

Chapter 1

Aquifers of the Gulf Coast of Texas: An Overview

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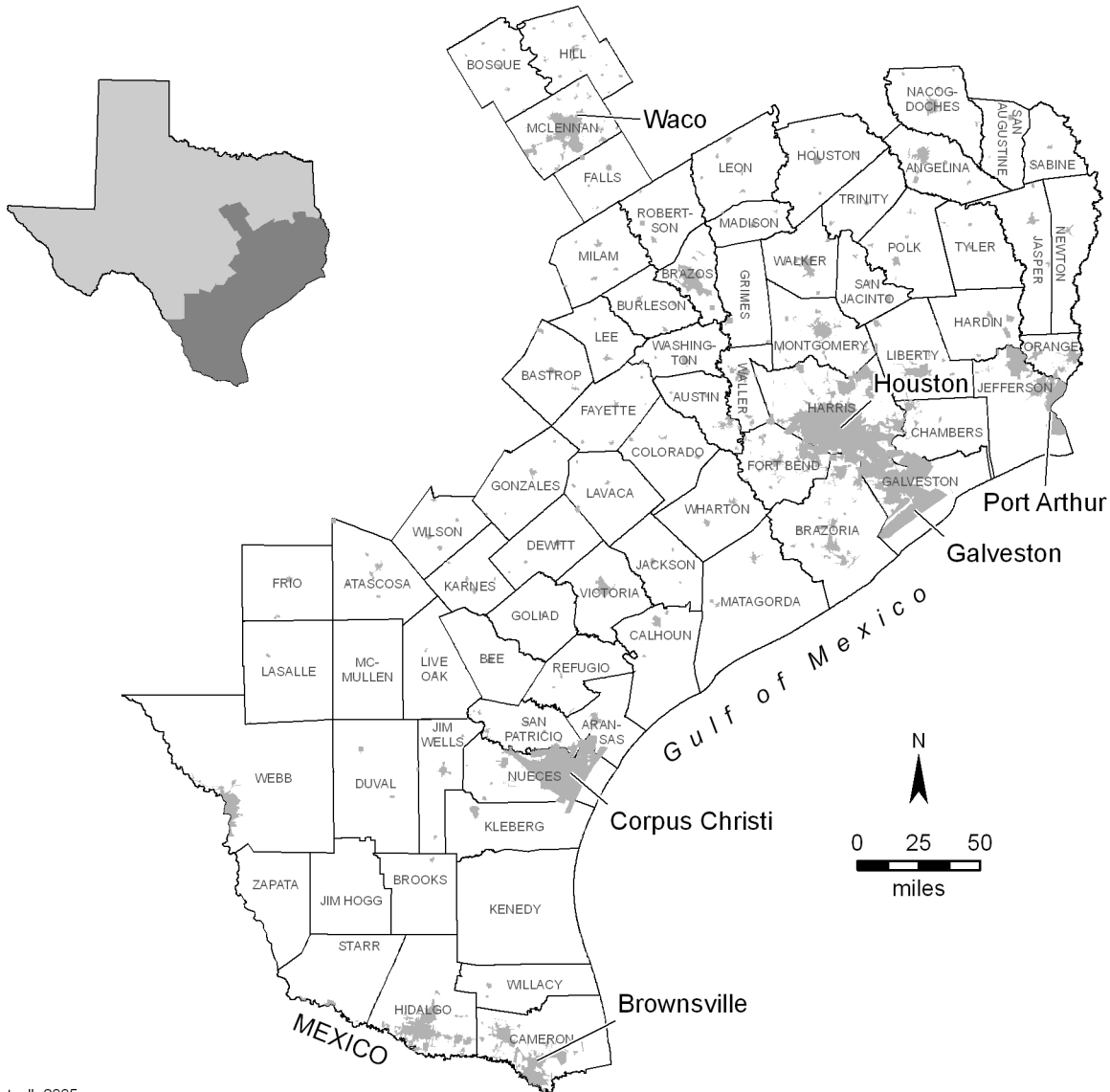
Introduction

The Gulf Coast region of Texas is located along the Gulf of Mexico in the southeastern part of the state. It includes the lower Rio Grande valley on the border with Mexico in the southwest, the Sabine River basin on the Louisiana border in the northeast, the Houston-Galveston and Corpus Christi metropolitan areas, and many other smaller communities. The Gulf Coast aquifer is the largest aquifer in the region and the area's main source of groundwater. In addition, the Yegua-Jackson and the Brazos River Alluvium aquifers are an important source of water in parts of the Gulf Coast area. There are many issues of concern within the region regarding groundwater that are currently being studied, including drought, land subsidence, salt domes, water quality, groundwater flow to estuaries, whether brackish water desalination technology can be used to meet water needs, and the effects of oil and gas production on water quality. In order to address these concerns, it is important to understand how the aquifers work and how they change in response to human activities. This paper provides a general overview of the area, the aquifers in the region, and recent research and planning that has focused on the groundwater in the area, and serves as an introduction to this report.

Location, Physiography, and Climate

For our purposes, the Gulf Coast region consists of the 73 counties that overlie the Gulf Coast, Yegua-Jackson, and Brazos River Alluvium aquifers (Figure 1-1). These counties include: Angelina, Aransas, Atascosa, Austin, Bastrop, Bee, Bosque, Brazoria, Brazos, Brooks, Burleson, Calhoun, Cameron, Chambers, Colorado, De Witt, Duval, Fayette, Fort Bend, Frio, Galveston, Goliad, Gonzales, Grimes, Hardin, Harris, Hidalgo, Hill, Houston, Jackson, Jasper, Jefferson, Jim Hogg, Jim Wells, Karnes, Kenedy, Kleberg, La Salle, Lavaca, Lee, Leon, Liberty, Live Oak, Madison, Matagorda, McLennan, McMullen, Milam, Montgomery, Nacogdoches, Newton,

