

Section 1 **Description of the Region**

1.1 Senate Bill 1

In June 1997, Governor George W. Bush signed into law Senate Bill 1 (SB1), a comprehensive bill for water planning and management enacted by the 75th Texas Legislature. This law stemmed from increased awareness of Texas' vulnerability to drought and of the limitations of existing water supplies to meet the needs of a growing population. The population of Texas is expected to increase from an estimated 20 million in 2000 to more than 36 million by the year 2050, and some areas of the State are already facing near-term water shortages. The purpose of SB1 is to ensure that the water needs of all Texans are met in the 21st century.

SB1 calls for a "bottom up" water planning process wherein Regional Water Planning Groups (RWPGs) are to be formed by members representing 11 different interests, including the environment, industry, water authorities, and the public. Each RWPG will prepare a water plan for its geographic area to address how to conserve water supplies, how to meet future demand, and how to respond to droughts. The Texas Water Development Board (TWDB) has established 16 regional water planning areas, each with its own RWPG.

In accordance with SB1 (as amended), all of the regional water plans must be completed and adopted by January 5, 2001. The TWDB must approve them and incorporate the 16 plans into one statewide plan by January 5, 2002. After that, the regional water plans will be updated every 5 years.

1.2 Brazos G Regional Water Planning Area

The Brazos G Regional Water Planning Area (BGRWPA), shown in Figure 1-1, comprises all or portions of 37 central Texas counties. The Brazos G Region is about 31,600 square miles in area, or 12 percent of the State's total area. About 90 percent of the region lies in the Brazos River Basin. Figure 1-2 shows the major physical features of the BGRWPA, such as major cities, reservoirs, and highways. This figure also shows that parts of several counties are in the basins of the Red, Trinity, Colorado, and San Jacinto Rivers. Cities in

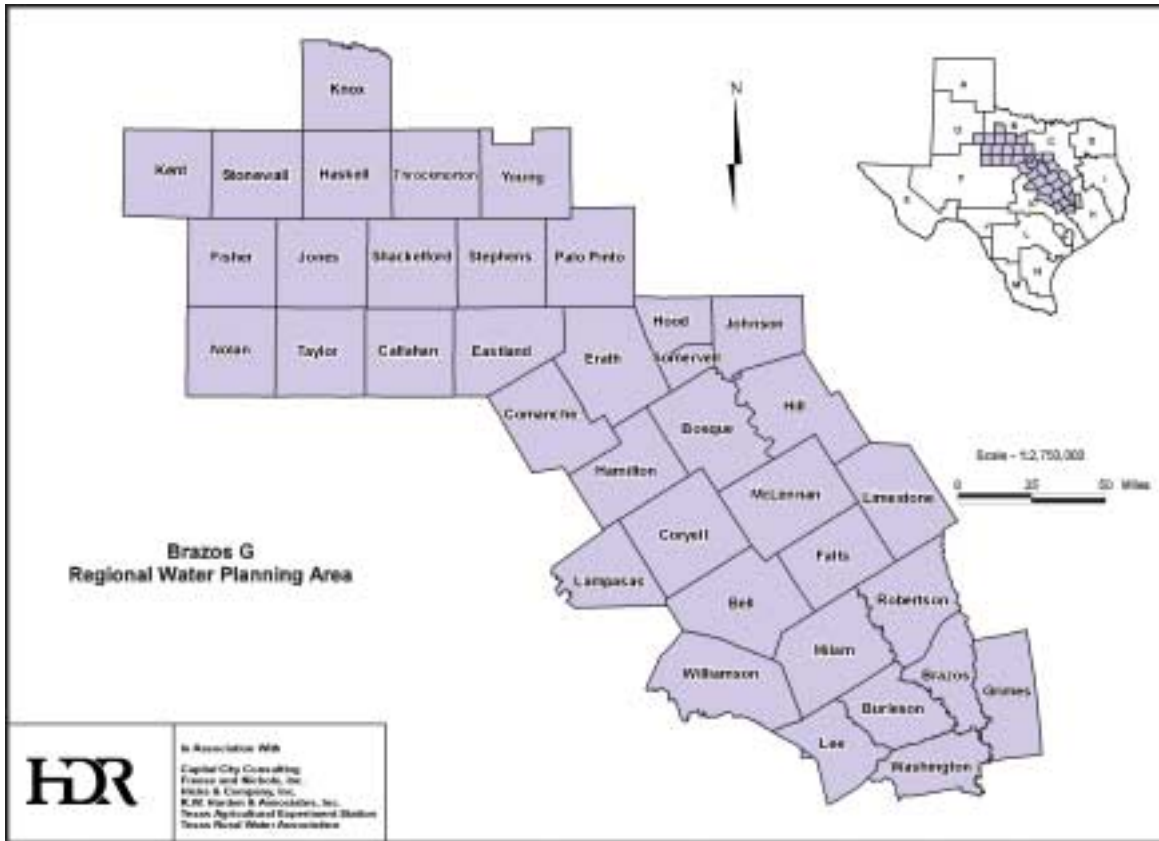


Figure 1-1. Location Map

the region with populations estimated in 1998 to be more than 50,000 are Abilene, Bryan, College Station, Killeen, Round Rock, Temple, and Waco.¹

The region's geography varies from the rugged, uneven terrain and sandy soils of Kent and Knox Counties in the northwest to the hilly, forested areas and rich soils in Grimes and Washington Counties in the southeast. In the central part of the region are the Blackland Prairies in Hill and McLennan Counties.²

The Brazos G RWPG consists of 18 individuals, listed in Table 1-1, who represent the following 11 interests: the public, counties, municipalities, industries, agriculture, the environment, small businesses, electric-generating utilities, river authorities, water districts, and

¹ Texas State Data Center, "Estimated 1998 Populations for Texas Cities and Counties", [Online] Available URL: <http://www.txsd.c.tamu.edu/txmsa97.html>, May 1998.

² The Dallas Morning News, *1998-1999 Texas Almanac*, 1997.

**Table 1-1.
Brazos G RWPG Members¹**

<i>Interest Group</i>	<i>Name</i>	<i>Entity</i>
Agricultural	Steve Sanford	Farmer/Rancher
	Chaunce Thompson	Cattlemen
Counties	John Garth	County Government
	Tony Jones	Brazos County Commissioners Court
	Judge David Perdue	Knox County
Electric Generating Utilities	Ken Smith	TXU Electric
Environmental	Stephen L. Stark	Sportsmans Conservationists of Texas
Industry	Mark Bryson	Alcoa Aluminum
Municipalities	Mayor Truman O. Blum	City of Clifton
	John Hatchel	City of Waco
	Mike Morrison	City of Abilene
	James Nuse	City of Round Rock
Public	Scott Mack, DDS	Dentist
River Authorities	Gary Gwyn	Brazos River Authority
Small Business	Horace R. Grace	AMG Enterprises, Inc.
Water Districts	A.V. Jones, Jr.	West Central Texas Municipal Water District
	_____	Seat Currently Empty
Water Utilities	Kent Watson	Wickson Creek Special Utility District

¹ As of July 2000.

water utilities. The Brazos G RWPG has retained the services of engineering firms and other specialists to prepare the regional plan, and it has designated the Brazos River Authority (BRA) as its administrative contracting agency.

1.2.1 Population

1.2.1.1 Regional Trends

Figure 1-3 illustrates population growth in the entire BGRWPA for 1900 to 1998 and projected growth for 2010 to 2050. Table A-1 in Appendix A gives historical population data for each county in the BGRWPA, as well as regional and State population totals, for 1990 to 1998.

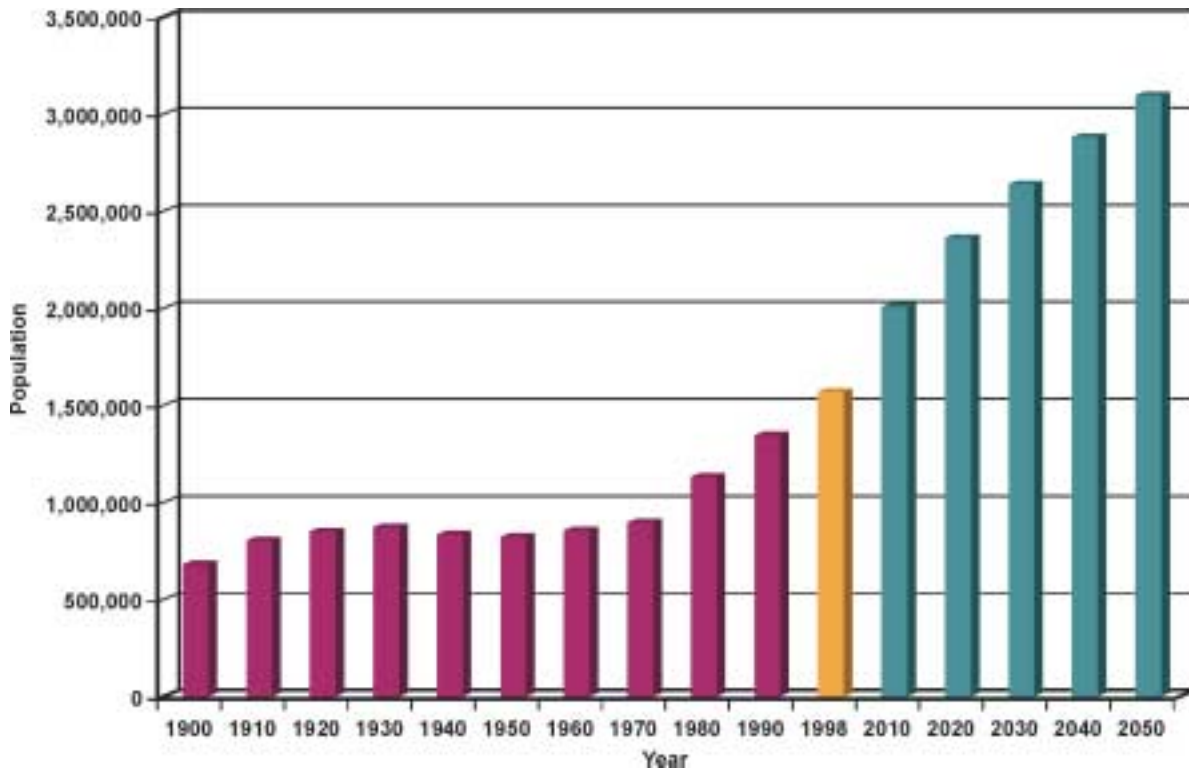


Figure 1-3. Historical and Projected BGRWPA Population

From 1900 to 1970, population in the Brazos G Region grew slowly at an average rate of 0.5 percent per year from 680,093 people to 895,682. During the same period, the total population of Texas grew at an average rate of 3.8 percent annually, from 3,048,710 to 11,196,730. Beginning in the 1970s, however, both the State's and the region's population began to increase at a faster rate. Growth in the region was about 2.5 percent annually, which was close to the State's total growth rate. Population in the BGRWPA is expected to increase by an average of 1.2 percent annually, reaching 3.1 million by 2050. This is roughly double the estimated population in 1998.

Population trends may be further understood by dividing the BGRWPA into three subregions: the northwestern Rolling Plains, the central IH-35 Corridor, and the southeastern Lower Basin. Table A-2 in Appendix A provides historical population data for all counties in each subregion from 1990 to 1998.

Figure 1-4 shows historical population growth in the three sub-regions from 1900 to 1998 and projected growth from 2010 to 2050. Projected growth is greatest in the IH-35 Corridor. Figure 1-5 shows population distribution by county in 1998, and Figure 1-6 shows the distribution for the year 2050. Table 1-2 shows 1998 populations and projected populations for 2010 and 2050 for the major cities in each sub-region. Major cities are defined as those having at least 10,000 people in 1998. This table also shows the percent change in populations from 2010 to 2050 in each city. About 53 percent of the population in the BGRWPA was in major cities in 1998, and this proportion is expected to increase to about 56 percent by 2050.

