfully accomplished; and (3) obtaining an adequate source of electric power to drive the desalination process using membranes. The cost model on which this strategy is based corresponds fairly closely with the costs developed for three large-scale seawater desalination strategies recently evaluated by the TWDB.[6] The treatment costs for a 25 MGD seawater desalination plant in the TWDB study ranged from $778 per acft to $1,133 per acft compared to $889 per acft shown in Table 4C.22-7 for the 25 MGD alternative.

[6] Texas Water Development Board, “The Future of Desalination in Texas Volume I, Biennial Report on Seawater Desalination”, December 2004.

Table 4C.22-7.
Cost Estimate Summary for
Desalination of Seawater
(Second Quarter 2002 Prices)

Item	***Estimated Costs 25 MGD***	***Estimated Costs 50 MGD***	***Estimated Costs 75 MGD***	***Estimated Costs 100 MGD***
Capital Costs				
Water Treatment Plant (Pretreatment and Desal)	$72,011,000	$129,272,000	$184,509,000	$239,581,000
Concentrate Disposal	$26,464,000	$43,279,000	$55,046,000	$66,197,000
Transmission Pump Stations	$17,148,000	$23,524,000	$30,055,000	$34,777,000
Transmission Pipeline	$115,979,000	$169,196,000	$237,391,000	$277,714,000
Integration	$33,175,000	$66,350,000	$86,825,000	$107,300,000
Total Capital Cost	**$264,777,000**	**$431,621,000**	**$593,826,000**	**$725,569,000**
Engineering, Legal Costs and Contingencies	$86,873,000	$142,608,000	$195,970,000	$240,063,000
Environmental & Archaeology Studies and Mitigation	$9,576,000	$11,559,000	$13,727,000	$15,787,000
Land Acquisition and Surveying (673 acres)	$6,485,000	$6,693,000	$6,768,000	$6,833,000
Interest During Construction (2.5 years)	$36,771,000	$59,249,000	$81,030,000	$98,826,000
Total Project Cost	**$404,482,000**	**$651,730,000**	**$891,321,000**	**$1,087,078,000**
Annual Costs				
Debt Service (6 percent, 30 years)	$29,385,000	$47,347,000	$64,753,000	$78,975,000
Operation and Maintenance				
Pipeline, Pump Stations, Tank, Distribution	$2,222,000	$3,437,000	$4,622,000	$5,476,000
Water Treatment Plants Except Energy	$6,848,000	$13,481,000	$19,329,000	$25,253,000
WTP Energy Costs (@$0.06/kWh)	$6,413,000	$12,819,000	$19,225,000	$25,633,000
Finished Water Pumping Energy Costs (@$0.06/kWh)	$4,607,000	$6,222,000	$8,835,000	$10,898,000
TOTAL				
Total Annual Cost	**$49,475,000**	**$83,306,000**	**$116,764,000**	**$146,235,000**
Annual Cost of Water ($ per acft)	**$1,767**	**$1,487**	**$1,390**	**$1,305**
Annual Cost of Water ($ per 1,000 gallons)	**$5.42**	**$4.56**	**$4.26**	**$4.01**
TREATMENT ONLY				
Total Annual Cost	**$24,896,000**	**$45,692,000**	**$65,397,000**	**$85,083,000**
Available Project Yield (acft/yr)	**28,004**	**56,008**	**84,012**	**112,016**
Annual Cost of Water ($ per acft)	**$889**	**$816**	**$778**	**$760**
Annual Cost of Water ($ per 1,000 gallons)	**$2.73**	**$2.50**	**$2.39**	**$2.33**
CONVEYANCE ONLY				
Total Annual Cost	**$24,579,000**	**$37,614,000**	**$51,368,000**	**$61,152,000**
Annual Cost of Water ($ per acft)	**$878**	**$672**	**$611**	**$546**
Annual Cost of Water ($ per 1,000 gallons)	**$2.69**	**$2.06**	**$1.88**	**$1.68**

Substantial verification of technology would need to be accomplished prior to building this project. Blending differing treated waters is critical for the wellbeing of the customers and the distribution system. The characteristics of the desalted water are likely to be dramatically different from other drinking water in the major municipal demand center of the South Central Texas Region. Considerable investigation would be needed to determine if additional conditioning of the desalinated seawater would be required to make the new water source compatible with existing distribution systems. Conditioning of the desalinated seawater may include addition of alkalinity and hardness to bring the corrosion chemistry closer to other existing water sources.

Finally, in spite of recent improvements in membrane technology, desalting seawater will require large amounts of electric power (Au79). Normally, this need is met by locating desalination plants near power plants. Future costs of electric power, however, are highly uncertain and represent a very significant component of annual operating costs for this strategy.

Requirements Specific to Water Rights

1. It will be necessary to obtain these permits:
   a. TCEQ Water Right permit.
   c. GLO Sand and Gravel Removal permits.
   d. GLO Easement for use of state-owned land.
   e. Coastal Coordination Council review.
   f. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flows and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Other Considerations:
   a. Water compatibility testing, including biological and chemical characteristics will need to be performed.

Requirements Specific to Pipelines

1. Necessary permits:
   a. USACE Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel, and Marl permit for river crossings.

2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads
   b. Creeks and rivers
   c. Other utilities

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