¹ Texas Water Development Board



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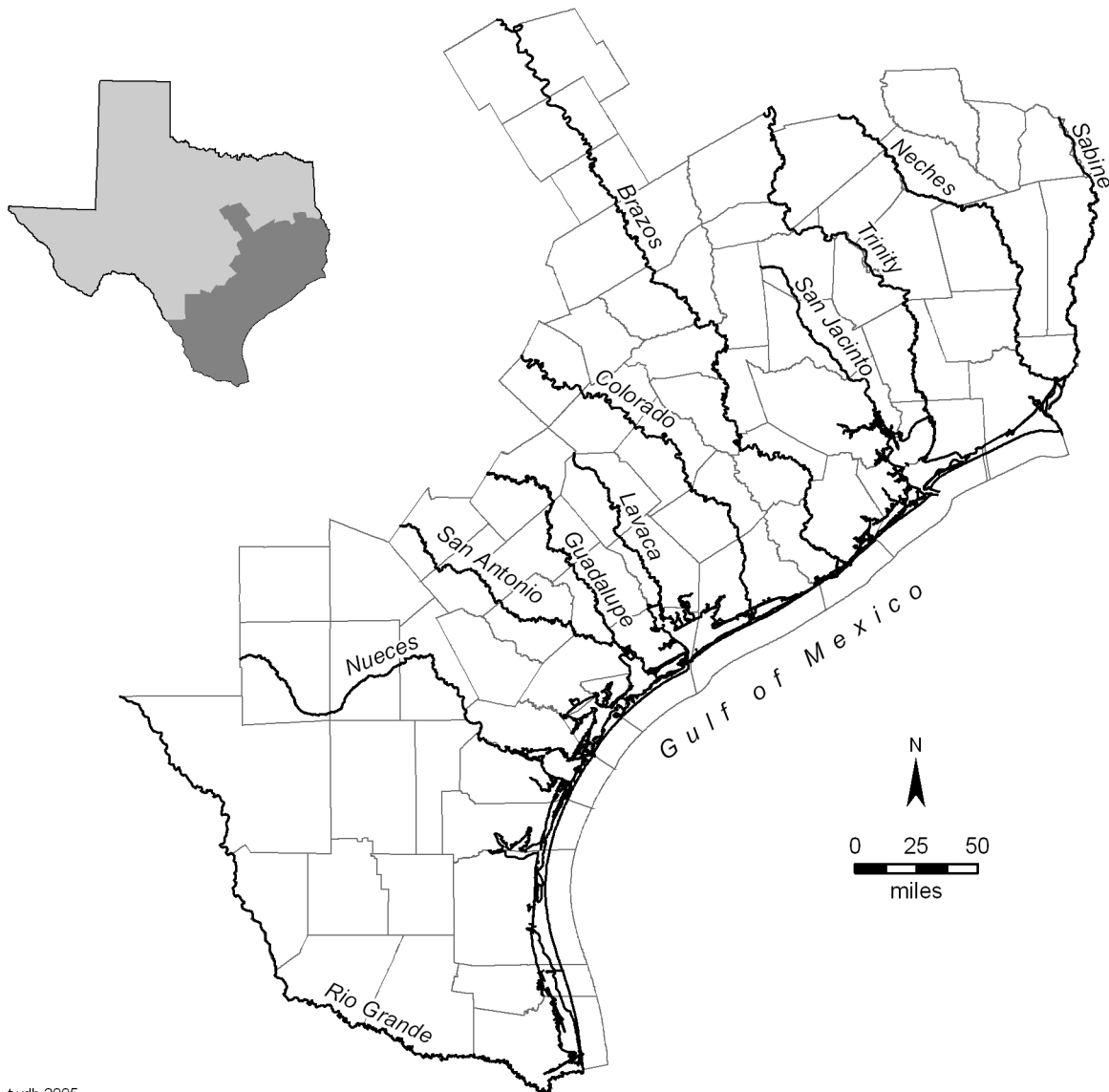
Figure 1-1. Location of the Gulf Coast region, showing counties and population centers.

Nueces, Orange, Polk, Refugio, Sabine, San Augustine, San Jacinto, San Patricio, Starr, Trinity, Tyler, Victoria, Walker, Waller, Washington, Webb, Wharton, Willacy, Wilson, and Zapata.*

* For those counties furthest from the Gulf of Mexico that only partially overlie the Yegua-Jackson or Brazos River Alluvium aquifers, the main topics of this report may only marginally apply.

Most of the Gulf Coast region is located within the West Gulf Coastal Plain, part of the Coastal Plain physiographic province. This province consists of marine sedimentary rocks that tilt gently seaward towards the Atlantic Ocean and the Gulf of Mexico (Fenneman, 1938). The elevation ranges from sea level at the coast to over 800 feet in the southwestern part of the region (BEG, 1992).

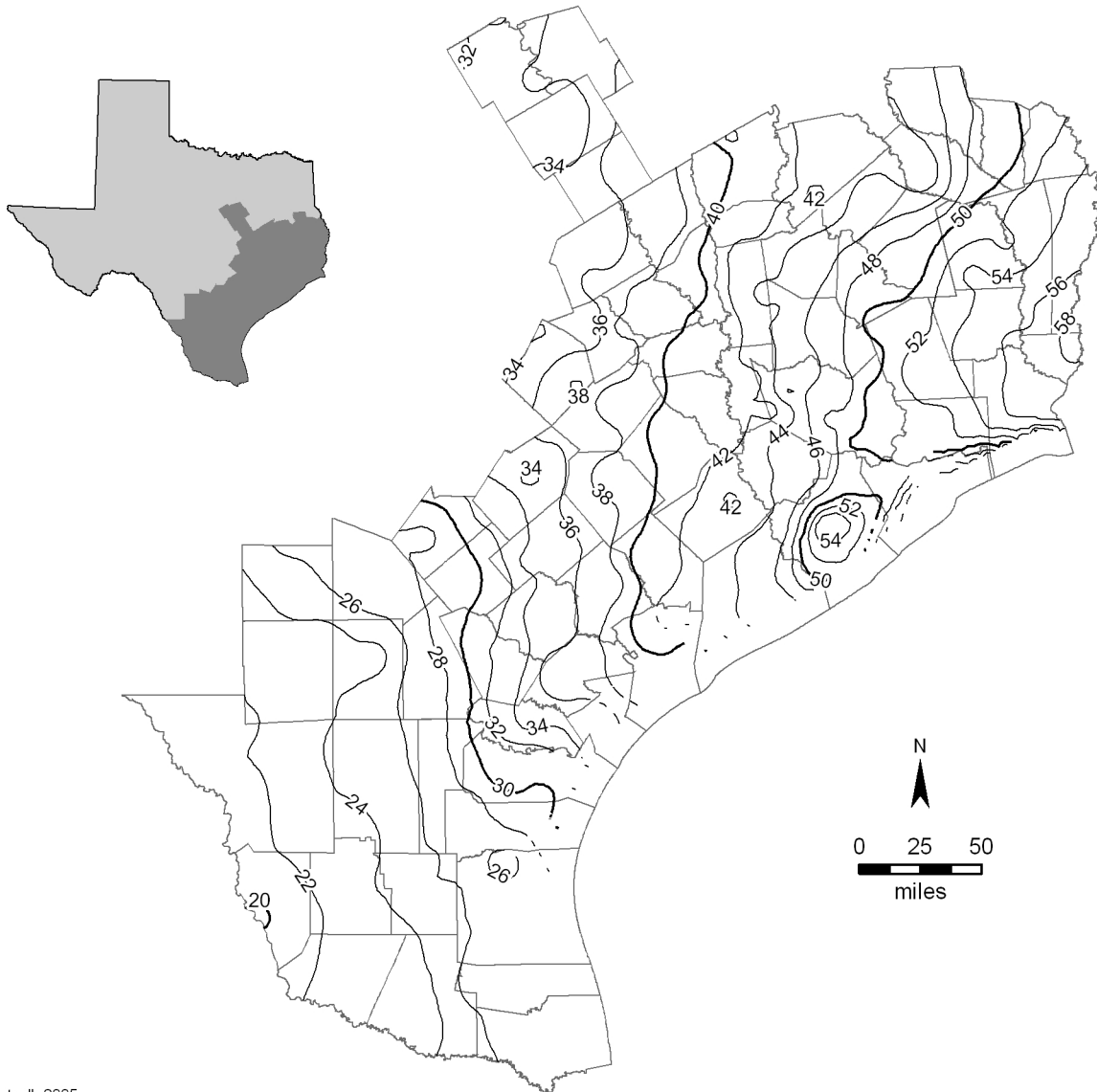
Of the sixteen major rivers of Texas that are recognized by the Texas Water Development Board (TWDB), eleven flow to the southeast through the Gulf Coast area and into the Gulf of Mexico. These are the Brazos, Colorado, Guadalupe, Lavaca, Neches, Nueces, Sabine, San Antonio, San Jacinto and Trinity rivers, as well as the Rio Grande (Figure 1-2).



