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**TRACKING MEMBRANE OPERATIONS
IN TEXAS PUBLIC WATER SUPPLIES:
WHAT'S DRIVING THE MARKET?**

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ABSTRACT

This paper presents the most up to date listing of membrane facilities in Texas, utilizing the Texas Commission on Environmental Quality (TCEQ) and Texas Water Development Board (TWDB) data bases along with research investigations of facilities not listed in the regulatory data bases. The paper provides a unique insight on how membrane technology is rapidly developing in Texas and what are the influencing factors and market drivers. The type, number and locations of membrane facilities provide a roadmap of this developing market around water supply sources that require the least amount of pretreatment. In addition to water source economics, other market drivers were found to be: productivity/flux rates have significantly increased, warranted membrane useful life has significantly increased, lower feed pressures and higher recovery rates (significant energy reduction), small footprint, security, attractive incremental sizing, acceptance by State regulatory agencies, and more stringent water quality regulations that are costly for conventional plants to meet.

Key Words

Membranes, Desalination, Public Water Systems, Membrane Data Base, Texas Membranes, Advanced treatment practices.

INTRODUCTION

Texas, Florida and California are the three most rapidly developing markets for membrane technology in the United States. The growth of membrane facilities in the "Public Water System" sector has been at an exponential rate. The purposes of this paper is two fold, first to explore what is driving this phenomenal growth in Texas and second to provide a start of a central database on membrane facilities in Texas. The Texas Water Department Board developed "A Desalination Database for Texas" initially issued in October 2005. The report was revised in October 2006. This report is the most comprehensive database available on desalination facilities in Texas. However, the vast majority of the growth in membrane facilities in Texas is associated with filtration technology and not desalination. The State agency regulating membrane filtration for Public Water Systems (PWS) in Texas is the Texas Commission on Environmental Quality (TCEQ). This State agency currently possesses databases of those PWS's which have membrane facilities. However, information publicly available is general and limited.

This paper is a first start at compiling a comprehensive database for both desalination and filtration membrane facilities in Texas. As a benefit from compiling and tracking the development of membranes in Texas a unique insight into the major market drivers behind this phenomenal growth rate is emerging.

DEFINING TERMINOLOGY

Membranes

There is a wide general public misconception that all “membranes” are for desalination of brackish or seawater. Membrane technology can be classified into three water treatment objectives: Filtration, Softening and Desalination. Seawater or brackish desalting is drastically more complex than simple filtration. The overwhelming majority of recently constructed membrane plants in Texas are not used for desalination but rather for the superior capabilities of membranes to replace conventional water treatment filtration. The membrane selection for filtration acts only mechanically to block bacteria, suspended particles and some organics which are too large to flow through the membrane pores. These membranes are classified as microfiltration (MF) or ultrafiltration (UF). Softening membranes block solutes as small as organic molecules and divalent ions (hardness). This type of membrane is classified as nanofiltration (NF). The desalination membranes block much smaller monovalent ions such as Sodium and Chloride and can produce low-salinity water. These membranes are classified as either Electrodialysis Reversal (EDR) or Reverse Osmosis (RO). The database and market drivers in this paper have been grouped into three water treatment objectives and their corresponding membrane technologies (Table 1).

Table 1 - Classifications of Membranes

Water Treatment Objectives	Membrane	Operating Pressures	Operating Vacuum	Percent Recovery	Pore Size Range ⁽¹⁾ µm
Filtration	MF	5 to 35 psi	-3 to -12 psi	95 to 99	0.1-0.2
	UF	10 to 50 psi	-4 to -12 psi		0.01-0.05
Softening	NF	70 to 140 psi	N/A	85 to 95	0.005-0.0005
Desalination	RO EDR	140-700 psi Electrically Driven	N/A	70 to 85	0.001-0.0001

⁽¹⁾ EPA Membrane Filtration Guidance Manual

The Texas Water Development Board database presented information on the softening/desalination (NF, RO & EDR) facilities in Texas. This paper expands the database to include all three categories of membrane facilities in Texas.

Pre-Treatment

To understand the economic drivers for membrane development in Texas a brief discussion of pre-treatment is necessary. The State regulatory agency requires full water treatment for PWS's using surface water sources. Full treatment for conventional water plants consists of rapid mix, flocculation, sedimentation and filtration. The extent of treatment preceding membrane filtration depends on the

water source quality and other treatment objectives. Thus membrane facilities could range from direct filtration (no pre-treatment other than an oxidant) to full pre-treatment consisting of rapid mix, flocculation and sedimentation. The typical pre-treatment schemes for softening and desalination membranes include either MF or UF directly ahead of the NF, RO & EDR and the same range of supplemental treatment of only oxidant to full pre-treatment ahead of the filtration membrane.

The amount of pre-treatment has a tremendous impact on direct costs and incidental expenses such as sludge production and energy.

The quality of the water source is the prime determinate regarding the extent of pre-treatment and pilot testing will establish the economics.

Growth of Membranes in Texas

Prior to the year 2000 Texas had only one PWS with a capacity of 10 MGD utilizing a (MF) membrane for pre-treatment of a desalination facility. Since 2000 the number of PWS membrane facilities has grown from 1 to 23 with over 177 MGD combined capacity with many more facilities in planning, design or construction phases.