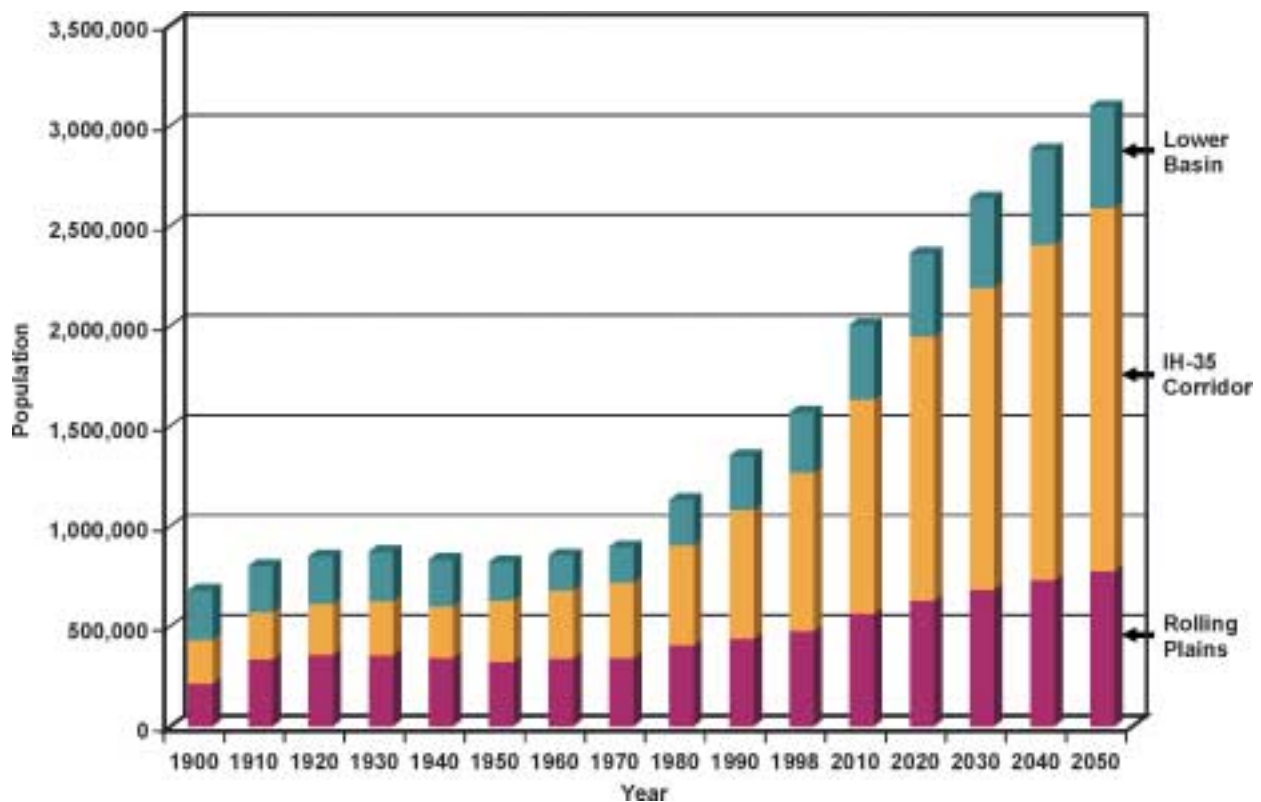


Figure 1-4. Historical and Projected Population by Sub-Region

1.2.1.2 Rolling Plains

The counties in the Rolling Plains subregion are Knox, Kent, Stonewall, Haskell, Throckmorton, Young, Fisher, Jones, Shackelford, Stephens, Palo Pinto, Nolan, Taylor, Callahan, Eastland, Erath, Hood, Somervell, Comanche, Hamilton, Bosque, Coryell, and

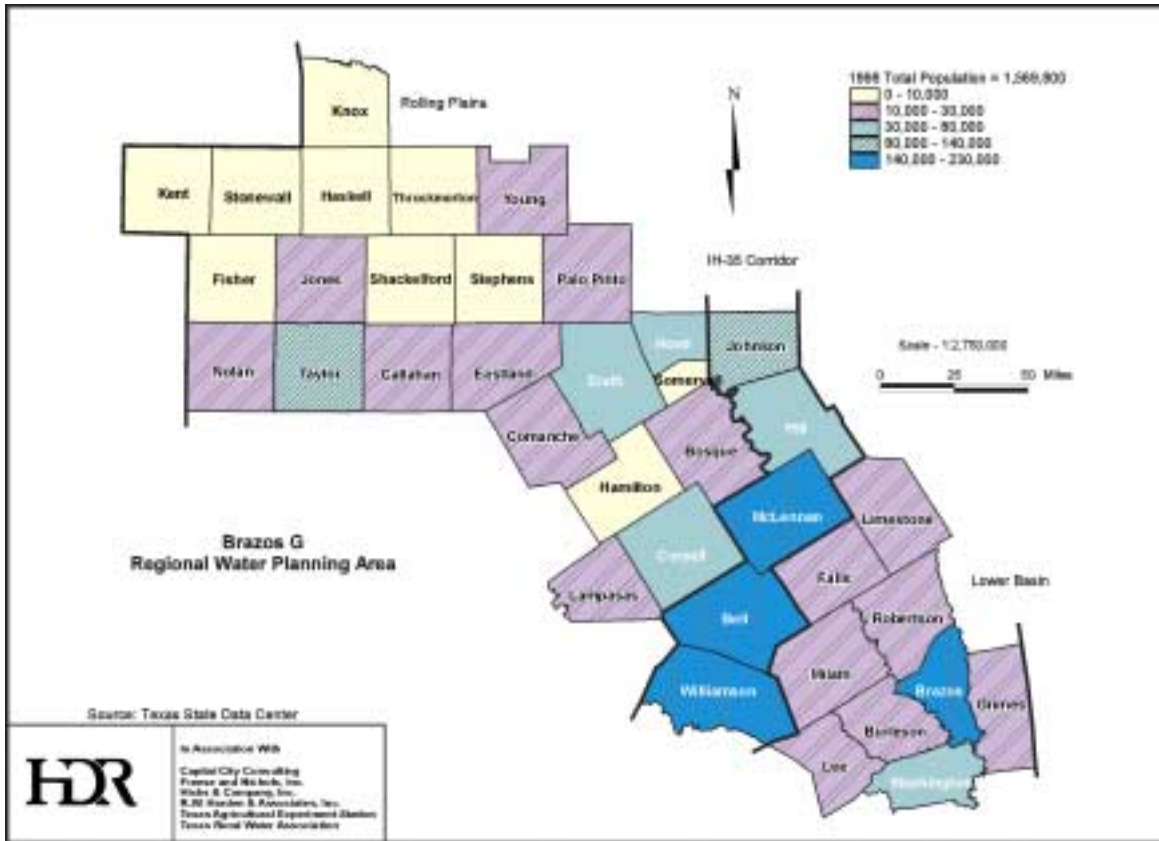


Figure 1-5. 1998 Population Distribution by County

Lampasas. These counties, with about 31 percent of the BGRWPA's population in 1998, have grown moderately since 1970 at an average rate of 1.4 percent per year. Major cities in this subregion include Abilene, Copperas Cove, Gatesville, Mineral Wells, Stephenville, and Sweetwater.

1.2.1.3 IH-35 Corridor

The counties in the IH-35 Corridor are Johnson, Hill, McLennan, Bell, and Williamson. Population growth in these counties has been rapid since 1970, averaging 3.9 percent annually. In this subregion, cities with a population estimated in 1998 to be at least 10,000 include Belton, Burleson, Cleburne, Fort Hood, Georgetown, Harker Heights, Hewitt, Killeen, Round Rock, Taylor, Temple, and Waco. Population in the IH-35 Corridor was about 50 percent of the region's total in 1998, and it is expected to keep growing at a fast rate.

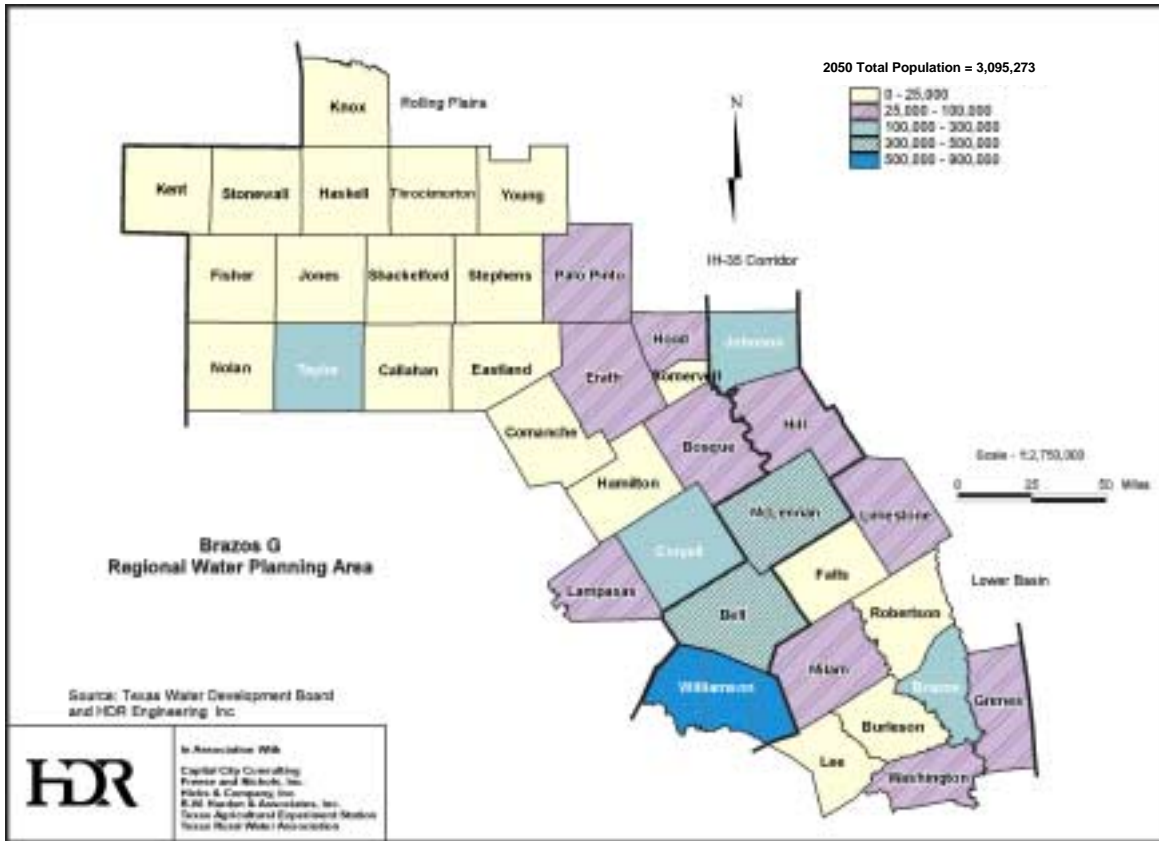


Figure 1-6. 2050 Population Distribution by County

1.2.1.4 Lower Basin

Counties in the Lower Basin are Limestone, Falls, Milam, Robertson, Lee, Burleson, Brazos, Washington, and Grimes. This subregion also has seen a relatively high growth rate averaging 2.5 percent annually since 1970. Major cities include Brenham, Bryan, and College Station. The Lower Basin held 19 percent of the population of the BGRWPA in 1998.

1.2.2 Economic Activities

The BGRWPA includes all or part of the following metropolitan statistical areas as defined by the Texas State Data Center: Abilene, Waco, Temple-Killeen, Austin-San Marcos, and Bryan-College Station. The economy of the region can be divided into the following general sectors: agriculture, agribusiness, mineral production, wholesale and retail trade, and varied

Table 1-2.
Population of Major Cities in the BGRWPA
(Greater than 10,000 People in 1998)

City	County	Population Data ¹			% Change
		1998	2010	2050	(2010 to 2050)
Rolling Plains					
Abilene	Jones, Taylor	117,111	132,480	178,617	34.8
Copperas Cove	Coryell	30,708	45,328	99,271	119.0
Gatesville	Coryell	12,340	22,423	49,287	119.8
Mineral Wells	Palo Pinto	15,367	16,012	18,712	16.9
Stephenville	Erath	15,589	18,638	26,143	40.3
Sweetwater	Nolan	11,733	12,644	12,297	-2.7
IH-35 Corridor					
Belton	Bell	15,541	20,088	29,593	47.3
Burleson	Johnson	20,500	24,039	43,773	82.1
Cedar Park	Williamson	13,659	30,978	56,026	80.9
Cleburne	Johnson	24,277	30,788	59,188	92.2
Fort Hood	Bell, Coryell	38,259	35,580	35,580	0.0
Georgetown	Williamson	26,576	54,419	163,777	201.0
Harker Heights	Bell	17,243	22,404	33,294	48.6
Hewitt	McLennan	10,718	20,713	28,523	37.7
Killeen	Bell	84,488	105,924	154,249	45.6
Round Rock	Williamson	53,427	92,430	197,313	113.5
Taylor	Williamson	14,722	22,028	48,996	122.4
Temple	Bell	51,476	69,800	102,060	46.2
Waco	McLennan	110,024	135,407	192,621	42.3
Lower Basin					
Brenham	Washington	13,796	14,863	15,337	3.2
Bryan	Brazos	62,685	76,382	119,709	56.7
College Station	Brazos	64,119	96,974	138,771	43.1
Total, Major Cities	—	824,358	1,100,342	1,803,137	63.9
% of Region Total	—	52.6	54.8	58.3	
Total, Rural Areas	—	743,437	905,888	1,292,136	42.6
% of Region Total	—	47.4	45.2	41.7	
Region Total	—	1,567,795	2,006,230	3,095,273	54.3

¹ 1998 population data obtained from Texas State Data Center. 2010 and 2050 projections are TWDB or approved revision.

manufacturing. Table 1-3 lists 1995 payrolls and employment in the BGRWPA by sub-region and economic sector.³ As of this writing, 1995 was the most recent year for which such data were available. Payroll and employment in the Brazos G Region were concentrated along the IH-35 Corridor, which in 1995 had a total payroll of about \$4.3 billion and employment of over 211,000 people. Primary economic activities accounting for about 69 percent of the region's total payroll in 1995 were manufacturing, retail trade, and services.

Table 1-3.
1995 Economic Data¹
(x\$1,000)

<i>Economic Sector</i>	<i>Rolling Plains</i>	<i>IH-35 Corridor</i>	<i>Lower Basin</i>	<i>Region Total</i>
Agricultural, Forestry, Fishing	\$11,062	\$18,546	\$8,258	\$37,866
Mining	\$93,360	\$19,259	\$49,813	\$162,432
Construction	\$116,711	\$295,443	\$82,851	\$495,005
Manufacturing	\$287,420	\$1,035,039	\$307,656	\$1,630,115
Transportation, Public Utilities	\$148,619	\$245,949	\$85,847	\$480,415
Wholesale Trade	\$118,579	\$295,645	\$92,806	\$507,030
Retail Trade	\$341,208	\$634,257	\$220,879	\$1,196,344
Finance, Insurance, Real Estate	\$114,908	\$361,882	\$93,548	\$570,338
Services	\$648,024	\$1,387,420	\$411,138	\$2,446,582
Unclassified	\$1,017	\$2,987	\$1,100	\$5,104
Not Categorized	\$88,868	\$0	\$5,927	\$94,795
Total Payroll	\$1,969,776	\$4,296,427	\$1,359,823	\$7,626,026
Total Employed	107,150	211,097	70,517	388,764

¹ Data from U.S. Census Bureau.