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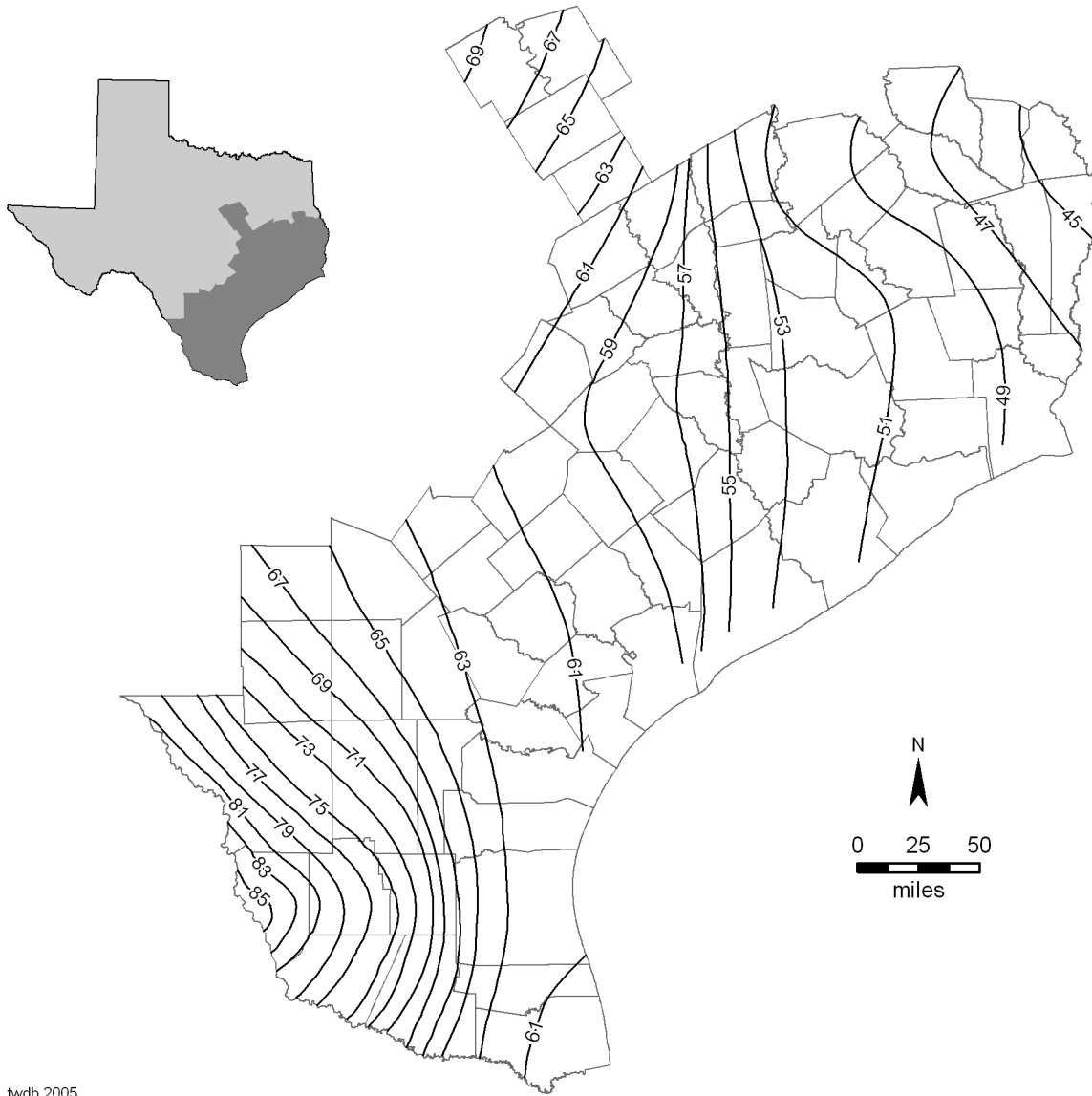
Figure 1-2. Location of major rivers in the region and the Gulf of Mexico coastline.

The climate of the region is subtropical and influenced primarily by the Gulf of Mexico. Winters are mild and summers are hot, with high humidity in the northeast and semi-arid to arid conditions in the southwest (Larkin and Bomar, 1983). Average annual precipitation ranges from 28 inches in the southwest to 58 inches in the northeast (Figure 1-3; Daly, 1998), and average annual gross lake-surface evaporation ranges from 85 inches in the southwest to 45 inches in the northeast (Figure 1-4; Larkin and Bomar, 1983).



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Figure 1-3. Contours showing average annual precipitation (in inches) in the Gulf Coast region from 1961 to 1990 (data from Daly, 1998).



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Figure 1-4. Contours showing average annual gross lake evaporation (in inches) in the Gulf Coast region from 1950 to 1979 (data from Larkin and Bomar, 1983).

Population and Groundwater Use

In 2000, more than 8 million people—nearly 40 percent of Texans—lived in the Gulf Coast region (U.S. Census Bureau, 2003). The population increased over 180 percent from 1950 to 2000 (Table 1-1). Despite this overall increase, 15 counties experienced a decline in population over this period. As of 2000, 26 counties had populations under 20,000, while 11 counties had populations over 100,000. Harris County had by far the highest population with 3.4 million people (Table 1-1).

Table 1-1. Population and groundwater use for counties within the Gulf Coast area for selected years (populations from U.S. Census Bureau, 2003).

County	Population				Groundwater use (acre-feet)			%GW 1997
	1950	1980	1990	2000	1980	1990	1997	
Angelina	36,032	64,172	69,884	80,130	33,152	26,886	25,186	73.2
Aransas	2,452	14,260	17,892	22,497	1,089	452	499	14.0
Atacosa	20,048	25,055	30,533	38,628	79,089	59,738	50,714	97.1
Austin	14,663	17,726	19,832	23,590	12,948	12,999	11,446	87.1
Bastrop	19,622	24,726	38,263	57,733	5,399	7,178	8,468	69.8
Bee	18,174	26,030	25,135	32,359	6,190	5,065	3,572	49.1
Bosque	11,836	14,943	15,125	17,204	3,100	3,813	3,967	48.7
Brazoria	46,549	169,587	191,707	241,767	49,454	28,559	32,133	10.2
Brazos	38,390	93,588	121,862	152,415	24,751	36,239	33,847	93.8
Brooks	9,195	8,428	8,204	7,976	1,723	1,726	3,179	85.0
Burleson	13,000	12,313	13,625	16,470	8,099	8,975	3,134	52.0
Calhoun	9,222	19,574	19,053	20,647	14,730	4,549	2,377	3.5
Cameron	125,170	209,727	260,120	335,227	910	2,309	3,277	1.0
Chambers	7,871	18,538	20,088	26,031	3,998	5,153	9,763	7.6
Colorado	17,576	18,823	18,383	20,390	69,522	49,133	28,258	14.6
De Witt	22,973	18,903	18,840	20,013	3,511	4,170	3,856	65.5
Duval	15,643	12,517	12,918	13,120	5,812	7,842	15,096	94.1
Falls	26,724	17,946	17,712	18,576	4,216	5,889	3,384	37.4
Fayette	24,176	18,832	20,095	21,804	4,061	3,719	4,002	23.9
Fort Bend	31,056	130,846	225,421	354,452	74,113	91,373	70,344	53.4
Frio	10,357	13,785	13,472	16,252	78,959	85,073	61,849	97.8
Galveston	113,066	195,738	217,396	250,158	24,322	8,203	5,735	6.0
Goliad	6,219	5,193	5,980	6,928	1,057	1,344	1,193	25.0
Gonzales	21,164	16,949	17,205	18,628	4,226	4,660	3,449	35.9
Grimes	15,135	13,580	18,828	23,552	2,662	3,750	4,665	48.5
Hardin	19,535	40,721	41,320	48,073	10,904	7,145	6,198	49.5
Harris	806,701	2,409,547	2,818,101	3,400,578	428,272	421,463	339,279	38.5
Hidalgo	160,446	283,323	383,545	569,463	12,925	27,485	16,840	4.3
Hill	31,282	25,024	27,146	32,321	3,767	2,519	2,942	41.5
Houston	22,825	22,299	21,375	23,185	2,393	2,784	3,041	48.8
Jackson	12,916	13,352	13,039	14,391	135,642	92,472	43,609	89.8
Jasper	20,049	30,781	31,102	35,604	51,471	49,486	53,071	82.8
Jefferson	195,083	250,938	239,389	252,051	15,046	10,736	12,318	3.4
Jim Hogg	5,389	5,168	5,109	5,281	1,065	828	770	52.9
Jim Wells	27,991	36,498	37,679	39,326	5,924	4,210	3,627	48.0
Karnes	17,139	13,593	12,455	15,446	3,233	4,610	3,426	70.1
Kenedy	632	543	460	414	283	154	132	19.4
Kleberg	21,991	33,358	30,274	31,549	9,459	7,509	7,058	71.5
La Salle	7,485	5,514	5,254	5,866	11,938	7,529	5,965	91.6
Lavaca	22,159	19,004	18,690	19,210	30,749	19,337	11,454	85.5
Lee	10,144	10,952	12,854	15,657	2,856	3,719	4,112	78.2
Leon	12,024	9,594	12,665	15,335	2,437	3,571	4,612	69.8
Liberty	26,729	47,088	52,726	70,154	37,016	19,966	26,765	29.9