Figure 1 and Figure 2 present the cumulative Membrane Filtration (MF/UF) in Texas and the cumulative membrane capacity through 2006. Figure 3 presents the cumulative softening/desalination capacity in Texas through 2005.

Figure 1 – Cumulative Number of MF/UF in Texas

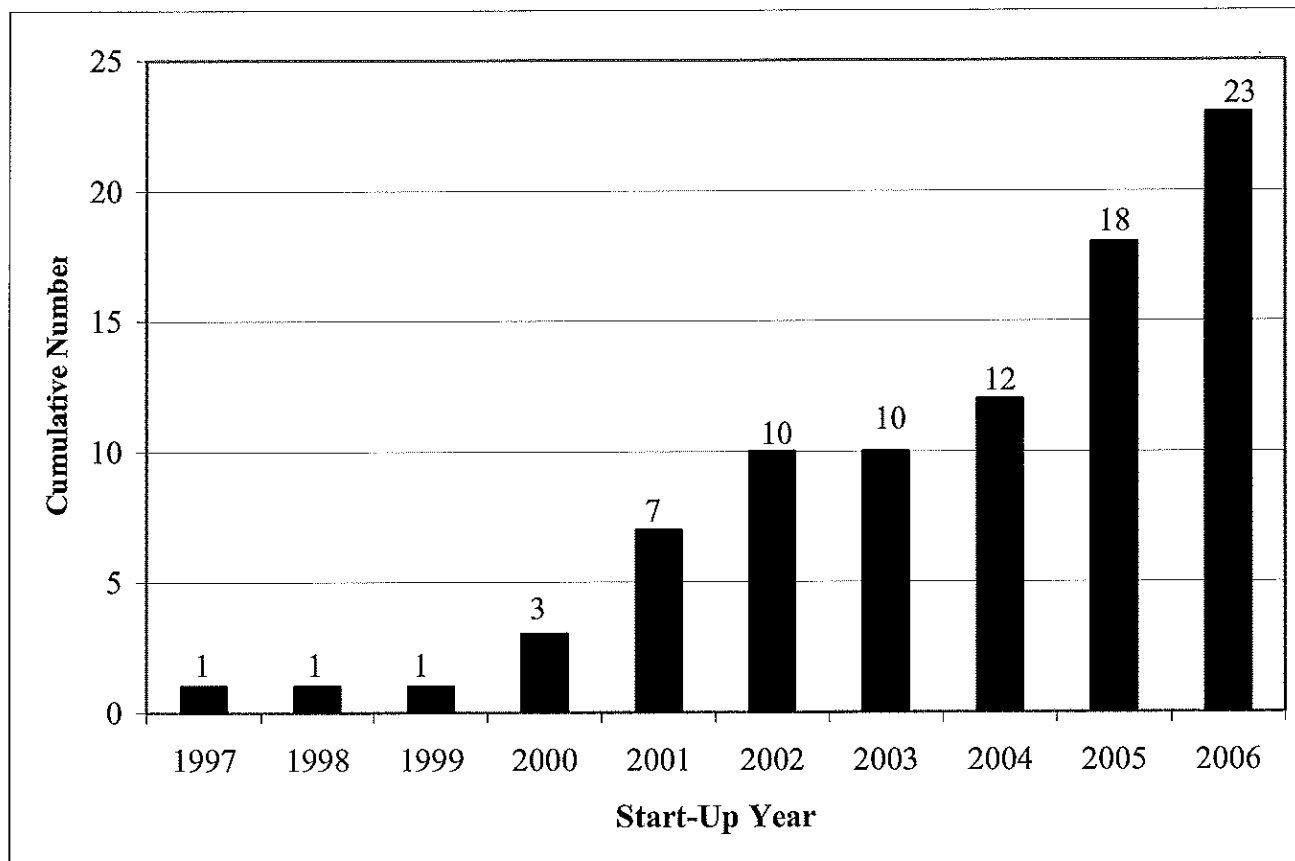


Figure 2 – Cumulative Membrane Filtration Capacity in Texas

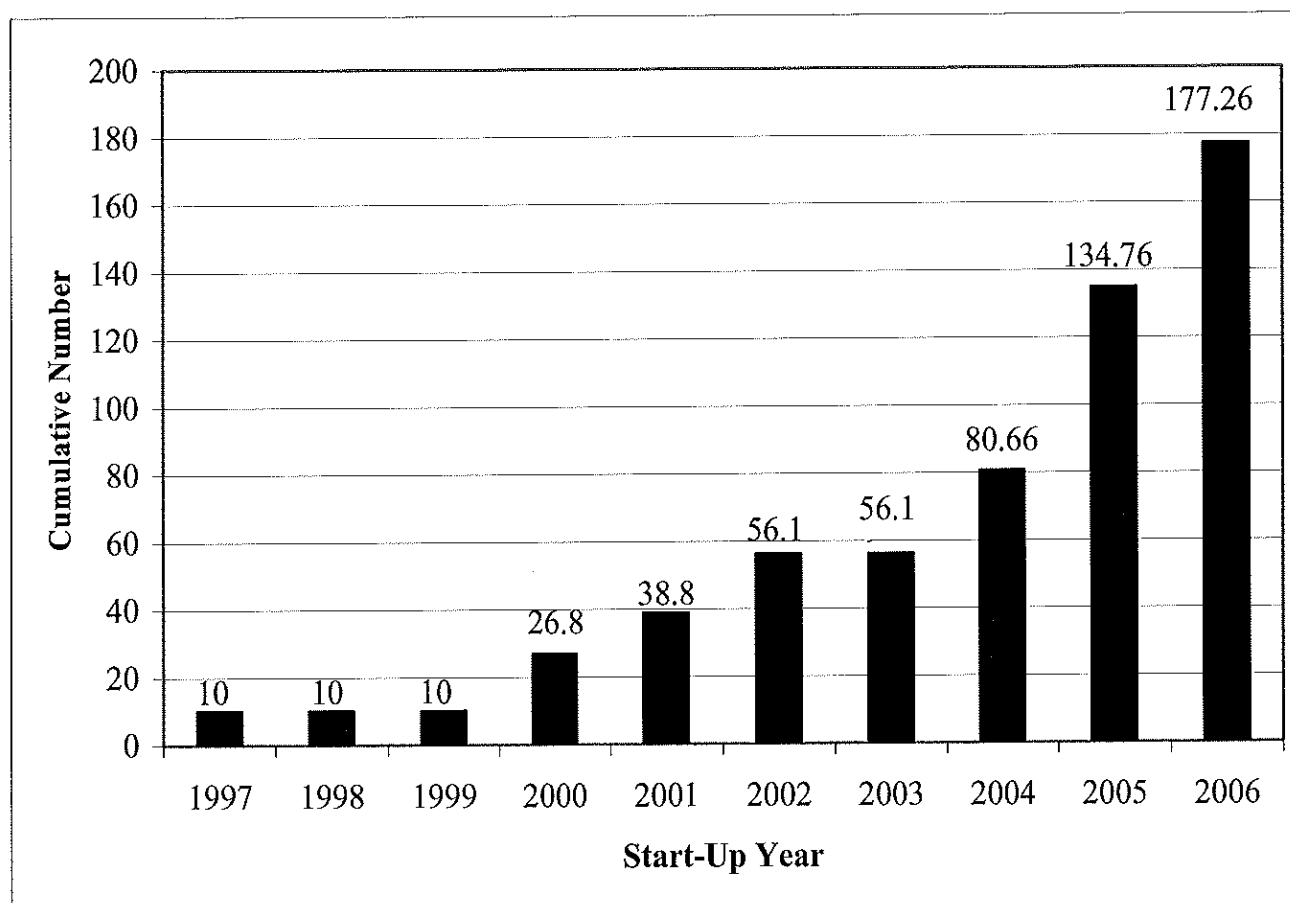
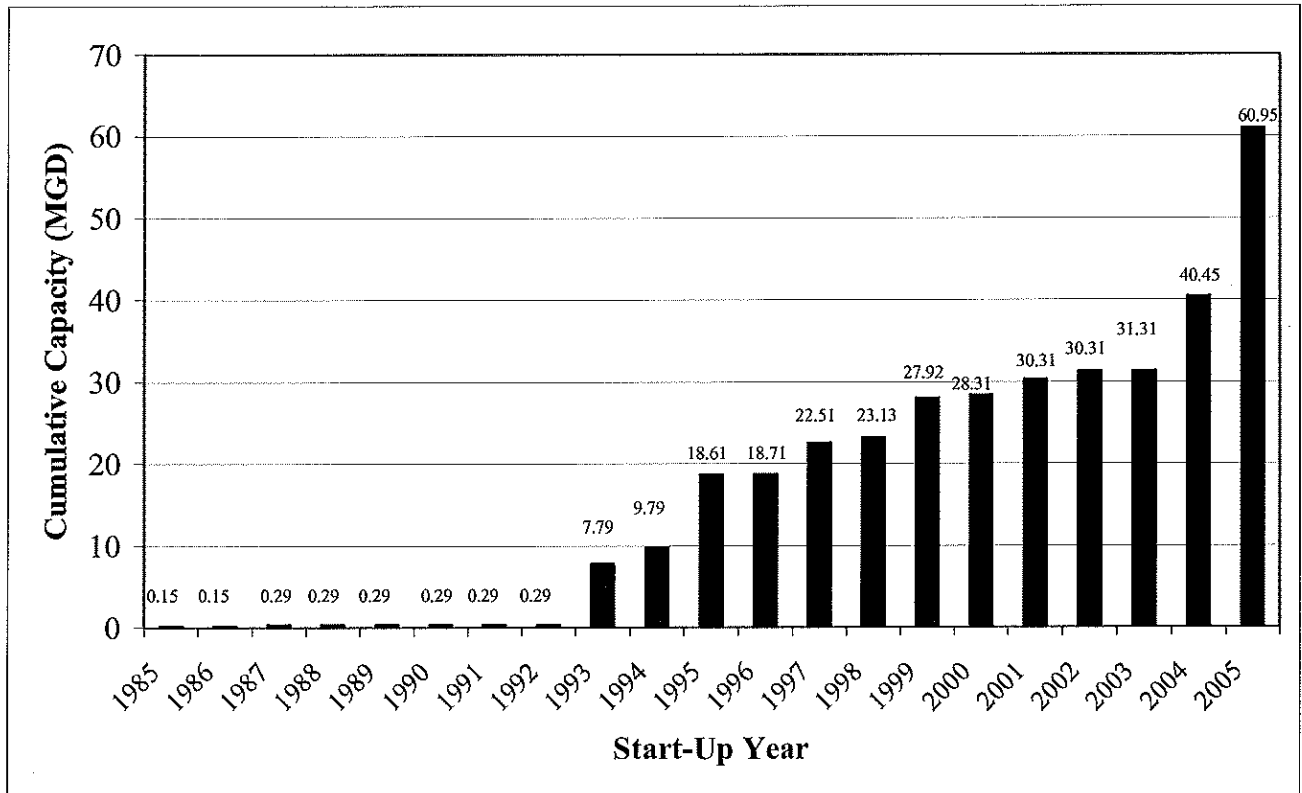