1.2.3 Climate

Temperatures in the Brazos G Region range from an average low of 35°F in January to an average high of 95°F in July. Average annual precipitation ranges from 20 to 24 inches in Kent County in the northwest corner of the region to 40 to 44 inches in Washington and Grimes Counties in the southeast. Figure 1-7 depicts average annual precipitation for the entire region.

³ U.S. Census Bureau, "1995 Economic Data," Online: available URL: <http://www.census.gov/datamap/May 1998>.

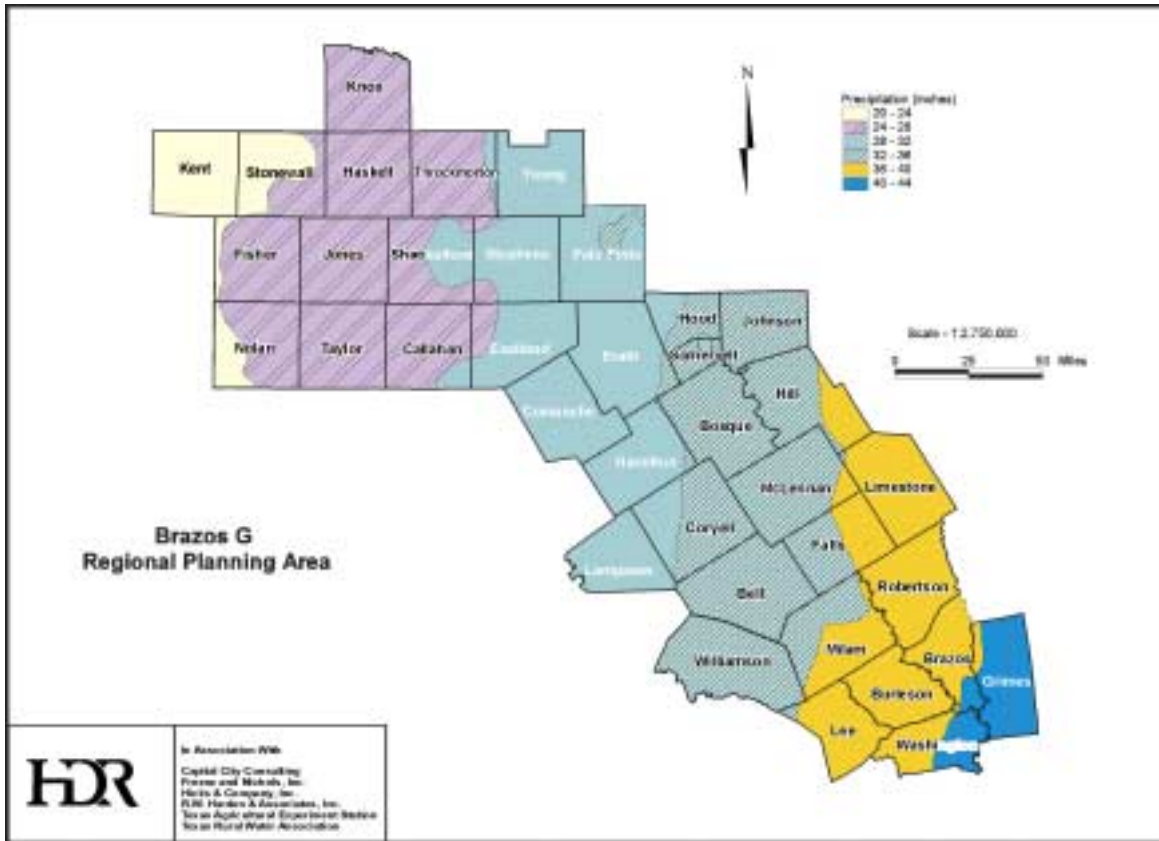


Figure 1-7. Average Annual Precipitation (1961 to 1990)

1.3 Sources of Water

Table A-3 in Appendix A provides historical data on use of groundwater and surface water by the BGRWPA from 1980 to 1997. These data suggest that the planning area has depended slightly more on surface water than on groundwater during the 1980s and 1990s. Figure 1-8 shows the proportion of surface water use to groundwater use in 1980, 1990, and 1996. While the proportions were equal in 1980, surface water use was slightly greater (by 4 percent) in 1990 and 1996.

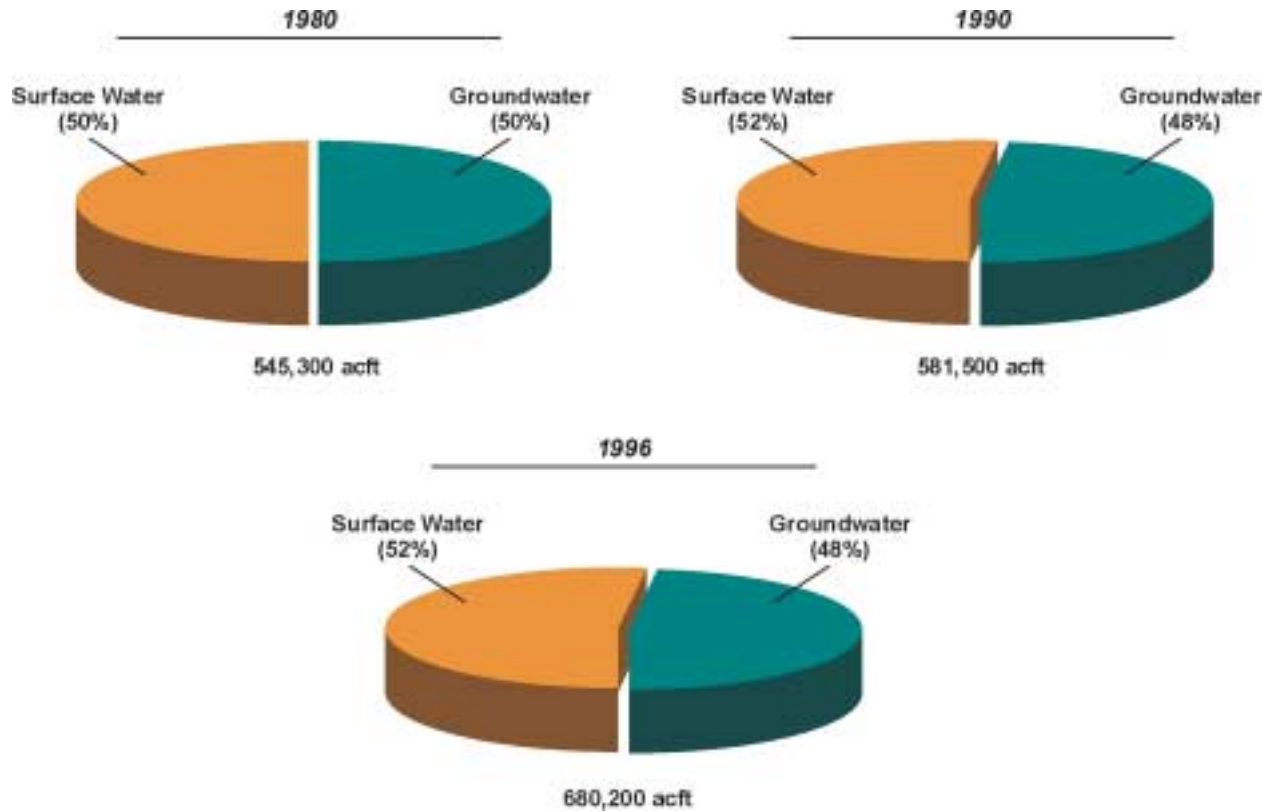


Figure 1-8. BGRWPA Historical Water Use by Source

1.3.1 Groundwater

1.3.1.1 Aquifers^{4,5,6}

Portions of 15 aquifers extend into the Brazos G Region. Of these, there are six major aquifers (Figure 1-9) and nine minor ones (Figure 1-10). Major aquifers were defined generally in the State's 1997 *Water for Texas* plan as those aquifers that supply large amounts of water to large areas of the State. Minor aquifers were defined as those that supply large amounts of water to small areas of the State or that provide small supplies to wide areas. Figure 1-11 shows water use for each aquifer in the BGRWPA in 1980, 1990, and 1996. In 1996, about 80 percent of the groundwater used came from three aquifers: Seymour, Trinity, and Carrizo-Wilcox.

⁴ Texas Water Commission, *Groundwater Quality in Texas - An Overview of Natural and Man-Affected Conditions*, TWC Report No. 89-01, 1989.

⁵ Texas Water Development Board (TWDB), *Water for Texas*, 1997.

⁶ TWDB, *Estimated Groundwater Pumpage by County and Aquifer*, 1998.

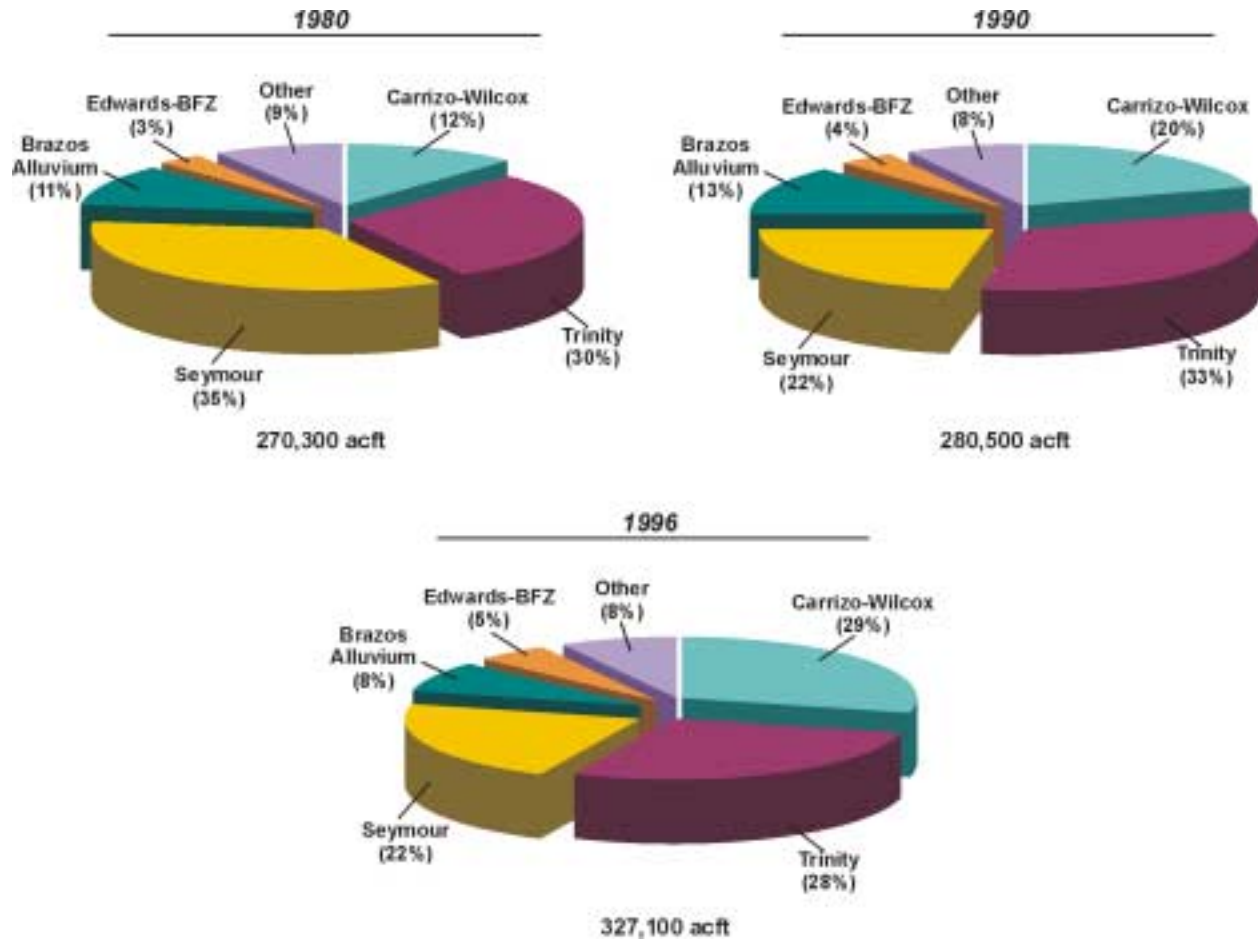


Figure 1-11. Brazos G Region Historical Water Use by Aquifer

Table 1-4 depicts use in 1996 and projected availability in 2050 of groundwater in each aquifer in the BGRWPA. Data on historical water use per aquifer in the 1980s and 1990s is in Table A-4 in Appendix A.

Fewer than half of the aquifers in the BGRWPA have potential for further development. Seven of them extend only slightly into the planning area. The several aquifers that do offer potential for further development are all in the southeastern part of the region.