Table 1-1. Continued.

County	Population				Groundwater use (acre-feet)			%GW 1997
	1950	1980	1990	2000	1980	1990	1997	
Live Oak	9,054	9,606	9,556	12,309	4,526	5,997	6,845	75.0
Madison	7,996	10,649	10,931	12,940	2,199	2,672	2,836	80.7
Matagorda	21,559	37,828	36,928	37,957	38,554	37,537	14,413	9.4
McLennan	130,194	170,755	189,123	213,517	13,017	12,588	15,091	25.7
McMullen	1,187	789	817	851	624	396	858	65.2
Milam	23,585	22,732	22,946	24,238	4,376	18,382	34,405	68.0
Montgomery	24,504	127,222	182,201	293,768	20,828	28,198	40,925	92.1
Nacogdoches	30,326	46,786	54,753	59,203	7,411	8,370	9,389	75.8
Newton	10,832	13,254	13,569	15,072	2,850	3,486	3,072	81.8
Nueces	165,471	268,215	291,145	313,645	2,862	842	3,180	3.4
Orange	40,567	83,838	80,509	84,966	20,638	18,603	17,954	23.9
Polk	16,194	24,407	30,687	41,133	4,306	4,434	5,158	71.3
Refugio	10,113	9,289	7,976	7,828	1,821	1,360	1,271	79.0
Robertson	19,908	14,653	15,511	16,000	20,613	21,364	19,084	87.3
Sabine	8,568	8,702	9,586	10,469	1,061	1,030	909	40.6
San Augustine	8,837	8,785	7,999	8,946	864	651	620	31.6
San Jacinto	7,172	11,434	16,372	22,246	1,512	2,013	2,453	89.7
San Patricio	35,842	58,013	58,749	67,138	4,091	3,163	2,328	11.5
Starr	13,948	27,266	40,518	53,597	677	1,515	1,393	2.4
Trinity	10,040	9,450	11,445	13,779	1,461	1,201	1,430	51.3
Tyler	11,292	16,223	16,646	20,871	2,383	2,193	2,645	95.2
Victoria	31,241	68,807	74,361	84,088	39,933	29,222	27,339	48.5
Walker	20,163	41,789	50,917	61,758	9,867	5,499	6,624	56.3
Waller	11,961	19,798	23,389	32,663	30,692	32,645	27,723	94.6
Washington	20,542	21,998	26,154	30,373	1,848	2,469	2,620	40.0
Webb	56,141	99,258	133,239	193,117	857	1,158	1,526	3.4
Wharton	36,077	40,242	39,955	41,188	175,210	162,820	178,219	53.7
Willacy	20,920	17,495	17,705	20,082	573	17	18	0.1
Wilson	14,672	16,756	22,650	32,408	9,663	15,898	16,585	81.2
Zapata	4,405	6,628	9,279	12,182	242	80	51	0.7
Total	2,920,144	5,751,743	6,706,372	8,268,783	1,708,032	1,580,123	1,385,576	29.7

%GW = percent of total water use in 1997 that was met with groundwater. Groundwater use includes use from all aquifers, including those not discussed in this paper.

In 1997, about one-third of the region's water supply came from groundwater, and 31 counties obtained more than 60 percent of their water supply from groundwater (Table 1-1). The region withdrew about 1.7 million acre-feet in 1980 and about 1.4 million acre-feet in 1997.

Aquifers of the Gulf Coast

The Gulf Coast area includes the Gulf Coast, Yegua-Jackson, and Brazos River Alluvium aquifers (Figure 1-5). The boundaries of these aquifers have been defined by the TWDB. Based on the quantity of water supplied by each aquifer, the TWDB has designated the Gulf Coast aquifer as a major aquifer and the Yegua-Jackson and Brazos River Alluvium aquifers as minor aquifers (Ashworth and Hopkins, 1995; TWDB, 2002). Additional water may be produced in smaller, localized aquifers not recognized by the TWDB.