Figure 3 – Cumulative Softening/Desalination Capacity in Texas



Tables 2 thru 5 present a listing of the facilities, capacity, manufacturer/type, operating type and start-up year.

Table 2 – Microfiltration (MF) Plants in the State of Texas

Entity Name	Membrane Capacity (MGD)	Manufacturer/Type	Operation Type	Start-Up Year
1. City of Abilene Southside	8	Pall/Microfiltration (MF)	Pressure	2005
2. City of Brady	6	Pall/Microfiltration (MF)	Pressure	2006
3. Village of Briarcliff	0.36	Microfiltration (MF)		2002
4. Brown County Water Improvement District #1 (Brownwood)	10	Pall/Microfiltration (MF)	Pressure	Construction
5. Brushy Creek MUD (Round Rock)	6	Pall/Microfiltration (MF)	Pressure	2005
6. City of Granite Shoals	3	Pall/Microfiltration (MF)	Pressure	2007
7. Lake LBJ MUD (Horseshoe Bay)	4	Microfiltration (MF)	Pressure	2005
8. Millersview Doole (Millersview)	3.0	US Filters/ Microfiltration (MF)		Pilot
9. City of San Marcos	1	Microfiltration (MF)	Pressure	2002
10. San Patricio Municipal Water District (Ingleside)	7.8	Pall/Microfiltration (MF)	Pressure	2000
11. City of Sherman	10	Pall/Microfiltration (MF)	Pressure	1993
12. City of Temple	15	Pall/Microfiltration (MF)	Pressure	2004
13. Travis Water District #17 (Austin)	4	Pall/Microfiltration (MF)	Pressure	2001
14. Travis Water District #18 (Austin)	2	Pall/Microfiltration (MF)	Pressure	2001
15. TRA (Huntsville)	10	Pall/Zeon Microfiltration (MF)	Undetermined	Pilot
16. City of Weatherford	6.5	Pall/Microfiltration (MF)	Pressure	2006
17. City of Wichita Falls Cypress WTP	10	US Filter Memcor/ Microfiltration (MF)	Pressure	2006
Total MF operating capacity = 83.66 MGD				

Table 3 – Ultrafiltration (UF) Plants in the State of Texas

Entity Name	Membrane Capacity (MGD)	Manufacturer/Type	Operation Type	Start-Up Year
1. Bexar-Met WD (City of San Antonio)	9	Aquasource/Ultrafiltration (UF)	Pressure	2000
2. Brazos River Authority Lake Granbury Surface Water and Treatment System (SWATS) Expansion	8	(Hydranautics)/Ultrafiltration (UF)	Pressure	2004
3. Canyon Regional Water Authority (New Braunfels)	4	Koch/Ultrafiltration (UF)	Pressure	2001
4. Canyon Regional Water Authority (San Marcos)	2	Koch/Ultrafiltration (UF)	Pressure	2001
5. City of Del Rio	16	Aquasource/Ultrafiltration (UF)	Pressure	2002
6. City of Eagle Pass	15	Ionics/Norit Ultrafiltration (UF)	Pressure	2005
7. City of Georgetown Southside GUI	3.1	Aquasource/Ultrafiltration (UF)	Pressure	2005
8. Martindale WS (Martindale)	1.0	Koch/Ultrafiltration (UF)	Pressure	Construction
9. Nueces Co WCID 3 (Robstown)	6.6	Koch/Ultrafiltration (UF)	Pressure	Construction
10. City of Pflugerville	10	Zenon/Ultrafiltration (UF)	Vacuum	2005
11. San Benito	2.5	US Filters/Ultrafiltration (UF)	Undetermined	Report
12. City of Sweetwater	6	Zenon/Ultrafiltration (UF)	Vacuum	2005
13. Upper Trinity River Authority (Harpool WTP) (Lewisville)	20	Zenon/Ultrafiltration (UF)	Vacuum	2006
Total UF operating capacity = 94.6 MGD				

Table 4 – Electrodialysis Reversal (EDR) Plants in the State of Texas

Entity Name	Membrane Capacity (MGD)	Start-Up – Year
1. Brazos River Authority Lake Granbury Surface Water and Treatment System (SWATS) (City of Granbury)	6	1995
2. City of Granbury	2	1995
3. Oak Trail Shores (Dallas)	0.144	1985
4. City of Sherman	7.5	1993
Total operating EDR capacity = 15.65 MGD		