In the western part of the region, the Seymour Aquifer is the most significant in terms of usage and yield. The Seymour Aquifer, which has an uneven distribution, is highly developed, and most of its water is used for irrigation. The aquifer is prone to depletion if subjected to a combination of prolonged drought and heavy use, but groundwater supply in the aquifer has

**Table 1-4.
Brazos G Region Aquifers**

Aquifer	1996 Use (acft)	2050 Availability (acft/yr)	Remarks
Western Area			
Seymour	70,790	69,893	Essentially developed
Dockum	2,860	3,484	Limited extent within region
Blaine	ND ¹	1,333	Limited extent within region
Edwards-Trinity (Plateau)	570	800	Limited extent within region
Subtotal:	74,220	75,510	
Central Area			
Trinity	93,130	77,563	Overdeveloped in some areas
Edwards (BFZ)	16,260	5,000	Overdeveloped in drought
Woodbine	1,590	2,432	Limited extent within region
Marble Falls	ND	4,183	Limited extent within region
Ellenburger-San Saba	ND	551	Limited extent within region
Hickory	ND	N/A ¹	Limited extent within region
Subtotal:	110,980	89,729	
Southeastern Area			
Brazos River Alluvium	24,850	66,700	Added potential, water quality variable
Carrizo-Wilcox	96,520	280,936	Large added potential
Queen City	2,280	3,459	
Sparta	1,880	10,333	Added potential
Gulf Coast	6,170	28,296	Added potential
Subtotal:	131,700	389,724	
Other and Undifferentiated	10,200	4,474	Many widely-scattered sources
Total:	327,100	559,437	
¹ ND indicates no data available from TWDB; NA indicates not determined.			

remained fairly constant. Also in the west, the fringes of three aquifers, the Dockum, Blaine, and Edwards-Trinity (Plateau), extend into the planning area, but these offer little room for further development. In the northeastern part of the region, there is a wide area with no aquifers. In this area, which includes the counties of Throckmorton, Young, Shackelford, Stephens, and Palo Pinto, groundwater is available only for individual homes and livestock.

In the central part of the BGRWPA, the Trinity Aquifer is the most significant. It is widespread and furnishes small to moderate amounts of groundwater to entities in 17 counties. In the artesian portions of the aquifer, however, development has resulted in significant declines in the water table.

In the southeastern part of the region, the most significant aquifer is the Carrizo-Wilcox. The Carrizo-Wilcox has significant potential for further development, and the Gulf Coast Aquifer has moderate potential. Several minor aquifers also have potential for further development over wide areas in this sector. Most of the BGRWPA's undeveloped groundwater lies in the southeastern sector.

The Trinity Aquifer and all other artesian aquifers to the southeast have outcrop areas under water-table conditions and downdip areas with overlying confining layers where artesian conditions occur. Most of these aquifers contain fresh water to considerable depths, and all contain slightly saline water just downdip, which is commonly to the southeast, of the fresh water. Maps in Appendix B show the locations of fresh water, defined as containing less than 1,000 milligrams per liter (mg/L) total dissolved solids (TDS), and slightly saline water, defined as having 1,000 to 3,000 mg/L TDS, within various aquifers. Maps are included for all aquifers within the BGRWPA that have sustainable yield exceeding 5,000 acft/yr. The use of aquifers with groundwater containing more than 1,000 mg/L TDS is an option only where consumers can use the saline water or where special treatment is available. More detailed descriptions of each aquifer in the BGRWPA are in Appendix B.

1.3.1.2 Major Springs

The BGRWPA contains a few major springs. There are springs with flows greater than 1 cubic foot per second (cfs) that issue from the Edwards-Balcones Fault Zone (BFZ) Aquifer in Bell and Williamson Counties and from the Marble Falls Aquifer in Lampasas County. Of the Edwards Aquifer springs, all but one are intermittent. The three largest Edwards springs are:

1. Salado Springs at Salado along the Lampasas River with flow ranging from 5 to 60 cfs.
2. Berry Springs 5 miles north of Georgetown with flow ranging from 0 to 50 cfs.
3. San Gabriel Springs at Georgetown with flow ranging from 0 to 25 cfs.

Springs from the Marble Falls Aquifer include Hancock Park Springs along the Sulfur River, which is a tributary to the Lampasas River, with flow reportedly ranging from 6 to 12 cfs, and Swimming Pool Springs at Hancock Park with a reported range in flow of 1.3 to 1.6 cfs.

Some springs in the region that significantly affect the quality of the water in the Brazos River. These are primarily the salt springs and seeps, such as Salt Croton and Croton Creeks, in the upper Brazos River Basin. These natural saltwater sources cause the water in the main stem of the Brazos River above Possum Kingdom Lake to be too saline for most uses. For example, from 1963 to 1986, TDS and chloride concentrations in Croton Creek near Jayton averaged 7,933 mg/L and 3,169 mg/L respectively. The mean values for TDS and chlorides in the Salt Croton Creek near Aspermont from 1969 to 1977 were 71,237 mg/L and 41,516 mg/L respectively. Water in Possum Kingdom Lake usually contains more than 400 mg/L chloride and 1,200 mg/L TDS. The natural chloride pollution in the upper Brazos River affects water quality in the lower basin. In the Brazos River at Richmond, it has been estimated that 85 percent (or about 95 mg/L for the years 1946 to 1986)⁷ of the chloride is from the upper basin.

There are many smaller springs in the Brazos G Region, but cataloging is inconsistent and incomplete. Only a few small springs have been cataloged in just nine of the 37 counties in the BGRWPA.⁸ These springs flow substantially less than 1 cfs, and most flow only a few gallons per minute.

1.3.2 Surface Water

The BGRWPA lies within the Brazos River Basin, the boundaries of which are the Red River Basin to the north, the Colorado River Basin to the west, the Trinity and San Jacinto River Basins to the east, and the counties of Fayette, Austin, Waller, and Montgomery to the south. The total drainage area for the Brazos River Basin is about 45,400 square miles, and of this about 28,400 square miles are in the BGRWPA.

The Brazos River is the third-largest river in Texas and the largest river between the Rio Grande River and the Red River in terms of total watershed area.⁹ The Brazos River rises in three upper forks: the Double Mountain Fork, Salt Fork, and Clear Fork. Twenty-nine major

⁷ Ganze, C. Keith and Ralph A. Wurbs, "Compilation and Analysis of Monthly Salt Loads and Concentrations in the Brazos River Basin," U.S. Army Corps of Engineers, Contract No. DACW63-88-M-0793, January 1989.

⁸ Brune, Gunnar, *Major and Historical Springs of Texas: TWDB Report 189*, 1970.

⁹ The Dallas Morning News, *1998-1999 Texas Almanac*, 1997.

reservoirs provide surface water to the BGRWPA. Major reservoirs are defined as having an authorized capacity greater than 10,000 acft, and these are listed in Table 1-5. This table shows amounts of storage and diversion that the Texas Natural Resource Conservation Commission (TNRCC) authorizes for each reservoir. Figure 1-2 shows locations of some of the reservoirs in the Brazos G Region, and Table A-5 in Appendix A provides more detailed information about all reservoirs in the BGRWPA with a permitted capacity greater than 2,500 acft. Diversions permitted for municipal, industrial, irrigation, and mining uses for each BGRWPA sub-region are in Table 1-6. Diversion permitted for these uses in each BGWRPA county are given in Table A-6 in Appendix A.

1.4 Water Providers

1.4.1 Authorities

1.4.1.1 Brazos River Authority

The primary provider of water to the Brazos G regions is the Brazos River Authority. The BRA also operates water and wastewater treatment systems, has programs to assess and protect water quality, does water supply planning, and supports water conservation efforts in the Brazos River Basin. BRA provides water from three wholly owned and operated reservoirs in the region: Lake Granbury, Possum Kingdom Lake, and Lake Limestone. BRA also contracts for conservation storage space in the nine U.S. Army Corps of Engineers reservoirs in the region: Lakes Waco, Proctor, Belton, Stillhouse Hollow, Georgetown, Granger, Somerville, Whitney, and Aquilla. The total permitted capacity of these 12 reservoirs in the BRA system is approximately 2.3 million acft. BRA holds rights for diversion in the region totaling more than 662,000 acft, and contracts to supply water to municipal, industrial, and agricultural water customers in the BGRWPA and other regions. BRA's largest municipal customers in 1999 included Bell County Water Control and Improvement District No. 1, the City of Round Rock, and the Central Texas Water Supply Corporation.

1.4.1.2 Lower Colorado River Authority

The Lower Colorado River Authority (LCRA) provides raw water to the City of Cedar Park from Lake Travis in Travis County (SB1 planning region K). The BRA and the LCRA

Table 1-5.
Major Reservoirs in BGRWPA
(Authorized Capacity Greater than 10,000 acft)

<i>Reservoir</i>	<i>Stream</i>	<i>County</i>	<i>Authorized Storage (acft/yr)</i>	<i>Authorized Diversion (acft/yr)</i>	<i>Owner</i>
Abilene	Elm Creek	Taylor	11,868	1,675	City of Abilene
Alcoa Lake	Sandy Creek	Milam	15,650	14,000	Aluminum Co. of America
Aquilla	Aquilla Creek	Hill	52,400	13,896	U.S. Army Corps of Engineers
Belton	Leon River	Bell	457,600	100,257	U.S. Army Corps of Engineers
Cisco	Sandy Creek	Eastland	45,000	2,027	City of Cisco
Cleburne ¹	Nolan Creek	Johnson	25,600	6,000	City of Cleburne
Daniel	Gonzales Creek	Stephens	11,400	2,100	City of Breckenridge
Dansby Power Plant	Unnamed Trib. Brazos River	Brazos	15,227	850	City of Bryan
Fort Phantom Hill ¹	Elm Creek	Jones	73,960	30,690	City of Abilene
Georgetown	North Fork San Gabriel River	Williamson	37,100	13,610	U.S. Army Corps of Engineers
Gibbons Creek	Gibbons Creek	Grimes	32,084	9,740	Texas Municipal Power Agency
Graham/Eddleman	Flint Creek	Young	52,386	20,000	City of Graham
Granbury	Brazos River	Hood	155,000	64,712	Brazos River Authority
Granger	San Gabriel River	Williamson	65,500	19,840	U.S. Army Corps of Engineers
Hubbard Creek	Hubbard Creek	Stephens	317,750	52,800	West Central Texas MWD
Leon	Leon River	Eastland	28,000	6,301	Eastland Co. WSD
Limestone	Navasota River	Robertson	225,400	65,450	Brazos River Authority
Palo Pinto ¹	Palo Pinto Creek	Palo Pinto	44,124	18,500	Palo Pinto MWD
Possum Kingdom	Brazos River	Palo Pinto	724,739	230,750	Brazos River Authority
Proctor	Leon River	Comanche	59,400	19,658	U.S. Army Corps of Engineers
Somerville	Yegua Creek	Washington	160,110	48,000	U.S. Army Corps of Engineers
Squaw Creek	Squaw Creek	Somervell	151,500	23,180	Texas Utilities Electric Co.
Stamford	Paint Creek	Haskell	60,000	10,000	City of Stamford
Stillhouse Hollow	Lampasas River	Bell	235,700	67,768	U.S. Army Corps of Engineers
Tradinghouse	Tradinghouse Creek	McLennan	37,800	27,000	Texas Utilities Electric Co.
Truscott Brine	Bluff Creek	Knox	107,000	N/A	Red River Authority of Texas
Twin Oak	Duck Creek	Robertson	30,319	13,200	Texas Utilities Electric Co.
Waco	Bosque River	McLennan	104,100	59,100	U.S. Army Corps of Engineers
Waco Enlargement			87,962	20,770	U.S. Army Corps of Engineers
Whitney	Brazos River	Hill	50,000	18,336	U.S. Army Corps of Engineers
Totals	—	—	3,474,679	980,210	—

¹ Data acquired from TNRCC.

**Table 1-6.
Permitted Surface Water Diversions by Subregion**

Sub-Region	Permitted Diversion (acft/yr)¹					Total
	Municipal	Industrial	Irrigation	Mining	Other²	
Rolling Plains ³	491,583	270,177	88,430	26,321	1,305	877,816
IH-35 Corridor ⁴	576,828	81,684	18,498	603	270	677,883
Lower Basin	129,652	164,073	48,850	200	127	342,902
Region Total	1,198,063	515,934	155,778	27,124	1,702	1,898,601

¹ Available supply may be less than the permitted diversion based on hydrologic conditions and priority of individual water rights.
² Category includes hydroelectric, navigation, recreation, and other uses as classified by the TNRCC.
³ 1,534,000 acft of industrial water in the Rolling Plains sub-region is non-consumptive for the Fort Phantom Hill Power Station.
⁴ 1,257,530 acft of other water in the IH-35 Corridor sub-region is non-consumptive for hydroelectric power generation.

have formed the Brazos-Colorado Water Alliance to identify water supply and treatment alternatives to meet the future needs of the Brazos and Colorado River Basins.

1.4.2 Districts

1.4.2.1 Bell County WCID No. 1

Bell County WCID No. 1 obtains raw water from Lake Belton for distribution to its customers. Major customers include the U.S. Department of the Army and the cities of Belton, Copperas Cove, Harker Heights, and Killeen.

1.4.2.2 West Central Texas Municipal Water District

The West Central Texas Municipal Water District gets raw water from Hubbard Creek Reservoir, which it owns and operates, for distribution to the cities of Abilene, Albany, Anson, and Breckenridge. This district has rights to 56,000 acft of water for municipal, industrial, irrigation, and mining uses.

1.4.3 Municipal

1.4.3.1 City of Abilene

The City of Abilene obtains raw water from Lake Fort Phantom Hill, Lake Abilene, and Lake Kirby, all of which it owns and operates. The total permitted capacity of these reservoirs is about 94,300 acft. The City has the right to divert up to 37,365 acft/yr from these lakes for municipal, industrial, and irrigation uses. The City also uses self-supplied groundwater and

surface water purchased from the West Central Texas Municipal Water District. In 1996, the City sold treated water to 10 entities in the BGRWPA, the largest of which was Dyess Air Force Base. The City of Abilene used about 24,000 acft of water in 1996.

West Texas Utilities Company operates a power-generating facility on Lake Fort Phantom Hill and has the right to divert up to 1,534,000 acft/yr for non-consumptive recirculating cooling use.