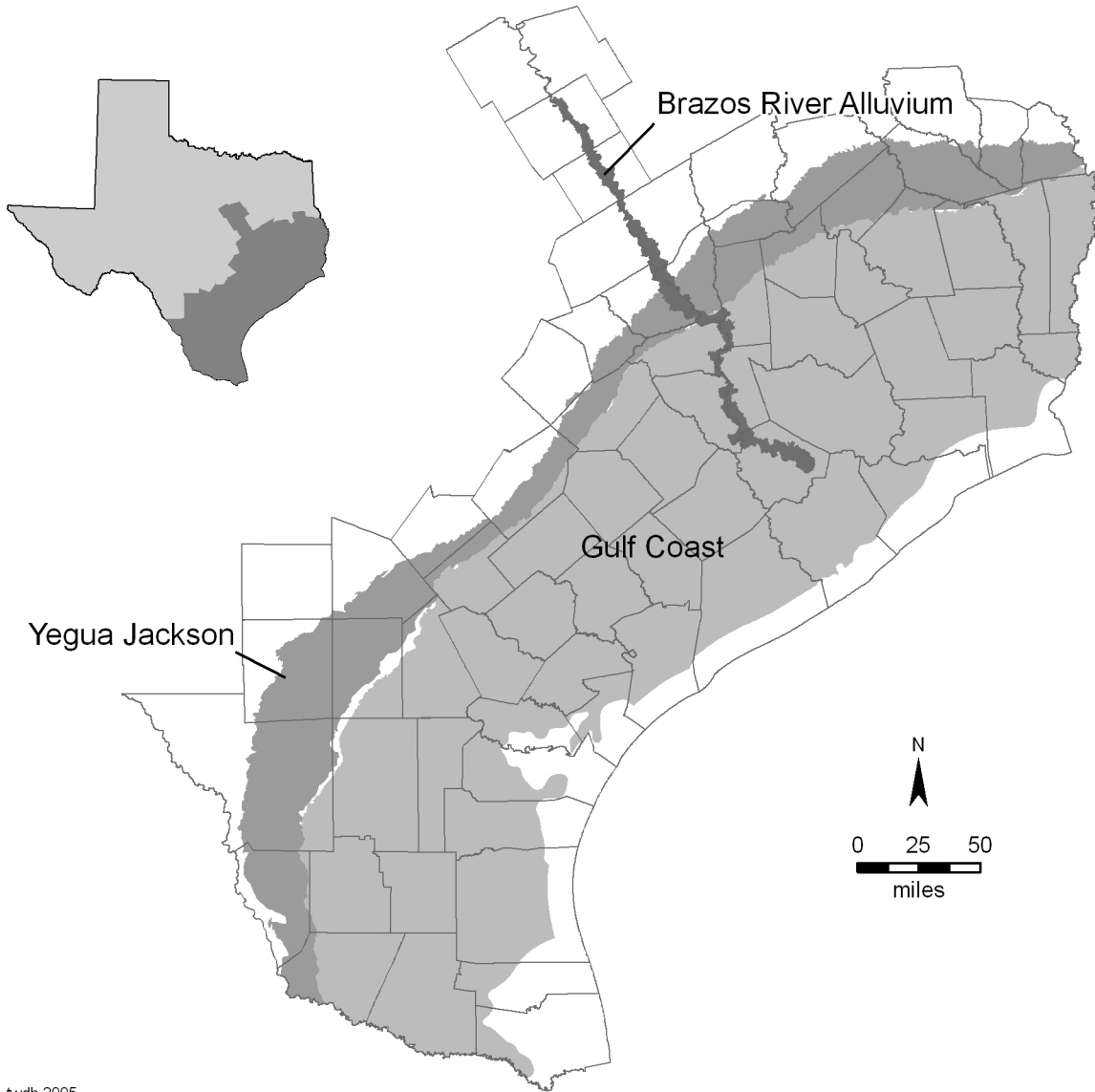


Figure 1-5. Location of major and minor aquifers recognized by the TWDB in the Gulf Coast region that are discussed in this paper and report (delineations from TWDB; this map does not show all aquifers in the upland areas).

Groundwater studies have focused primarily on the major aquifers, but additional research has also addressed the minor aquifers. Below are brief descriptions of each of the three recognized aquifers in the Gulf Coast area—more detailed information on these aquifers is available throughout this report.

Gulf Coast Aquifer

The Gulf Coast aquifer is located along the Gulf of Mexico coast throughout all or parts of Aransas, Austin, Bee, Brazoria, Brazos, Brooks, Calhoun, Cameron, Chambers, Colorado, De Witt, Duval, Fayette, Fort Bend, Galveston, Gonzales, Goliad, Grimes, Hardin, Harris, Hidalgo, Jim Hogg, Jim Wells, Jackson, Jasper, Jefferson, Karnes, Kenedy, Kleberg, Lavaca, Liberty, Live Oak, Matagorda, McMullen, Montgomery, Newton, Nueces, Orange, Polk, Refugio, San Jacinto, Sabine, San Patricio, Starr, Trinity, Tyler, Victoria, Walker, Waller, Washington, Webb, Wharton, Willacy, and Zapata counties.

The aquifer has been divided into four units, each of which can be generally correlated to different sedimentary formations (Baker, 1979) and has different hydraulic properties (Chowdhury and Mace, 2003; Chowdhury and others, 2004; Kasmarek and Robinson, 2004). The deepest of these is the Catahoula confining system, which includes the Frio Formation, the Anahuac Formation, and the Catahoula Tuff or Sandstone. The Catahoula is overlain by the Jasper aquifer, which consists of the Oakville Sandstone and Fleming Formation. The upper part of the Fleming Formation forms the Burkeville confining system. This separates the Jasper aquifer from the Evangeline aquifer, which is made up of water within the Goliad Sand. The shallowest unit, the Chicot aquifer, is made up of the Willis Sand, the Bentley and Montgomery formations, the Beaumont Clay, and alluvial deposits at the surface (Baker, 1979). The total sand thickness in all four units ranges from 700 feet in the south to 1,300 feet in the north (Ashworth and Hopkins, 1995).

Groundwater quality in the Gulf Coast aquifer is generally good northeast of the San Antonio River but declines to the southwest due to increased chloride concentrations and saltwater encroachment near the coast. In addition, heavy pumpage has caused saltwater intrusion to occur along the coast as far north as Orange County (Ashworth and Hopkins, 1995). Pumping from the Gulf Coast aquifer between 1985 and 2000 ranged from around 1 million to 1.3 million acre-feet per year. Water level declines of up to 350 feet in Harris, Galveston, Fort Bend, Jasper, and Wharton counties have led to land-surface subsidence (Kasmarek and Robinson, 2004), which is discussed in Chapter 7 of this report. For further information on the Gulf Coast aquifer, see chapters 2, 5, 6, 10, 12, and 16 of this report.

Yegua-Jackson Aquifer

The Yegua-Jackson aquifer runs approximately parallel to the Gulf of Mexico coastline, approximately 100 miles inland, and is located in all or parts of Angelina, Atascosa, Bastrop, Brazos, Burlinson, Duval, Fayette, Frio, Gonzales, Grimes, Houston, Jasper, Jim Hogg, Karnes, LaSalle, Lavaca, Lee, Leon, Live Oak, Madison, McMullen, Nacogdoches, Newton, Polk, Sabine, San Augustine, Starr, Trinity, Tyler, Walker, Washington, Webb, Wilson, and Zapata

counties. It includes water contained in Tertiary deposits of sand, silt and clay that form the Yegua Formation and the Jackson Group (TWDB, 2002). The aquifer is separated from the overlying Gulf Coast aquifer by the Catahoula Sandstone and divided from the underlying Sparta aquifer by the clay-rich Cook Mountain Formation. The aquifer is approximately 15 to 40 miles wide and is found between the Gulf Coast aquifer to the southeast and the Sparta aquifer to the northwest.

From 1980 to 1997, between approximately 11,000 and 14,000 acre-feet of water was withdrawn from the Yegua-Jackson aquifer. Most withdrawals take place where other aquifers are not present or where the cost of pumping from other aquifers is comparatively high. To learn more about this aquifer, see Chapter 3 of this report.

Brazos River Alluvium

The Brazos River Alluvium aquifer is located in parts of Austin, Bosque, Brazos, Burleson, Falls, Fort Bend, Grimes, Hill, McLennan, Milam, Robertson, Waller, and Washington counties. It consists of water-bearing sediments, primarily gravel and sand, within the floodplain and terrace deposits of the Brazos River. The deposits reach up to 100 feet thick in some places and up to 8 miles wide, with the thickness generally widening and thickening towards the coast. Water quality in the aquifer is typically hard, and the concentration of dissolved solids in the water varies and can reach more than 1,500 milligrams per liter. The Brazos River Alluvium aquifer is hydraulically connected to the Brazos River as well as to underlying bedrock aquifers, including the Yegua-Jackson and Gulf Coast aquifers (Cronin and Wilson, 1967).

Most water is found in the alluvium within the floodplain. The primary use of water pumped from the aquifer is for irrigation. Between 1980 and 1997, withdrawals from the aquifer typically ranged between 20,000 and 40,000 acre-feet per year. Chapter 4 provides a more detailed description of the Brazos River Alluvium aquifer and discusses a model created to simulate the conjunctive use water stored in the aquifer with surface water in the Brazos River.

Groundwater Issues in the Gulf Coast Region

The people of the Texas Gulf Coast have to consider a wide variety of issues that can affect their groundwater. Some of these are common throughout the state, and some are unique to the region. Below are brief descriptions of topics related to groundwater in the region that are addressed in more detail in other chapters of this report.