Table 5 – Reverse Osmosis Plants in the State of Texas

Entity Name	Membrane Capacity (MGD)	Start-Up Year
1. City of Abilene	8	2004
2. City of Beckville	0.14	2004
3. BRA SWATS Expansion	9.5	2005
4. City of Brady	1.5	2005
5. Dell City	0.1	1996
6. El Paso/Ft. Bliss joint facility	27.5	Construction
7. City of Electra	0.5	1999
8. City of Fort Stockton	3.8	1997
9. Harlingen WS (Harlingen)	4	1999
10. City of Kenedy	0.72	1995
11. City of Laredo Santa (Webb County)	0.1	1998
12. City of Primera	2	2005
13. City of Raymondville	1	2004
14. River Oaks Ranch (Hays County)	0.14	1987
15. City of Robinson	2	1994
16. City of Seadrift	0.52	1998
17. City of Seymour	2	2001
18. SRWA (Brownsville)	7.5	2005
19. Study Butte Telingua Water System (Brewster County)	0.14	2000
20. City of Tatum	0.29	1999
21. Valley MUD #2 (Rancho Viejo)	0.25	2000
22. Wichita Falls	10	Construction
23. Windermere Water System	1.0	2003
Total RO operating capacity = 45.2 MGD		

What's Driving the Market?

A locational mapping of membrane installations in Texas, Figure 4, reveals the clustering in the Central Region which has water supply sources of extremely good quality requiring a minimal degree of pre-treatment. There is a noticeable lack of facilities in East and West Texas where the water sources are of less quality (high turbidity and organics). Some of the filtration membrane installations on the Gulf Coast, Rio Grand and Red River are associated with desalination treatment as shown on Figure 5.