1.4.3.2 City of Waco

The City of Waco obtains raw water from Lake Waco. The City has the right to divert 59,100 acft/yr for municipal and irrigation uses. The City, in cooperation with BRA, is currently implementing a project to enlarge Lake Waco that will provide for an additional 20,770 acft/yr of supply. In 1996, the City provided roughly 26,770 acft of treated water to its citizens and to the Cities of Hewitt, Lacy-Lakeview, and Woodway.

1.4.3.3 City of Round Rock

The City of Round Rock obtains raw water from the Edwards (BFZ) Aquifer and purchases additional water from Lake Georgetown. The City provided about 12,556 acft to its citizens in 1996. The City also sells water to four other entities in the region. Its largest customer, Brushy Creek MUD, bought 1,895 acft in 1996. The City has contracted to purchase 18,134 acft/yr from the BRA at Stillhouse Hollow Reservoir in Bell County. The pipeline that will deliver this water to Lake Georgetown is scheduled to be completed by the end of 2001.

1.4.3.4 City of Temple

The City of Temple obtains raw water primarily from the Leon River, to which it holds a run-of-the-river permit. This permit from the TNRCC gives the City the right to divert water from the river but not to store it. The City also has contracted for stored water from BRA in Lake Belton. In 1996, the City provided about 12,700 acft of water to its own citizens and to the Cities of Morgans Point and Troy.

1.4.3.5 City of Killeen

The City of Killeen obtains water from Lake Belton through Bell County WCID No. 1, and it obtains additional water from Nolan Creek, to which it holds diversion rights. In 1996, the City of Killeen used 10,212 acft.

1.4.3.6 City of Bryan

The City of Bryan obtains raw water from the Carrizo-Wilcox Aquifer. The City distributed about 10,300 acft in 1996. About 100 acft were sold to the Wellborn Special Utility District.

1.4.3.7 City of College Station

The City of College Station also obtains its water from the Carrizo-Wilcox Aquifer, and it used about 17,258 acft in 1996. The City sold about 600 acft to the Wellborn Special Utility District.

1.4.3.8 City of Georgetown

The City of Georgetown obtains raw water from the Edwards (BFZ) Aquifer. It also purchases water from Lake Georgetown from the BRA. In 1996, the City purchased about 6,700 acft of raw water and distributed about 2,400 acft. The City has contracted to purchase 15,448 acft/yr from the BRA at Stillhouse Hollow Reservoir in Bell County. The pipeline that will deliver this water to Lake Georgetown is scheduled to be completed by the end of 2001.

1.4.3.9 City of Sweetwater

The City owns and operates two reservoirs, Lake Sweetwater and Lake Trammel. However, the City's primary source of water is the Oak Creek Reservoir in Coke County (SB1 planning region F) in the Colorado River Basin. In 1996, the City sold 5,400 acft of water to its citizens and to other BGRWPA entities.

1.4.3.10 City of Cedar Park

In 1996, the City of Cedar Park purchased all of its water from the LCRA and the City of Austin (SB1 planning region K). The City sold about 3,141 acft to its citizens and 800 acft to other entities in 1996. The City's largest customer was the Williamson-Travis MUD No. 1.

1.4.4 Others

1.4.4.1 Texas A&M University

Texas A&M University obtains raw water from the Carrizo-Wilcox Aquifer and treats it at the College Station campus. The University used about 6,820 acft of water in 1996. The

University also has a contract with the BRA for rights to raw water in Lake Limestone totaling 6,945 acft.

1.4.4.2 U.S. Department of the Army

The U.S. Department of the Army has a water right to store and divert 12,000 acft in Lake Belton and the yield available from this right is estimated to be about 3,336 acft. The Army has contracted with Bell County WCID No. 1 and the City of Gatesville to divert, treat, and deliver this water to Fort Hood.

1.4.4.3 Central Texas Water Supply Corporation

Central Texas Water Supply Corporation contracts with the BRA to obtain raw water from Lake Stillhouse Hollow. This provider sold a total of 6,500 acft of treated water to 16 other water-supply entities in 1996. Its largest customer was Kempner Water Supply Corporation, which purchased about 3,300 acft.

1.5 Current Water Users and Demand Centers

1.5.1 Regional Water Use

Total water use by each county in the Brazos G planning area is provided in Figure 1-12 for 1996. Water use can be better understood by looking at four general types of use: municipal, industrial, agricultural, and non-consumptive. Figure 1-13 shows historical water consumption for municipal, industrial, and agricultural use in the BGRWPA. Industrial use can be further broken down into three sub-categories: manufacturing, steam-electric cooling, and mining. Agricultural use comprises the subcategories of water used for irrigation and livestock. Table 1-7 summarizes historical water use in the planning area for six such categories. Each category is defined below. In Appendix A, Table A-7 gives historical water-use data for all counties in the BGRWPA, and Table A-8 gives historical water-use data by category of use. Water use, greater than or equal to 1,000 acft, by each water-right holder is given in Appendix D. A complete list of water rights for the planning area is in Appendix G.

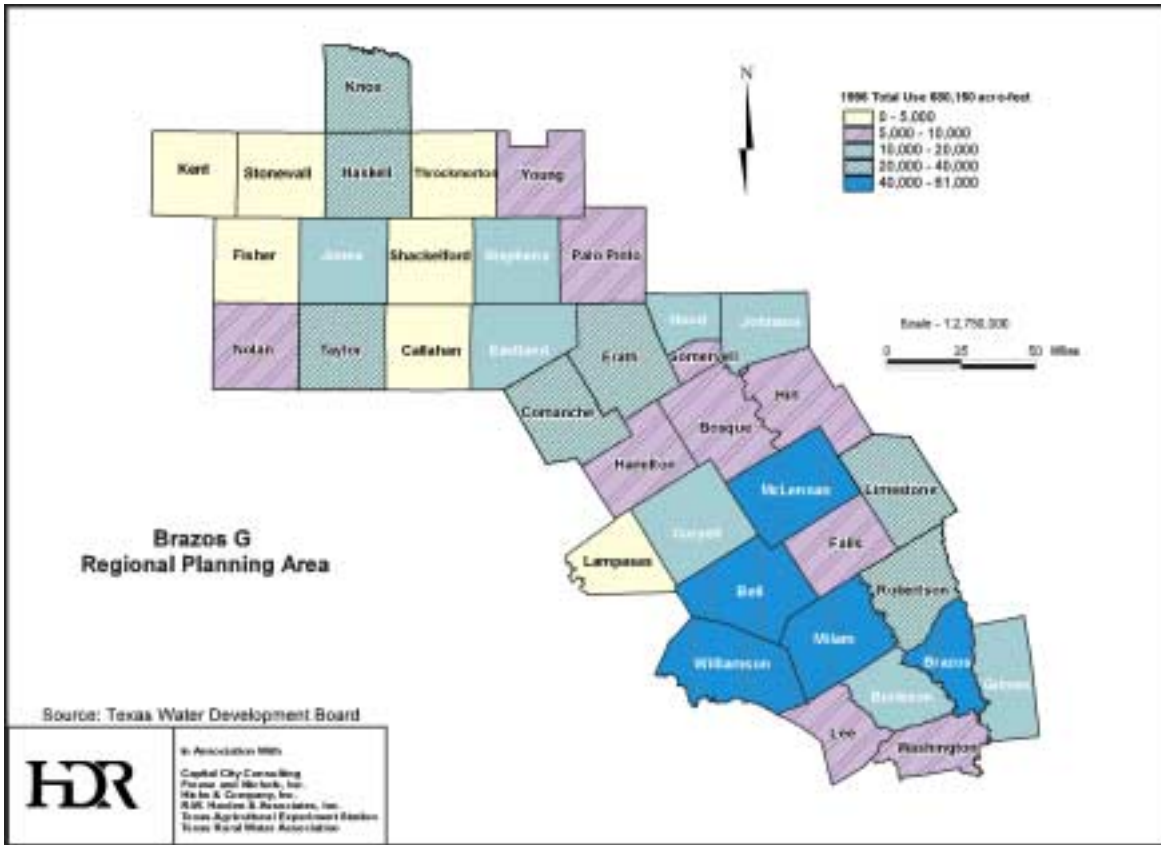


Figure 1-12. 1996 Total Water Use by County

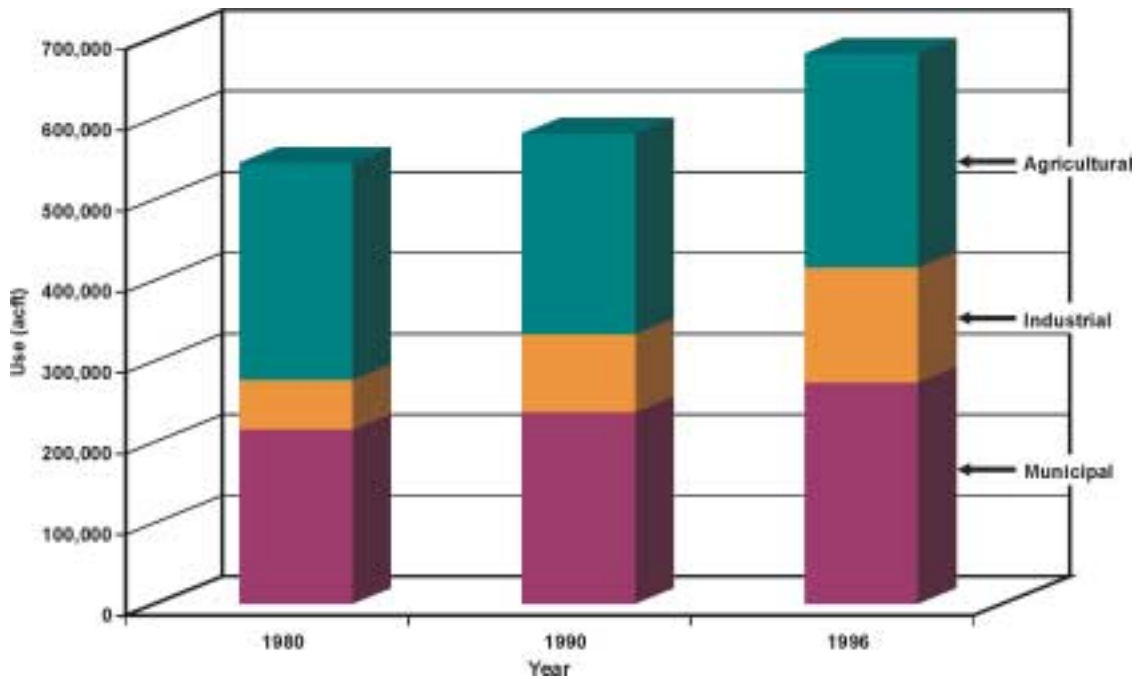


Figure 1-13. BGRWPA Historical Water Use by Type

Table 1-7.
BGRWPA Historical Water Use¹ (acft/yr)

Category	1980	1990	1996
Municipal Use	215,744	236,955	273,887
Manufacturing Use	21,124	32,240	55,647
Steam-Electric Use	28,686	57,657	69,118
Mining Use	11,413	6,944	17,387
Irrigation Use	229,387	200,954	198,687
Livestock Use	38,915	46,770	65,424
Total Use	545,269	581,520	680,150
Percent of State Total	3.06	3.70	4.05

¹ Historical data obtained from TWDB.

1.5.2 Municipal Use

Municipal water use includes water consumed for residential and commercial enterprises and institutions. Residential and commercial uses are categorized together because they are similar types of uses (i.e., they both use water primarily for drinking, cleaning, sanitation, air-conditioning, and landscape watering). Municipal use does not include water use by industries. Projections for future municipal use take into account population growth and anticipated efforts at water conservation. Municipal use of 273,887 acft accounted for about 40 percent of the region's total water use in 1996. Figure 1-14 shows municipal water use in each BGRWPA county in 1996.

1.5.3 Industrial Use

Industrial use consists of water used for manufacturing, for steam-electric cooling during power generation, and for mining operations. Projections for industrial use take into account expected growth of industries, population changes, available mineral reserves, and production rates. In 1996, industrial use was 142,152 acft, or about 21 percent of the total water used in the BGRWPA. Refer to Figure 1-15 for 1996 industrial water use by county.

1.5.3.1 Manufacturing

Manufacturing use is water used for producing finished goods. Manufacturing use was 55,647 acft in 1996, or 39 percent of total industrial water usage that year.