Groundwater Quality

Water quality often determines whether or not water can be used for drinking, industry, irrigation, or other uses. The salinity—or amount of dissolved solids—of groundwater in the aquifer increases naturally in deep parts of the Gulf Coast aquifer, toward the coast. In addition, the southern part of the aquifer contains significantly higher amounts of chloride, sulfate, and sodium than the northern part. The presence of arsenic, radium, and many other constituents that

are found in the Gulf Coast aquifer and that affect water quality is described and analyzed in detail in Chapter 5.

Subsidence

Land-surface subsidence has been a persistent problem in the Harris, Galveston, and Fort Bend counties for several decades. As water is withdrawn from deep, confined portions of the Gulf Coast aquifer, the hydraulic pressure on the sediments decreases. This causes the de-watered sediments to compact due to the weight of overlying sediments. If pumping rates are low, this will have little effect, because sand layers are dewatered first and these compact only slightly. However, if pumping continues, water will start to be drawn from less transmissive clay layers. While sand grains are fairly round, clay grains are sheet-like. As they become de-watered and compacted, they align perpendicular to the load applied by overlying sediments. As clay grains line up in the same direction, the porosity and thickness of the clay layer decreases. (For a very rough comparison, imagine the difference in thickness between a house of cards—with cards balanced and aligned at different directions—and the same cards aligned flat on the ground.) Even if the layer is saturated with water again, about 90 percent of this compaction is permanent (Kasmarek and Robinson, 2004). To read more about how land-surface subsidence has affected the northern Gulf Coast region of Texas and how Texans have worked to combat the problem, see Chapter 7 of this report.

Drought

Drought can affect groundwater supplies in many ways—low precipitation levels can lead to reduced recharge to the aquifer and increased pumping by users. Records of precipitation in the Gulf Coast region go back as far as the mid-1800s in some places, allowing a long-term look at the frequency and duration of drought in the area.

The Palmer Drought Severity Index, which is the most commonly used drought index in Texas and the rest of the U.S., and the Standardized Precipitation Index, which can measure drought over time scales varying from three months to four years, are two systems that have been created to quantify drought. Using these indexes, Chapter 8 describes historical drought events in different parts of the Gulf Coast region.

Groundwater Flow and Estuaries

Estuaries, or coastal bays that are influenced by tides and freshwater inputs, often have high biological productivity and are of environmental and economic importance. Estuarine ecosystems cover more than 2.6 million acres along the Gulf Coast of Texas. The economy of the region depends on these areas for navigation, minerals, fisheries, recreation, and natural waste treatment. The total value of these services to the residents of the region is in the billions of dollars (TWDB, 2005).

Surface water discharge at the coast has long been known to affect the chemistry and ecology of estuaries. In the Gulf Coast region of Texas, TWDB and Texas Parks and Wildlife Department

have been studying freshwater inflows from surface water into estuaries for over twenty years. Groundwater discharge to the ocean, on the other hand, is much more difficult to see or measure and has undergone much less study in Texas and in much of the world. Researchers are starting to find that groundwater can constitute a significant amount of freshwater flow to coastal areas and may have important impacts on coastal areas, including estuaries. See Chapter 9 of this report for a discussion of how groundwater discharge to coasts is currently understood and being studied.

Salt Domes

As the sediments that now make up the Gulf Coast aquifer were being deposited, underlying evaporite (salt-rich) deposits were deformed. In some areas, this deformation resulted in the upwelling of salt domes into the overlying sediments. These domes are one to three miles in diameter and are composed almost entirely of crystalline rock salt covered by a cap rock of sulfate and carbonate minerals.

The 38 salt domes that are found within the Gulf Coast aquifer in Texas provide natural resources such as oil, gas, salt, and sulfur, and have been used for storing petroleum products. However, the development of salt domes can lead to the formation of sinkholes and creates a potential for groundwater contamination. Despite these risks, there has been little data collection or research over the past twenty years to address how salt dome development may affect the Gulf Coast aquifer. Chapter 12 of this report describes salt domes in more detail and summarizes what is known about salt domes and hydrogeology.

Brackish Groundwater Desalination

As demand for water in Texas grows, additional sources of water are being sought, in particular to provide adequate supplies in times of drought. Desalination technology offers a way to use the large amounts of water that are available in aquifers but are too saline for normal use. Brackish desalination plants remove dissolved solids from groundwater using processes such as filtration, reverse osmosis, and electro dialysis reversal.

Brackish groundwater desalination offers a promising water resource option for the Gulf Coast region. The Gulf Coast aquifer contains about one-fifth of the estimated quantity of brackish groundwater that is suitable for desalination in Texas. As desalination is becoming more cost effective, plants are being built, planned, and incorporated into the water management strategies of regional water planning groups in the area. For more information, see Chapters 13 and 14.

Oil and Gas Production

For over 150 years, oil and gas development in Texas has co-existed with groundwater use. As these resources were developed, so too did the risk that hydrocarbon extraction would lead to the contamination of groundwater resources. For example, products used in and created by production can contaminate groundwater through pipeline leaks, accidental spills, or produced water of poor quality.

The Railroad Commission of Texas is the state agency with the authority and responsibility to regulate oil and gas operations, in part to protect groundwater resources. More information about the regulation of oil and gas production to protect groundwater supplies can be found in Chapter 15 of this report.

Historical and Future Production of the Gulf Coast Aquifer

One-third of the state's population lives in counties where the Gulf Coast aquifer is found. More water is pumped from the Gulf Coast aquifer in Texas than from any of the state's other aquifers except for the Ogallala. Thus, production in the Gulf Coast aquifer is a topic of interest for many people who are concerned with the quality of life and the economy in the state. Chapter 16 describes the history and future of groundwater development from the Gulf Coast aquifer, including information on past pumping statistics and development projects currently under consideration.

Groundwater Management

Several chapters of this report discuss various aspects of groundwater management in the Gulf Coast region of Texas. Chapter 11 describes optimization models, which can be used by decision-makers to maximize or minimize specific constraints, such as maintaining a certain level of springflow, based on their goals. It then considers how the groundwater availability models (GAMs) developed by the TWDB can be used along with optimization models to help make groundwater management decisions. Chapter 17 provides one perspective on how the scientific and legal framework for groundwater management in the Texas Gulf Coast relates to the values held by individuals that shape the state's localized form of groundwater management. It then gives some ideas for how to promote understanding and cooperation between stakeholders. Chapter 20 gives information on groundwater management through groundwater conservation districts.

Local Studies

As demand for water increases and new groundwater development projects are considered, public and private groups are conducting detailed local studies of the hydrogeology in the Gulf Coast region. The results of these studies help to predict whether a project will meet its goals and maximize the success of the project.

Several chapters in this report discuss the results of such studies. Chapter 4 describes a groundwater model of the Brazos River Alluvium aquifer that was created to help assess the possibility of temporarily storing extra water in the aquifer during wet periods to use during times of low precipitation and river flow. Chapter 6 and the extended abstracts in chapters 18 and 19 describe several studies that are being done to plan for the Lower Colorado River Authority-San Antonio Water System Water Project. These studies look at the geology and hydraulic properties of the Gulf Coast aquifer, recharge to the Gulf Coast aquifer, and interactions between the Gulf Coast aquifer and the rivers that cross it.

Regional Water Planning

In 1997, the Texas Legislature enacted Senate Bill 1, a comprehensive water legislation created to plan for managing water resources as the population and water demand of Texas grows. This bill calls for a “bottom up” planning process, creating sixteen regional water planning areas and corresponding regional water planning groups. Each regional water planning group is formed by members representing 11 different interest groups, including agriculture, counties, the environment, industries, municipalities, the public, river authorities, small business, steam-electric generating facilities, water districts, and water utilities located within the regional water planning area, as well as additional entities chosen by the regional water planning groups.