Figure 4 – Membrane Filtration Plants in the State of Texas

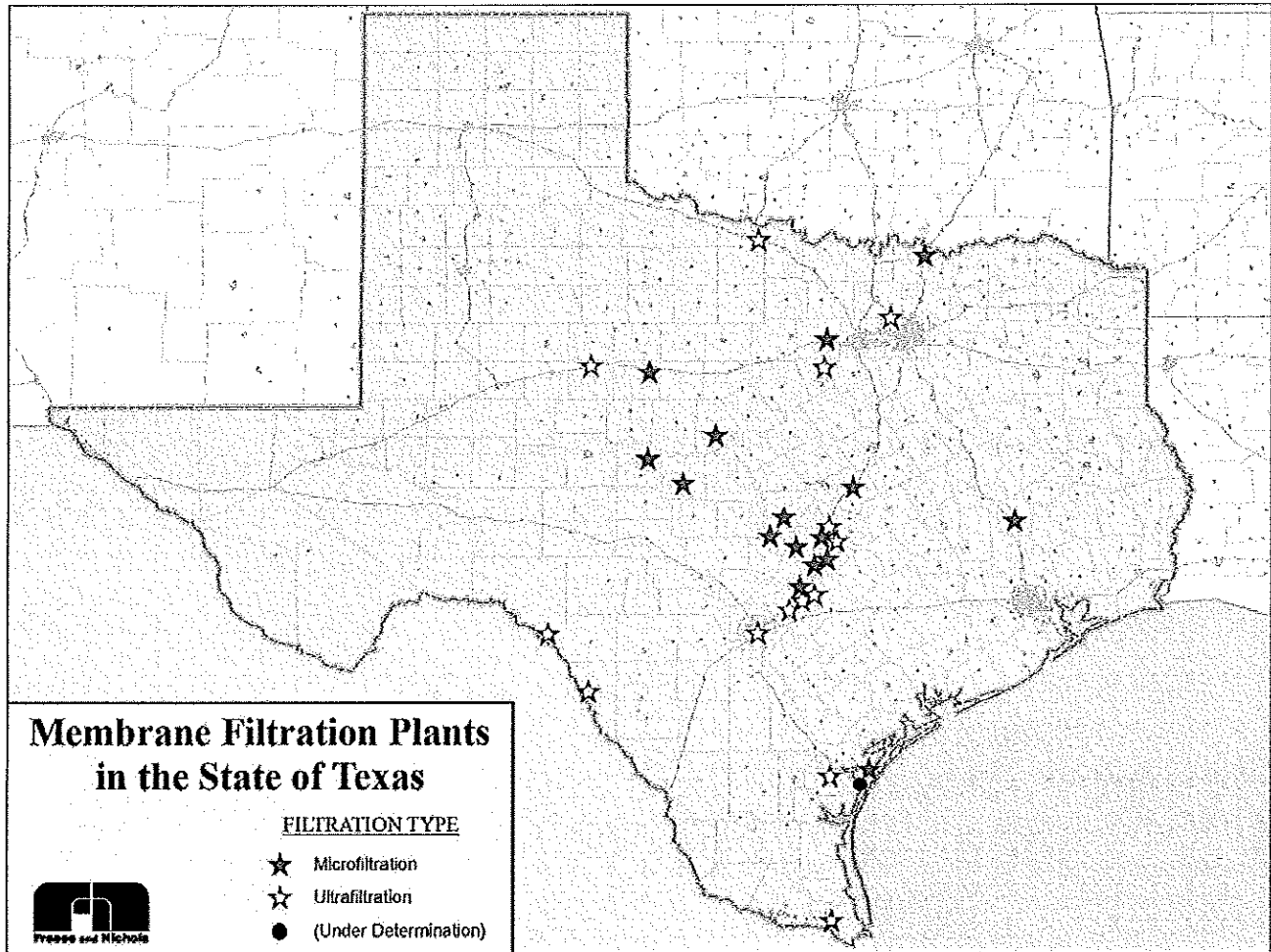
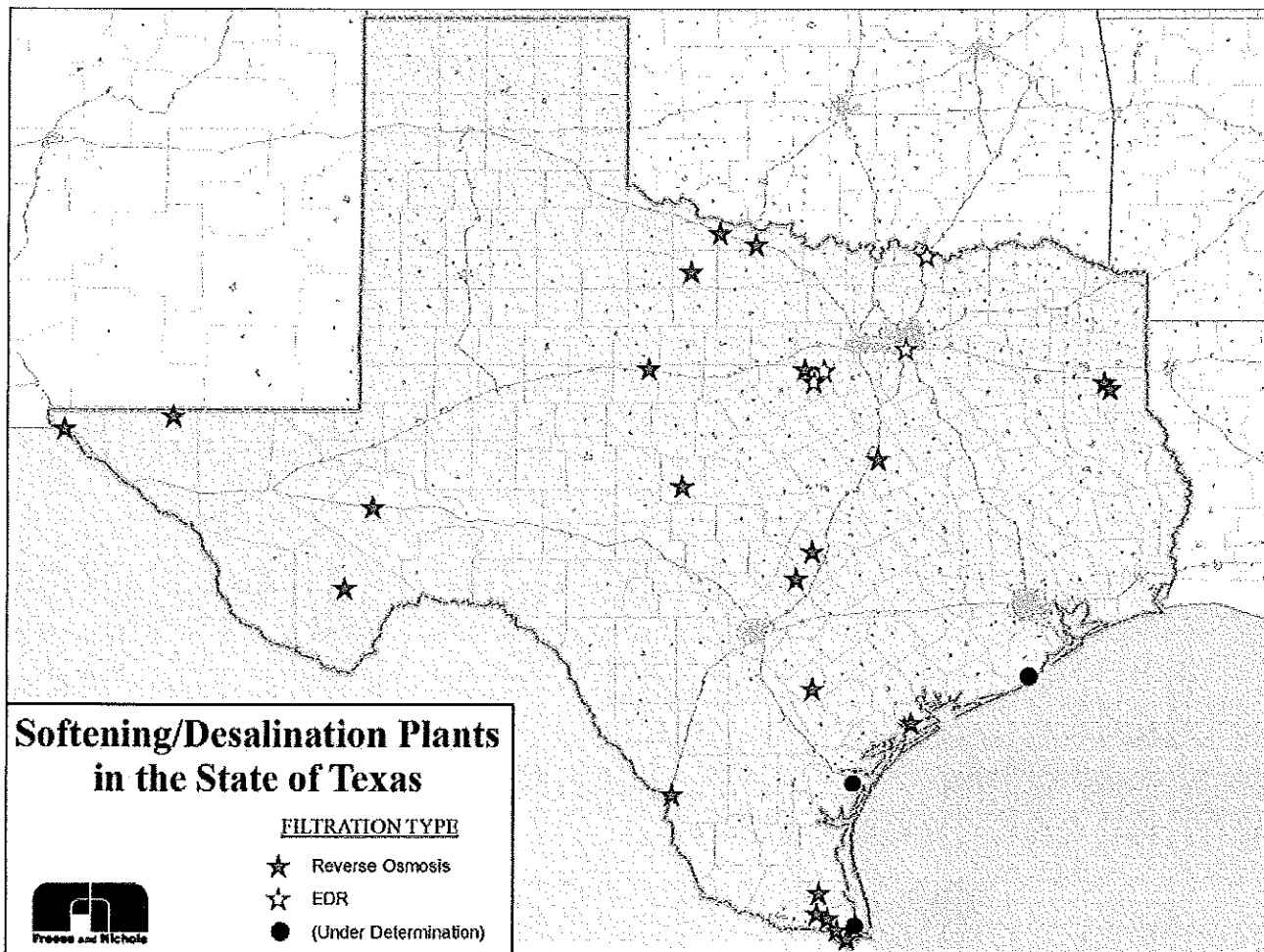