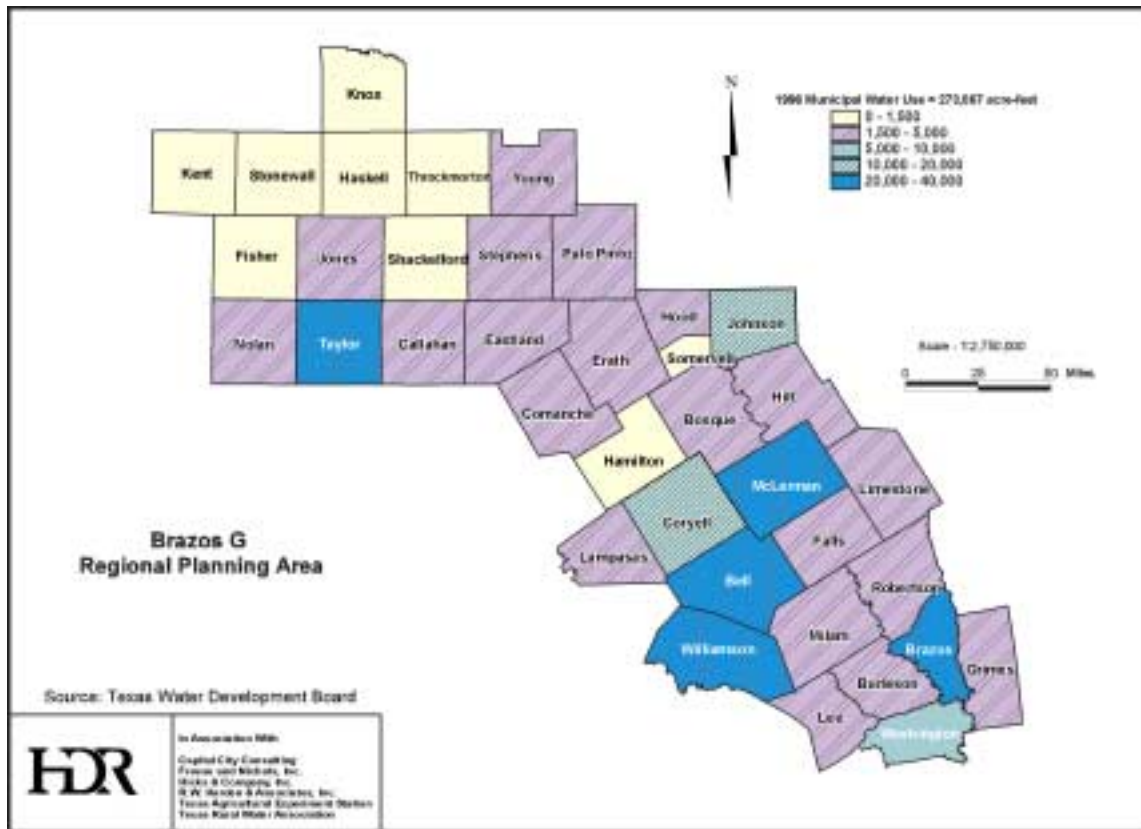


Figure 1-14. 1996 Municipal Water Use

1.5.3.2 Steam-Electric Cooling

This category is water used during the power-generation process and is typically losses due to evaporation during cooling. Water that is diverted and not consumed (i.e., return flow) is not included in the power-generation total. Water use for steam-electric cooling in 1996 was 69,118 acft, or 49 percent of total industrial water use.

1.5.3.3 Mining

Mining use is water consumed for exploration and production of oil and gas, and for mining of lignite, sand, gravel, and such. Mining use in 1996 was 17,387 acft, or 12 percent of the total industrial water use.

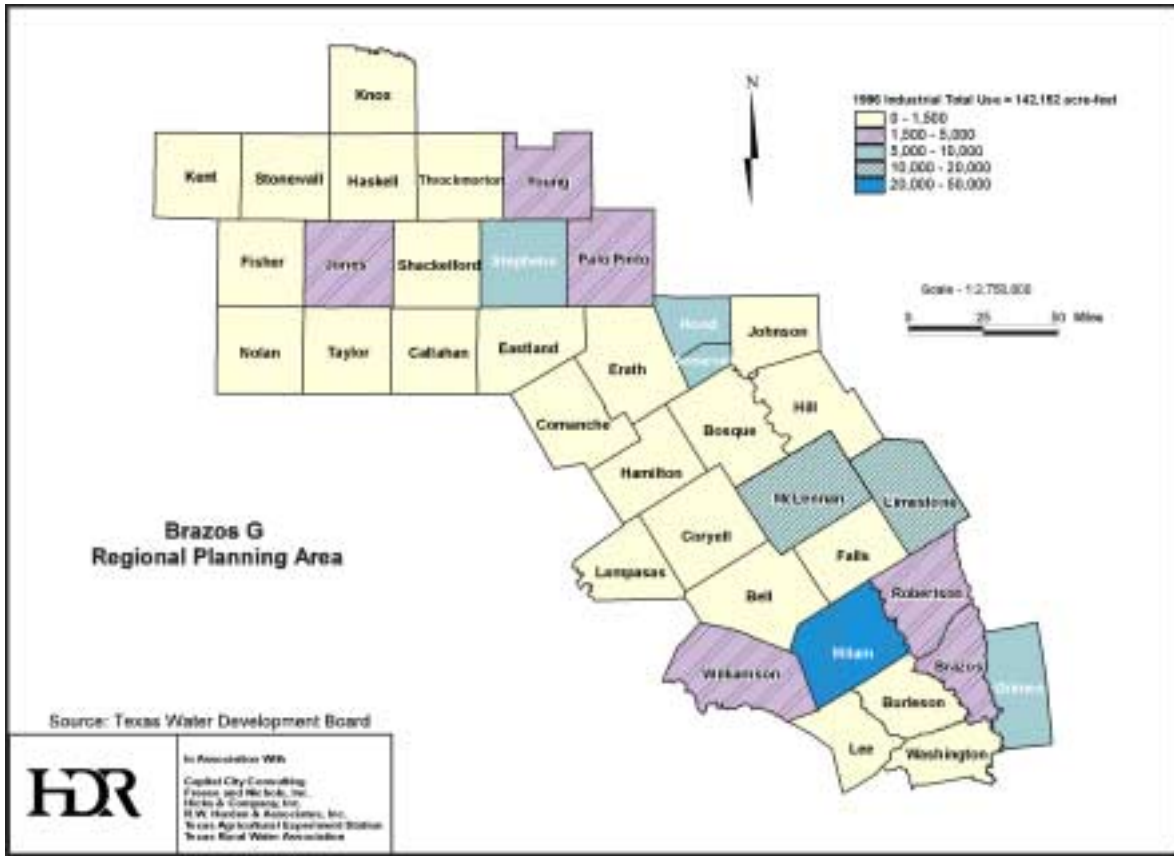


Figure 1-15. 1996 Industrial Water Use (Manufacturing, Steam-Electric Cooling, and Mining)

1.5.4 Agricultural Use

Agricultural use is water used for irrigation and for watering livestock. Agricultural use was 264,111 acft in 1996, or 39 percent of the BGRWPA’s total water use. Refer to Figure 1-16 for agricultural water use by each county in the planning area in 1996.

1.5.4.1 Irrigation

Irrigation use in 1996 totaled 198,687 acft, or about 75 percent of the total agricultural water use. Refer to Appendix G for more detailed information about irrigation use in the BGRWPA.

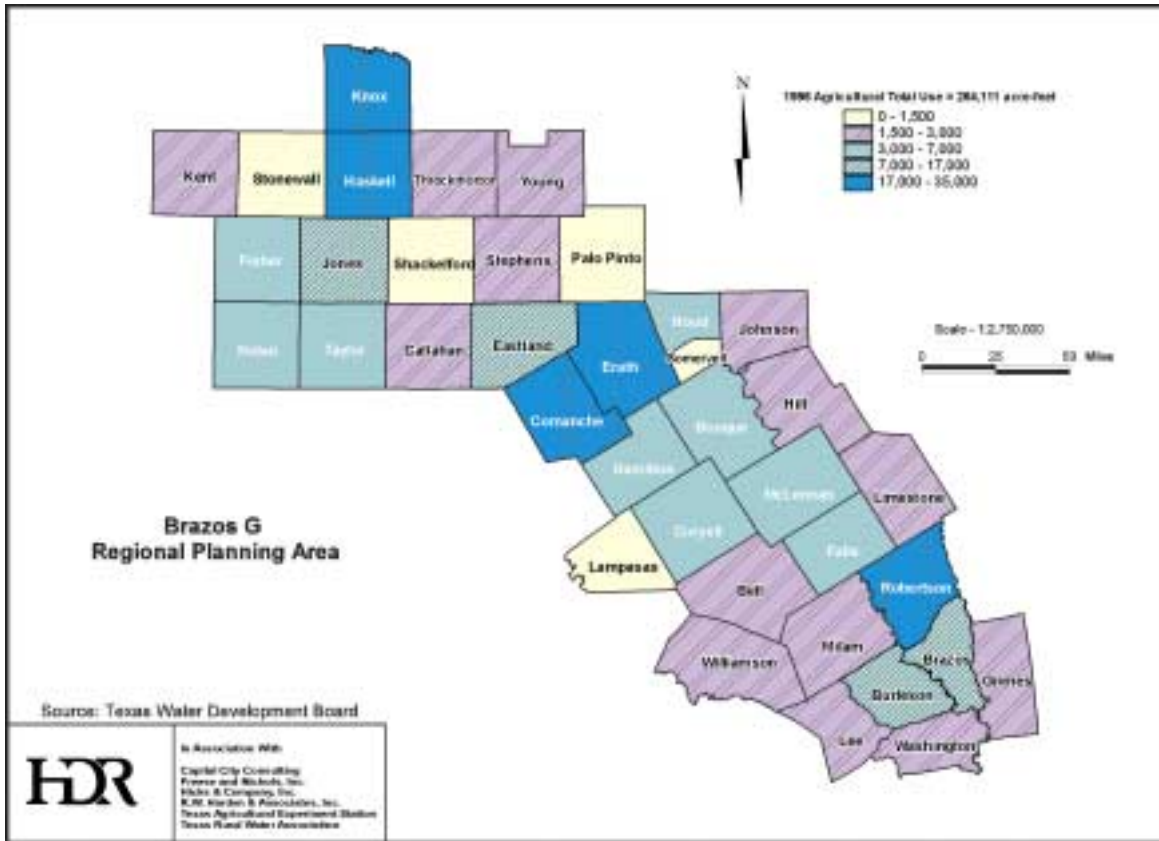


Figure 1-16. 1996 Agricultural Water Use (Livestock and Irrigation)

1.5.4.2 Livestock Watering

The estimate of use for livestock watering is based on a determination of the total number of livestock in the region. A uniform water-consumption rate for each type of animal is applied to this total number.¹⁰ The categories of livestock considered are cattle and calves; poultry; sheep and lambs; and hogs and pigs. Livestock watering totaled 65,427 acft, or 25 percent of agricultural use in 1996. Refer to Appendix G for more detailed information on water used for livestock.

1.5.5 Non-Consumptive Use

The majority of non-consumptive water use is recreational use and the return flow from power generation. Water-related recreational activities include boating, camping, fishing, and

¹⁰ TWDB, *Water for Texas*, August 1997.

swimming. Recreational use in the BGRWPA is supported by numerous state parks and by public facilities for boating and camping at various lakes and reservoirs along the Brazos River.

Power generation demands large amounts of water for cooling equipment. Fifteen steam-electric power-generating facilities were operating in the BGRWPA in 1996. Most of the diverted water was returned to the Brazos Basin, but some was lost to evaporation during the cooling process.

1.6 Natural Resources

1.6.1 Regional Vegetation

The BGRWPA lies within several different vegetational areas, or ecoregions, as defined by Gould.¹¹ Figure 1-17 shows the locations of these ecoregions, which are relatively homogenous areas in terms of geography, hydrology, and land use. The five ecoregions in the BGRWPA are the Rolling Plains, Blackland Prairies, Post Oak Savannah, Cross Timbers and Prairies, and Edwards Plateau. A general description for each ecoregion is provided below. More detailed information is provided in Appendix E.

1.6.1.1 Rolling Plains

The Rolling Plains are part of the Great Plains of the central United States. The Rolling Plains region covers about 24 million acres of gently rolling to moderately rough terrain. The region is bordered on the west by the Caprock Escarpment, on the south by the Edwards Plateau, and on the east by the Cross Timbers and Prairies region. Annual precipitation averages about 22 to 30 inches, and elevations range from 800 to 3,000 feet above sea level. The eastern part of the Rolling Plains is called the Reddish Prairie. Soils vary from coarse sands in outwash terraces near streams to tight clays or red-bed clays and shales.

1.6.1.2 Blackland Prairies

The Blackland Prairies region consists of nearly level to gently rolling topography. It covers about 11.5 million acres from Grayson and Red River Counties in northeast Texas to Bexar County in the south-central part of the State where it merges with the brushland of the Rio Grande Plains. Annual precipitation is 30 to 45 inches, and elevations range from 300 to

¹¹ Gould, F.W., *The Grasses of Texas*, Texas A&M University Press, College Station, Texas, 1975.