It is the responsibility of each of the regional water planning groups to create a regional water plan for its region that defines current and projected water supplies and water demand and shows how the region plans to meet future water supply needs and respond to drought. These regional water plans were submitted to the TWDB in January of 2001 for the first round of regional water planning. The TWDB used these individual plans to create a comprehensive state water plan, which it released in January of 2002. Most of the regional water plans for 2006 were submitted to TWDB in January of 2006 for the second round of regional water plans. The next state water plan will be released in January of 2007. These regional and state plans are available on the TWDB website at www.twdb.state.tx.us. In order to respond to changes in the regional water planning areas, the water plans will be updated every five years. Financial assistance from the TWDB and water right permits from the Texas Commission on Environmental Quality will only be provided if the purpose of the project or permit is consistent with the state water plan.

The Gulf Coast area includes all of the Coastal Bend, Lavaca, and Region H planning areas, and parts of the Rio Grande, South Central Texas, Lower Colorado, Brazos G, and East Texas planning areas (Figure 1-6). The planning groups in all these areas have identified specific user groups that will have unmet needs for water by 2050. Projections indicate all but one region (Brazos G) will have unmet water demands by 2050 if water management strategies are not implemented (TWDB, 2002). The regions have recommended several water management strategies to meet their future water needs, including:

- increased use of current groundwater and surface water supplies,
- well field development,
- dredging of existing reservoirs,
- creation of new reservoirs,
- municipal and agricultural conservation,
- water reuse,
- transfer and acquisition of water rights,
- interbasin transfers,
- aquifer storage and recovery,

- desalination,
- rainwater harvesting,
- brush management, and
- weather modification (TWDB, 2002).

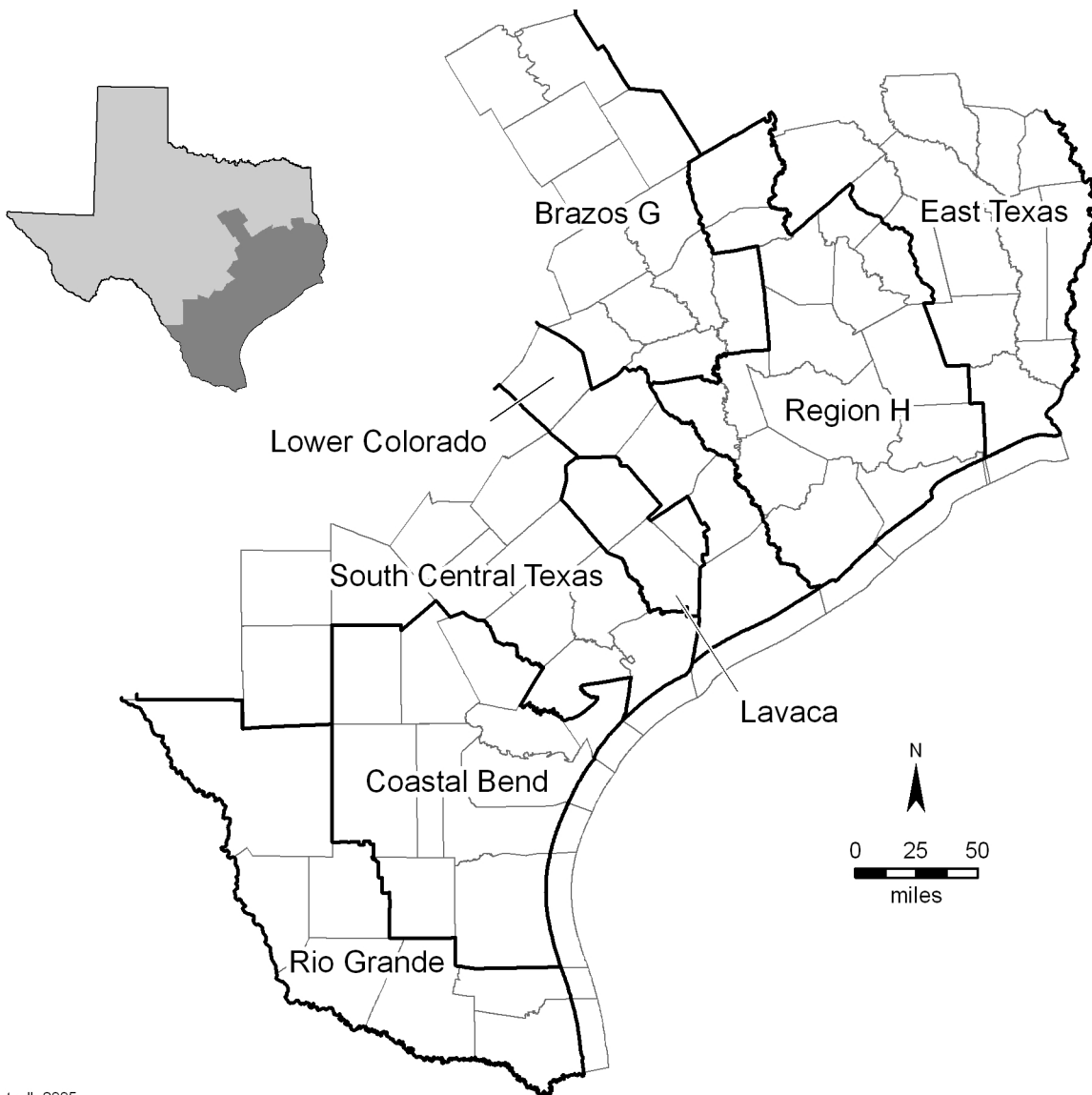


Figure 1-6. Location of regional water planning areas in the Gulf Coast region.

Groundwater Conservation Districts

Since 1904, Texas has governed groundwater use through the Rule of Capture. This rule allows landowners to pump as much groundwater as they like, so long as the purpose of pumping is not “malice or willful waste” and not be held liable if neighbors complain that their wells have been depleted by pumping. In order to allow the option of locally controlled groundwater regulation, the Legislature authorized the creation of groundwater conservation districts in 1949 (Mace and others, 2004). Today these districts are recognized by the Legislature as the state’s preferred method of managing groundwater resources. Each groundwater conservation district has the authority to regulate groundwater pumping within its boundaries and must complete a ten-year groundwater management plan every five years, describing how it plans to address relevant groundwater issues such as changes in water use, drought, and water quality.

House Bill 1763, passed by the Texas Legislature in 2005, will change the way that groundwater conservation districts manage groundwater. The bill requires that all groundwater conservation districts coordinate their planning efforts with other districts that are located within the same groundwater management area. There are 16 groundwater management areas in Texas, and the Gulf Coast region includes all or part of 7 of them (Figure 1-7).

By the year 2010, the groundwater conservation districts in each groundwater management area will need to establish desired future conditions for aquifers within their groundwater management area boundaries. After this time, the groundwater conservation districts will need to ensure that their management plans are designed to meet the newly decided conditions. The role of the TWDB in this process will be to provide each groundwater conservation district with the estimated amount of managed available groundwater that will be available based on the desired future conditions that are agreed upon within the groundwater management areas. The TWDB will only provide these numbers—the agency will not approve or disapprove of the conditions that the groundwater conservation districts give to them unless the conditions are hydrologically unreasonable.