Figure 5 – Softening/Desalination Plants in the State of Texas



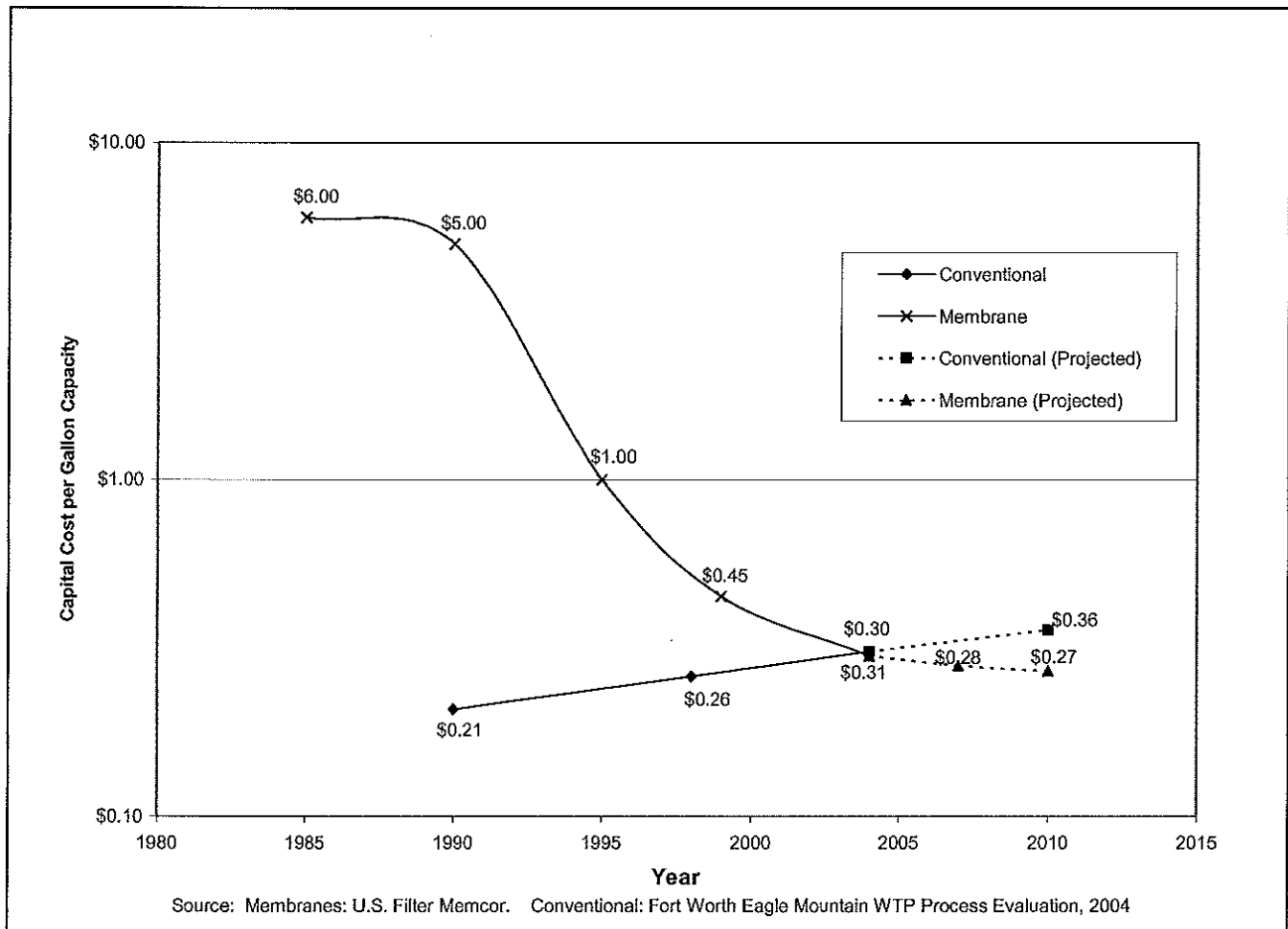
There has been a fairly even distribution between MF and UF installations (Table 6). The vast majority of operating filtration systems are of the pressure type. However, the most recently constructed membrane facilities have been fairly evenly awarded between pressure and vacuum operating systems.

Table 6 – Membrane Filtration Plants in the State of Texas

Total operating capacity (2006) = 177.26 MGD
Number of operating MF facilities = 14 Total MF operating capacity = 83.66 MGD
Number of operating UF facilities = 10 Total UF operating capacity = 94.6 MGD
Number of pressure membrane facilities = 20
Number of vacuum membrane facilities = 3

The cost trends for membranes continue to decline compared to conventional filtration systems. A recent comparison made for the City of Fort Worth's 35 MGD expansion of its Eagle Mountain water treatment plant is shown in Figure 6.

Figure 6 – Cost Trends Conventional vs. Membrane Filtration



What has driven membrane cost down for the last 10 years?

- Number of membrane facilities in Texas have increased over 2,000% in last 10 years.
- Membrane Productivity/Flux rates have doubled.
- Membrane useful life (warranted) has doubled.
- Energy use reduction (lower feed pressures and higher recovery rates).
- Economics of Scale (more and larger projects).