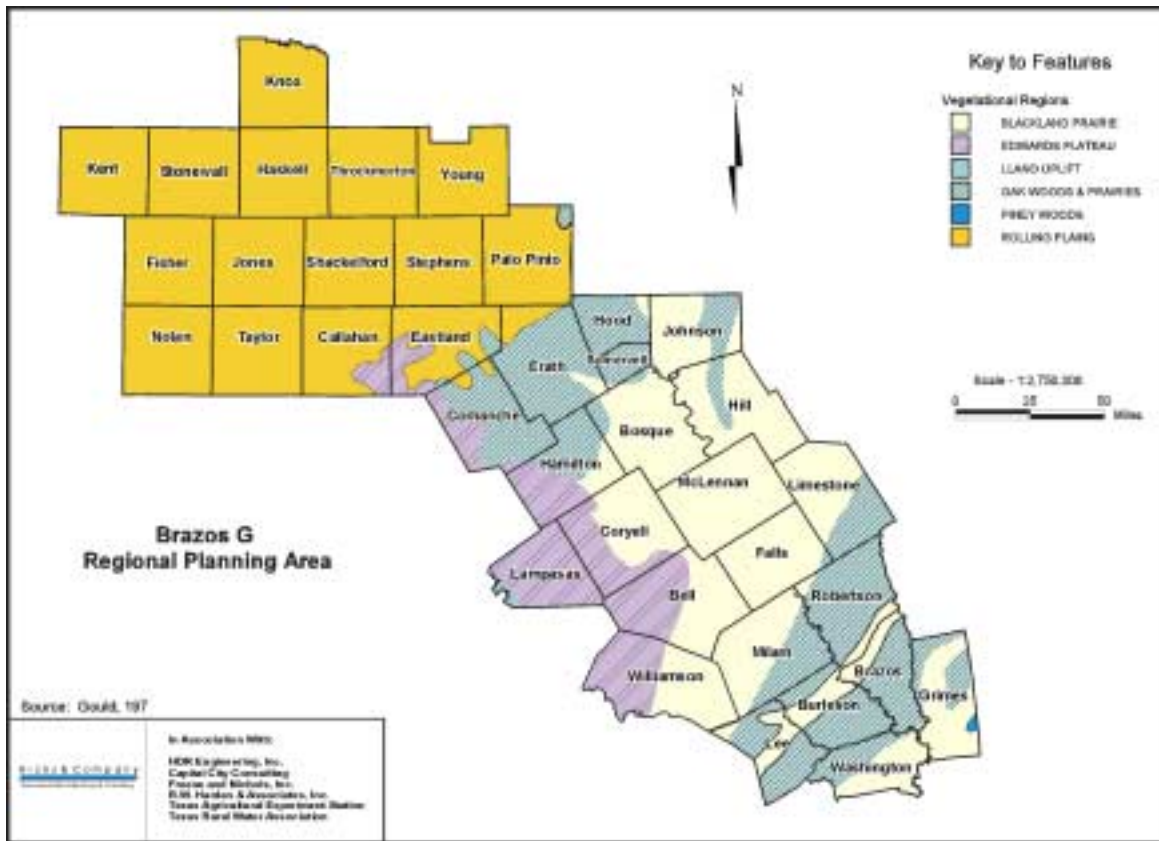


Figure 1-17. Vegetational Areas of the Brazos G Region

800 feet above sea level. The term blackland comes from the uniformly dark-colored, calcareous clays in the Alfisols (fertile mineral soils). Soils in the Blackland Prairies are interspersed with gray-colored, acidic sandy loams. This highly fertile region has widely been used for agriculture, but it is increasingly used for ranching.¹² Experts estimate that less than one percent of the Blackland Prairies ... in a near-natural condition.¹³

1.6.1.3 Post Oak Savannah

The Post Oak Savannah covers about 8.5 million acres in east-central Texas and consists of closely associated and intermingled prairies and woodlands on slightly acidic sandy or clay loams. Topography in this region is gently rolling to hilly, with moderate to deeply dissected drainage paths. Soils in uplands are generally light-colored, acidic sandy loams or sands, and

¹² Gould, F.W. and Schuster, J.L. and Hatch, S.L., *Texas Plants B, An Ecological Summary*, Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas, 1990.

¹³ Smeins and Diamond, 1986.

soils in bottomlands are light-brown to dark-gray acidic sandy loams or clays. Much of this vegetational area is used for crops and grazing.

1.6.1.4 Cross Timbers and Prairies

The Cross Timbers and Prairies vegetational area covers about 17 million acres in north-central Texas. Geology in this area is diverse, and the topography varies from gently rolling to hilly to deeply dissected. Rapid surface drainage is typical throughout the region. Soils are typically brown, neutral-to-slightly acidic, sandy or clay loams.

1.6.1.5 Edwards Plateau

The Edwards Plateau area covers about 24 million acres. This includes a large portion of the Hill Country in west-central Texas, the Llano Uplift, and the Stockton Plateau. Average annual precipitation increases from west to east across this region. Limestone or caliche typically underlie the shallow, variably-textured soils, although granitic rock underlies soil in the Llano Uplift. Land use in this vegetational area is dominated by ranching of cattle, sheep, and goats. This region reportedly once was dominated by a grassland or an open savannah climax community, except in steep canyons and slopes where junipers and oaks were dominant. The widespread disturbance associated with grazing livestock eventually allowed brush and tree species to spread widely throughout the original grasslands and savannahs.

1.6.2 Regional Geology

Figure 1-18 shows the varied geology of the planning area. Generally, the formations in the northwest part of the planning area are the older Blaine and San Angelo Formations of the Paleozoic era. The central part of the planning area is typically dominated by younger formations from the Cretaceous era, such as the Trinity Group; the Navarro and Taylor Groups; and the Austin, Eagle Ford, Woodbine, and U. Washita Groups. The youngest formations are in the southern part of the planning area. These formations include the Cook Mountain, Weches, Sparta, and Yegua, among others. Many areas near streams and rivers are dominated by alluvial deposits.

1.6.3 Soils

The soils of the upper Brazos River Basin are agriculturally and ecologically important. Throughout Brazos G Region, soils are varied and are influenced by both geology and surface drainage. Figure 1-19 shows the locations of different orders of soil in the BGRWPA. These soil types are briefly described in the following subsections.

1.6.3.1 Alfisols

Alfisols are mineral soils with a gray-to-brown surface horizon. These soils form under humid, cool-to-hot areas of native grasslands. They are productive and favor good crop yields.

1.6.3.2 Entisols

Entisols are typical of rangeland in west and southwest Texas. In this order, soils range from infertile sands and bedrock to highly productive soils on recent alluvium. A characteristic common to all Entisols is the lack of significant profile development.

1.6.3.3 Inceptisols

Inceptisols are thought to form relatively quickly from the alteration of parent material. Productivity varies among soils in this order, and it is affected by factors such as levels of organic matter and drainage. Typically, Inceptisols have slightly higher profile development than Entisols.

1.6.3.4 Mollisols

Mollisols are considered important agriculturally and are characterized by a thick, dark **surface horizon**. These soils develop under grassland-prairie vegetation typical of the central United States. Mollisols cover more land area in the United States than any other soil order.

1.6.3.5 Vertisols

Vertisols have a high clay content and therefore may develop deep cracks from shrinking during dry periods. The fine texture of Vertisols and their tendency to shrink excessively makes them generally unstable for building foundations and even for some agricultural uses.

1.6.4 Wetlands

Wetlands are defined by the U.S. Army Corps of Engineers as areas that, due to a combination of hydrologic and soil conditions, are capable of supporting hydrophytic vegetation. In the Brazos G Region, wetlands are found primarily in narrow strips along rivers and streams.

As a natural resource, wetlands are especially valued because of their location on the landscape, the wide variety of ecological functions they perform, and the uniqueness of their plant and animal communities. Many wetlands are also valued for their aesthetic qualities, as sites for educational research, as sites of historic and archaeological importance, and as locations for conveying floodwaters. Wetlands provide high-quality habitats for wildlife, including foraging and nesting areas for birds and spawning and nursery areas for fish.

1.6.5 Water Resources

Rivers and reservoirs are also important ecological resources for the Brazos G Region. These support diverse aquatic plants and animals as well as terrestrial wildlife living along the banks. Important rivers and creeks in the planning area include the Brazos, Leon, Bosque, Lampasas, San Gabriel, South Wichita, Little, Clear Fork of the Brazos, and Yegua Creek. These rivers contribute to unique vegetational communities that provide habitat for wildlife. There are more than 40 species of aquatic amphibians, reptiles, and mammals in the planning area. Waterfowl heavily use the mature, hardwood, bottomland forests and forested wetlands often associated with rivers. Aquatic habitats include riffles and pools, which support both invertebrates and fish.

Reservoirs (Figure 1-20) provide habitat for inland fish stocks and waterfowl. Reservoirs in the planning area that are important habitats for fish stocks and waterfowl include Lake Stamford, Hubbard Creek Reservoir, Possum Kingdom Lake, Lake Leon, Lake Proctor, Lake Whitney, Lake Stillhouse Hollow, Lake Belton, Lake Waco, and Lake Somerville.

Although few in number, those major springs and seeps in the planning area that produce frequent flows are often rich in wildlife habitat and ecological diversity. Springs represent a transition from groundwater to surface water. Where frequent springflow occurs, an abundance of moisture is provided, resulting in diverse vegetational communities unique to such areas. Typical vegetation includes willows, cottonwoods, hackberry, elms, rushes, sedges, and smartweed. These vegetational communities often provide optimal habitat for native wildlife.

1.6.6 Wildlife Resources

1.6.6.1 Biotic Provinces

Just as Gould¹⁴ described the major plant zones of Texas, Blair¹⁵ classified the State into biotic provinces based on the distribution of topographic features, climate, vegetation types, and terrestrial vertebrates (Figure 1-21). The BGRWPA includes the Kansan, Austroriparian, Balconian, and Texan biotic provinces.

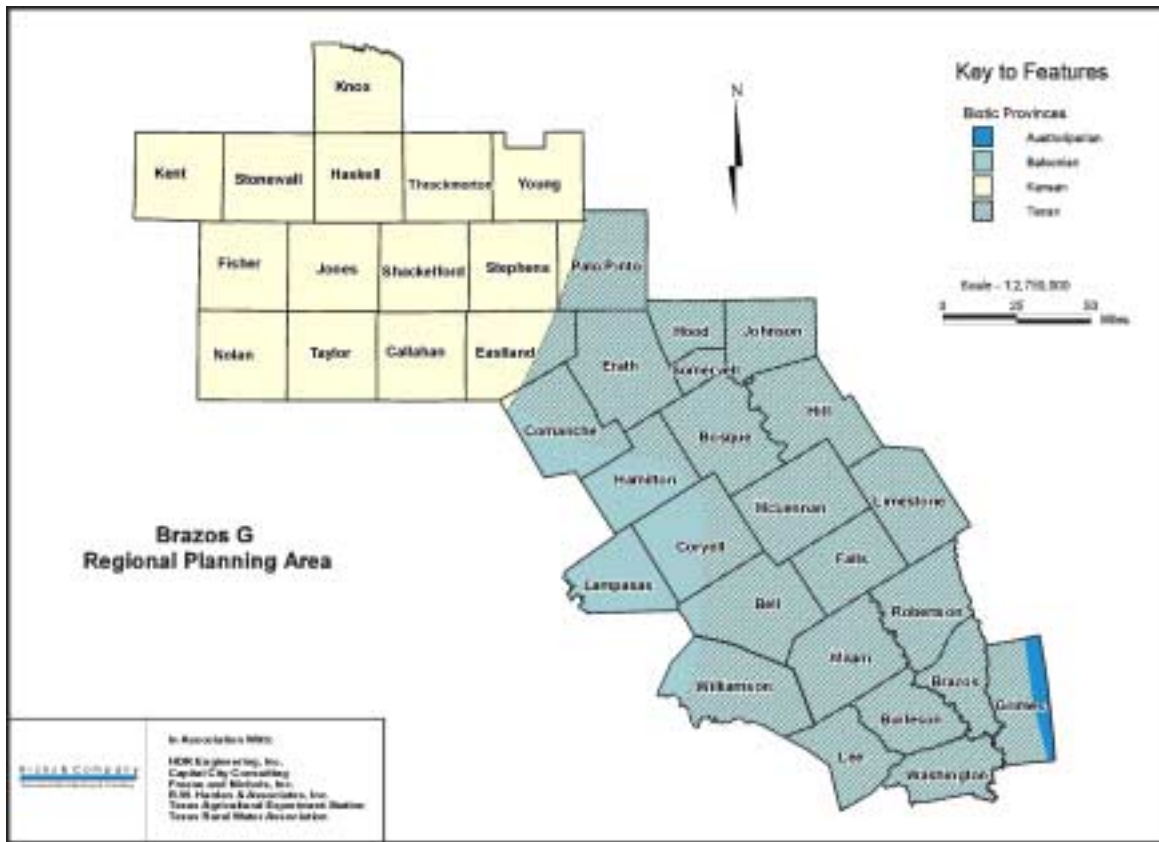


Figure 1-21. Biotic Provinces of the Brazos G Region

1.6.6.1.1 Kansan

The Kansan province runs southward from the Texas panhandle and across the Rolling Plains area of the Brazos G Region. It meets the Texan biotic province at the western boundary of the Cross Timbers and Prairies vegetational area. There is little available moisture in the

¹⁴ Gould, Op. Cit., 1975.

¹⁵ Blair, 1950.

province, and moisture that is available decreases from east to west. The plant associations vary. However, they fall into three general categories of associations: the mixed-grass plains, the mesquite-grass association, and the short-grass plains.

1.6.6.1.2 Austroriparian

The western fringe of the Austroriparian province extends into the southeastern rim of the Brazos G Region. This province comprises the pine and hardwood forests of the eastern Gulf Coastal plain. The province is limited to the west due to low moisture. However, vegetational communities found in the westward extensions of the province occur along drainageways where environmental conditions allow.

1.6.6.1.3 Balconian

The Balconian province includes most of the Edwards Plateau excluding the region west of the Pecos River. The Edwards Plateau is a physio-graphically discrete unit. It has a variety of wildlife, and its vegetation is different from that found in adjacent provinces. The abundant vertebrate species are a mixture of Austroriparian, Tamaulipan, Chihuahuan, and Kansan.

Most of the Balconian province lies on Cretaceous limestone, but igneous intrusives and sediments of Precambrian age are exposed in the Llano Uplift. Limestone caverns and springs are common features of this province. Massive outcrops of limestone are characteristic of the stream canyons, and limestone fragments occur at the surface over almost the entire area.

Rainfall amounts typically decrease from east to west. The most characteristic plant association is the juniper-oak scrub. Mesquite is also distributed throughout the province.

1.6.6.1.4 Texan

The Texan biotic province has no true endemic species of vertebrates. In this area, western species tend to encroach into open habitats, and eastern species encroach along the many wooded drainageways extending through the landscape. The Texan province has supported 49 species of mammals, 39 species of snakes, 16 species of lizards, 2 types of land turtles, 18 types of toads and frogs (anurans), and 5 species of salamander (urodeles).

1.6.6.2 Threatened and Endangered Species

In planning water-management strategies, one major consideration is the potential impact on threatened and endangered species. Nineteen of the species listed as threatened or endangered by the U. S. Fish and Wildlife Service are found in the Brazos G planning area. Some of the more widely seen of these are the golden-cheeked warbler (*Dendroica chrysoparia*), the black-capped vireo (*Vireo atricapillus*), and the bald eagle (*Haliaeetus leucocephalus*). Table E-1 in Appendix E gives a complete list of threatened and endangered species in each county in the BGRWPA.