The Gulf Coast area is home to 25 confirmed groundwater conservation districts, as well as 1 aquifer storage and recovery conservation district and 2 subsidence districts (Figure 1-8):

1. Bee Groundwater Conservation District,
2. Bluebonnet Groundwater Conservation District,
3. Brazoria County Groundwater Conservation District,
4. Brazos Valley Groundwater Conservation District,
5. Coastal Bend Groundwater Conservation District,
6. Coastal Plains Groundwater Conservation District,
7. Corpus Christi Aquifer Storage and Recovery Conservation District,
8. Evergreen Underground Water Conservation District,
9. Fayette County Groundwater Conservation District,

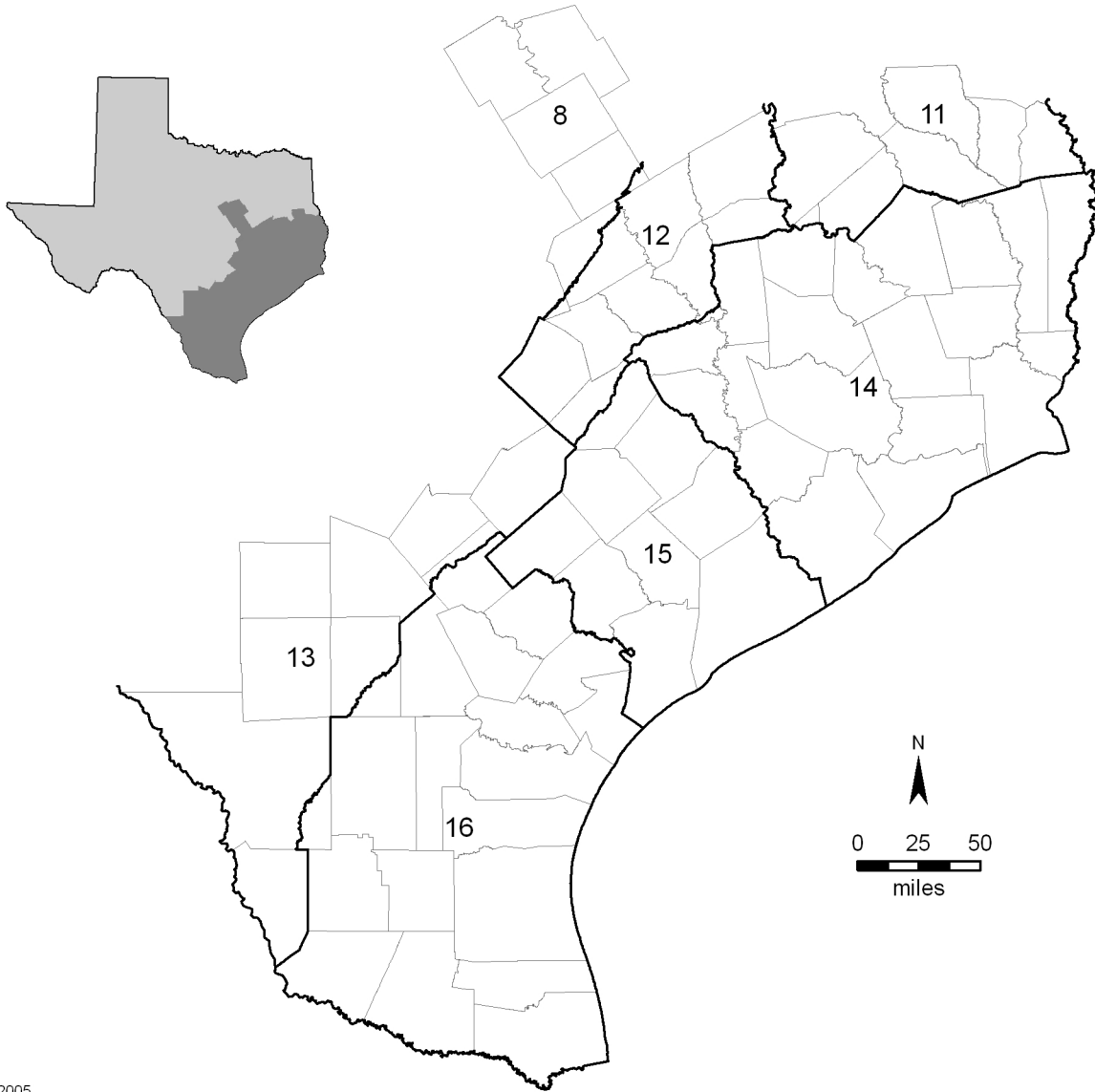
10. Fort Bend Subsidence District,
11. Goliad County Groundwater Conservation District,
12. Gonzales County Underground Water Conservation District,
13. Harris-Galveston Subsidence District,
14. Kenedy County Groundwater Conservation District,
15. Live Oak Underground Water Conservation District,
16. Lone Star Groundwater Conservation District,
17. Lost Pines Groundwater Conservation District,
18. McMullen Groundwater Conservation District,
19. Mid-East Texas Groundwater Conservation District,
20. Pecan Valley Groundwater Conservation District,
21. Pineywoods Groundwater Conservation District,
22. Post Oak Savannah Groundwater Conservation District,
23. Red Sands Groundwater Conservation District,
24. Refugio Groundwater Conservation District,
25. Southeast Texas Groundwater Conservation District,
26. Texana Groundwater Conservation District,
27. Victoria County Groundwater Conservation District, and
28. Wintergarden Groundwater Conservation District.

At the time of publication, there were three unconfirmed groundwater conservation districts in the region: Starr County Groundwater Conservation District, Duval County Groundwater Conservation District, and Lower Trinity Groundwater Conservation District (Liberty, Polk, and San Jacinto counties).

Groundwater Availability Modeling

The development of state-of-the-art, publicly available computer models of groundwater resources in Texas began in 1999, when the Legislature provided initial funding for the TWDB to create groundwater availability models (GAMs) for the major aquifers of Texas. In 2001, the Legislature enacted Senate Bill 2, which directed the TWDB to complete groundwater availability models for the minor aquifers.

A main purpose of these models is to provide regional water planning groups and groundwater conservation districts with information to use in assessing the availability of groundwater in their regions or areas. With information from the models, they can evaluate their social and economic demand for water in relation to the effects of groundwater use on the quantity and quality of groundwater, groundwater flow to springs, land surface subsidence, and other aquifer



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Figure 1-7. Location of groundwater management areas in the Gulf Coast region.

characteristics. This can help them make more informed decisions on how to manage their groundwater supplies and to meet their current and future demands for water.

Three GAMs have been completed for the Gulf Coast aquifer. In addition, the TWDB will be creating GAMs for the Brazos River Alluvium aquifer and the Yegua Jackson aquifer; however, the schedule is not yet set for their development. Because of the large size of the Gulf Coast aquifer, separate models were created for different portions of the aquifer. A GAM on the lower Rio Grande valley region was completed in October of 2003. The second GAM, covering the central part of the aquifer, was completed in September of 2004. The third GAM, which models the northern part of the aquifer, was also completed in September of 2004. Reports describing these models and how they were developed are available on the TWDB website (Chowdhury and

Summary

More than a third of all Texans live in the Gulf Coast region, an area that runs from the Rio Grande Valley in the south to the Sabine River basin in the north. The population has increased dramatically over the last 50 years and with it the demand for water. Many people in the region depend partly or entirely on groundwater to meet their needs. As water users, groundwater conservation districts, and regional water planning groups work to meet their groundwater needs today and plan for the future, a diverse range of issues must be addressed. Among these are the quantity and quality of water in the region's aquifers, the threat of drought, impacts of pumping such as land subsidence and reduced flow to estuaries, and possible effects of oil and gas production on groundwater supplies. We continue to improve our understanding of these issues through the development of groundwater availability models and through regional studies carried out by public and private groups. In the following chapters, experts from a variety of disciplines and industries offer more detailed information and ideas about all of these topics.

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