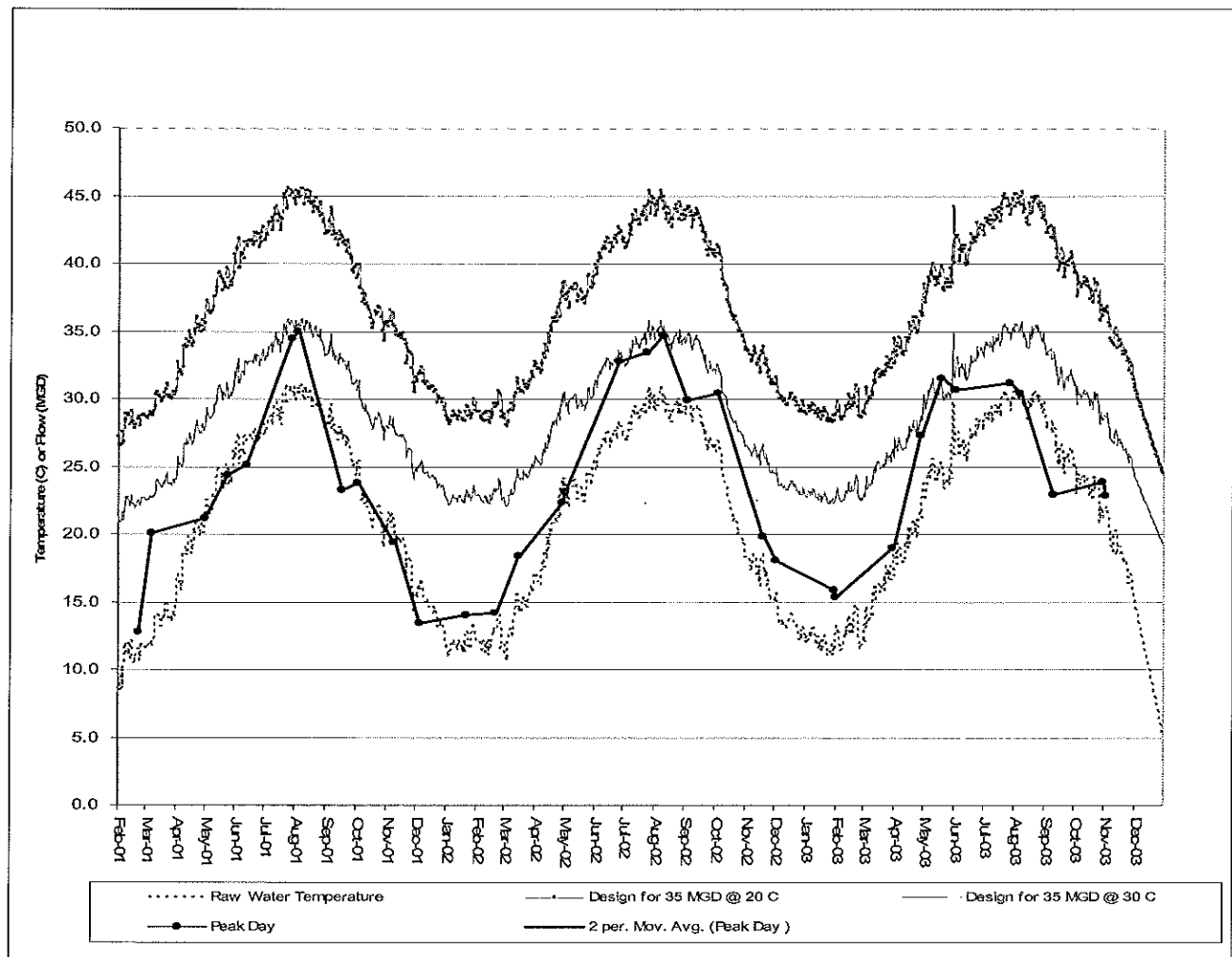
What has driven membrane construction cost down over the last 10 years?

- High quality water supply sources (low turbidity and low organics) that require no or minimal pre-treatment.
- More general contractor's gaining experience and confidence in construction and warranty of this technology.
- Less sensitive to heavy construction price fluctuation in steel, concrete and site work.

Why are more PWS selecting membranes?

- More stringent water quality regulations that are costly for conventional plants to meet.
 - Forced to use water of lower quality requiring a higher level of treatment.
 - Can “Right Size” the facility for current needs and expand in smaller and economical increments.
 - Security.
 - Less chemicals and solid handling.
 - Able to match water temperature (viscosity) with water production demands.
- See Figure 7.

Figure 7 – Impact of Water Temperature on Membrane Production



- Membrane facilities are more automated and require less operating staff.
- Supportive State regulatory agency toward membrane development.
- More and larger projects offering an operator support network.

Summary

In Texas the past few years have seen an explosion in both membrane filtration and desalination facilities state wide. The membrane filtration technology has begun to cluster around high water quality sources (low turbidity and organics) where pre-treatment is minimal.

The cost of membrane filtration plants with minimal pre-treatment is competitive with (more or less than) conventional treatment. The State of Texas regulatory agency is supportive of this technology which affords positive barriers against waterborne pathogens and parasites. A membrane facility has the advantage to expand in small incremental additions to more closely match customers growth demands.

Small footprints, security, less chemicals, and automation are very attractive market drivers.

As the number of installations increase around the Central Region of Texas' higher water quality areas, the growth of this technology will spread to the north, east, south and western regions of the State. The development of brackish ground water in West and South Texas is of primary interest to the State and possibly the next major development area for membranes in Texas.

The impediment which has been restricting desalination has been concentrate disposal. The State is developing plans to more closely align the requirements of PWS concentrate disposal with those which the oil and gas industry has been employing for decades. Resolution of this issue will result in dramatic development of brackish water in Texas.