1.6.7 Agricultural Resources

Agriculture is a mainstay of the BGRWPA rural economy. Among livestock, cattle were the most significant component, approaching 2.5 million head with an additional 145,000 dairy cows in 1997. Over 17 million acres, or about 84 percent of BGRWPA's total area, were classified as farmland in 1997. Of the 17 million acres of farmland, about six million acres were classified as cropland, of which about three million acres were harvested. Refer to Tables F-1 through F-4 in Appendix F for detailed listings of agricultural information for the BGRWPA.

The Texas Department of Agriculture has specified several Agricultural Statistics Districts for the purpose of keeping records. The districts within the BGRWPA are 2N and 2S (Rolling Plains), 3 (Cross Timbers), 4 (Blacklands), 5S (South East), 7 (Lampasas County), and 8N (South Central).

1.6.7.1 Rolling Plains

Counties in the Rolling Plains (Districts 2N and 2S) are Fisher, Haskell, Jones, Kent, Knox, Nolan, Stonewall, and Taylor. The major dryland products are extensive row-crops, such as cotton, and wheat. Irrigation comes from the Seymour Aquifer where available. Major crops include wheat and cotton. Hay and silage are also produced, but because of low rainfall, their acreage is much less than in other districts in the BGRWPA.

1.6.7.2 Cross Timbers

The Cross Timbers counties (District 3) are Callahan, Comanche, Eastland, Erath, Hood, Palo Pinto, Shackelford, Somervell, Stephens, Throckmorton, and Young. Combined, these counties lead the State in dairy production. This is due to several factors such as available

groundwater from the Trinity Aquifer, soils suitable for forage production, topography conducive to dairy operation, and an existing infrastructure. The major crops produced in the Cross Timbers are hay and silage, with smaller amounts of peanuts, pecans, and vegetables irrigated from the Trinity Aquifer.

1.6.7.3 Blacklands

The Blacklands counties (District 4) are Bell, Bosque, Coryell, Falls, Hamilton, Hill, Johnson, Limestone, McLennan, Milam, and Williamson. Lampasas County (District 7) is included for the purposes of this analysis. The Blacklands is noted for dryland production of corn for grain, grain sorghum, wheat for grazing and grain, cotton, and hay. Irrigation in the Blacklands is limited by lack of sufficient groundwater supply.

1.6.7.4 South East and South Central Texas

South East and South Central Texas counties (District 5S and 8N) are Brazos, Burleson, Grimes, Lee, Robertson, and Washington. This sub-region has limited row-crop agriculture because suitable topography and soils are limited. Hay and silage are the major agricultural products. The Brazos River Bottoms counties (Brazos, Burleson, and Robertson) produce most of the crops in the sub-region, including corn for grain, grain sorghum, and cotton. The Brazos River Alluvium is the major source of groundwater for the Brazos River Bottoms.

1.7 Threats and Constraints to Water Supply

Projected population growth in the region, particularly along the IH-35 Corridor, may strain existing municipal supplies. The population of Williamson County, for example, is expected to increase more than four-fold by the year 2050 to about 886,000 people. Water will become even more valuable, especially in the western and central parts of the BGRWPA, due to limited options for new reservoirs and because the aquifers in these areas have limited potential for further development.

Other concerns include the high content of chloride in surface-water runoff from the upper Brazos River Basin. Water with a high chloride content is expensive to treat and therefore places capital constraints on suppliers who obtain surface water from affected streams and reservoirs.

1.7.1 Susceptibility of Water Supplies to Drought

1.7.1.1 Groundwater

The 15 aquifers within the BGRWPA vary in drought resistance, but all tend to have more resistance than most surface-water reservoirs. Most of the thick, deep, and extensive sand aquifers with moderate to high transmissivity react very slowly to droughts. Their supplies are virtually drought-proof even during long droughts. These aquifers, such as the Carrizo-Wilcox and Gulf Coast Aquifers, store enormous amounts of water. Somewhat thinner, yet still extensive, sand aquifers with low to moderate transmissivity commonly are only slightly less drought-resistant. These aquifers include the Trinity, Woodbine, Queen City, Sparta, and Hickory.

During long droughts, shallow alluvial aquifers from which large withdrawals are made experience water level declines that are relatively large in comparison to total saturated thickness. Supplies from these aquifers, such as the Seymour and Brazos River Alluvium Aquifers, can be affected by drought but generally only by extended droughts. In extended droughts, available well yields are typically reduced, and pumps must run longer for a given level of supply.

In thin aquifers with shallow supplies, drought resistance may not be adequate. Such aquifers in the BGRWPA include the Dockum, Blaine, and Edwards-Trinity (Plateau). Also, shallow supplies in or near outcrop areas of aquifers, even of major aquifers, may have limited drought resistance.

Aquifers composed of limestone and/or dolomite are commonly the least drought-resistant. This is because these aquifers typically have only about one-tenth as much storage per cubic foot as sand aquifers. For limestone aquifers, the amount of well development is also an important factor in drought resistance. Thus, the Edwards (BFZ) Aquifer, with more developed well capacity than is available in extended droughts, is the least drought-resistant of all the aquifers in the BGRWPA. Depending on location and exact local conditions, springflows and some Edwards (BFZ) well supplies are substantially reduced in only moderate droughts. In contrast, the Marble Falls and Ellenburger-San Saba Aquifers, which are relatively undeveloped by wells, can more slowly discharge a part of their stored water during long droughts.

In the Brazos G Region, for supplies drawing from the Edwards (BFZ) Aquifer, drought planning is critical. All of the other aquifers in the region are very drought resistant due to their inherent characteristics.

1.7.1.2 Surface Water

Surface water supplies in the region vary greatly, as rainfall ranges from 20 to 24 inches in Kent County in the northwest, to 40 to 44 inches in Grimes County in the southeast. Evaporation rates show a similarly wide variation, with the highest rates occurring in the northwestern part of the region.

Drought originates from a deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector. Drought should be considered relative to some long-term average condition of balance between precipitation and evapotranspiration (i.e., evaporation + transpiration). It is also related to the timing (i.e., principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness of the rains. Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with drought in many regions of the world and can significantly aggravate its severity.

Hydrological drought is associated with the effects of periods of precipitation shortfalls on surface water supply. The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency affects the system water supply. Firm yields of reservoirs are estimated based on water that would be available through a repeat of the historic drought of record, which includes the effects of reduced runoff and high evaporation rates during the drought period. Water supply from run-of-the-river diversions are estimated based on water that would be available¹⁶ through a repeat of the drought of record. The water supply estimates throughout this water plan are reliable through a repeat of the drought of record and are therefore not particularly susceptible to drought-induced shortages. However, the northwestern counties of the Brazos G region are currently suffering through a

¹⁶ Estimates of municipal and industrial run-of-river diversions are for 100 percent reliability. For irrigation uses, run-of-river reliability is less than 100 percent reliable.

particularly dry spell and data shows that in some areas the 1997 through 2000 period has produced less runoff than the first three years of the drought of record in the 1950s. This situation is obviously being closely monitored by affected water supply entities and drought contingency plans may need to be implemented.

1.7.2 Identified Water Quality Problems

Water quality in the BGRWPA varies. Water quality is generally good in aquifers and in the tributaries of the Brazos River. However, high concentrations of chloride are found in the main stem of the Brazos River. Three factors affecting water quality in the Brazos G Region are wastewater disposal, high-density agricultural activities, and natural saline contamination.¹⁷ Except for the third factor, these threats are associated with the growth of both population and the economy, and these are expected to continue growing in the future.

The 1997 *Water for Texas* plan identifies problems with water quality in the Brazos River Basin, and several of these problems occur in the BGRWPA. Citing the TNRCC's 1996 *Water Quality Inventory*, the *Plan* notes elevated levels of fecal coliform bacteria in several areas: the main stem of the Brazos River just downstream of the Navasota River, downstream of the Clear Fork of the Brazos, and near the cities of Marlin and Cameron. Tributaries of the Brazos River with elevated levels of fecal coliform are the Leon River downstream from Lake Proctor, Oyster Creek, and the North Bosque River and Upper North Bosque River. Also in the Bosque River, elevated levels of nutrients from several sources are contributing to excessive growth of plankton and attached algae. The TNRCC's Clean Rivers Program¹⁸ has identified water quality concerns in the region with respect to levels of nutrients, turbidity, dissolved metals, algae, chlorophyll alpha, fecal coliform, ammonia, phosphorous, nitrogen, nitrate-nitrogen, total suspended solids, dissolved minerals, and dissolved oxygen. Natural salt loading is typical of the upper Brazos River in the Brazos G Region, and its effects have rendered much of the river and its three main-stem reservoirs (Possum Kingdom Lake, Lake Granbury, and Lake Whitney) unsuitable for drinking water supply without expensive demineralization treatment.¹⁹

¹⁷ Texas Natural Resource Conservation Commission (TNRCC), *Summary Report: Regional Assessments of Water Quality Pursuant to the Texas Clean Rivers Act (Senate Bill 818)*, 1992.

¹⁸ TNRCC, *Summary Report: Regional Assessments of Water Quality Pursuant to the Texas Clean Rivers Act (Senate Bill 818)*, 1996.

¹⁹ TNRCC, Op. Cit., 1992.

1.7.3 Identified Threats to Agricultural and Natural Resources

Drought is the primary threat to agricultural resources in the Brazos G Region. During long droughts, surface water supplies for unconfined livestock are diminished. If the drought extends through the season for growing forages, production is reduced due to the lack of rainfall. Additional threats to livestock arise from the reduced water supply for rural water systems that are not interconnected or that are not supplied by a reliable source. This is especially in the northwest part of the region. Water for confined livestock (e.g., dairy cattle and poultry) and for crop irrigation typically comes from groundwater. Threats to groundwater supplies were discussed in Section 1.3.1. An additional threat to crop production is the migration into agricultural land of municipal well fields near cities supplied by groundwater (e.g., Bryan and College Station). Groundwater Conservation Districts and Underground Water Conservation Districts have been created in part to address this issue. Section 1.8 contains additional information.

1.8 Drought Preparations

Drought contingency plans are required by the TWDB for wholesale water suppliers, irrigation districts, and retail water suppliers. To aid in the preparation of the water plans, the TNRCC, TWDB, Texas Water Utilities Association, and Texas Rural Water Association have sponsored workshops for those required to submit plans. The BRA was among the first to prepare and file a drought contingency plan in 1985, and the plan is routinely updated.

For surface water right-holders that supply 1,000 acft/yr or more for non-irrigation use and 10,000 acft/yr for irrigation use, SB1 requires a water conservation plan. Entities required to prepare and submit plans are identified in Table 1-8. The entities listed are those identified by the TNRCC as of April 1999.

In addition, conservation plans are commonly included in the management plans of Groundwater Water Conservation Districts or Underground Water Conservation Districts. Within the BGRWPA, five districts have been created: the Salt Fork Underground Water Conservation District in Kent County, the Saratoga Underground Water Conservation District in Lampasas County, the Lost Pines Underground Water Conservation District in Bastrop and Lee Counties, the Brazos Valley Underground Water Conservation District in Robertson and Brazos Counties, and the Clearwater Underground Water Conservation District in Bell County.

The Saratoga Underground Water Conservation District has filed a management plan, which the TWDB has certified. The plan addresses conservation measures but contains no specific initiatives for addressing droughts. The Clearwater Underground Water Conservation District was allowed to be created by the 71st Texas Legislature through an election in 1999. The Salt Fork Underground Water Conservation District has not filed a management plan with the TWDB. The Lost Pines and Brazos Valley entities were created by the 76th Legislature and are subject to future ratification or creation action by the 77th Legislature. No plans have been developed by either of these entities.

**Table 1-8.
Entities Required to Submit
Water Conservation Plans¹**

Entity Name		
Acton MUD	City of Georgetown	Ebba Iron, Inc.
Aluminum Company of America	City of Graham	Franklin Federal Bancorp
Aquilla WSD	City of Granbury	
Bell County WCID No. 1	City of Groesbeck	Johnson County FWSD No. 1
Bistone MWSD	City of Harker Heights	Jonah Water Special Utility District
Bluebonnet Water Supply Corporation	City of Lampasas	Kempner Water Supply Corporation
Brazos Electric Cooperative	City of Lorena	Oryx Energy Company
Central Texas Water Supply Corporation	City of Marlin	Palo Pinto County Municipal Water District No. 1
Chisholm Trail Special Utility District	City of Robinson	Phillips Petroleum Company
City of Abilene	City of Rosebud	South Texas Water Company
City of Belton	City of Round Rock	Tex/Con Oil and Gas Company
City of Breckenridge	City of Stamford	Texaco, Inc.
City of Brenham	City of Stephenville	Texas Municipal Power Agency
City of Bryan	City of Strawn	TXU Electric
City of Cameron	City of Sweetwater	U.S. Department of the Army
City of Cedar Park	City of Taylor	Upper Leon River Municipal Water District
City of Cisco	City of Temple	West Central Texas Municipal Water District
City of Clyde	City of Waco	West Texas Utilities Company
City of Gatesville	Eastland County WSD	

¹ Information provided by TNRCC, April 1999.

1.9 Existing Programs and Goals

1.9.1 Texas Clean Rivers Act

In 1991, the 72nd Legislature passed the Texas Clean Rivers Act²⁰ to establish for the first time a watershed basis for water quality planning in Texas.^{21,22} The Act requires each river basin in the State to be assessed for water quality and management strategies on an on-going basis. It also requires reports to be provided to the TNRCC every even-numbered year.²³ The Act provides specific guidelines for accomplishing the water quality assessments, including: (1) comprehensive assessments on a watershed basis with emphasis on non-point sources, nutrients, and toxic materials; (2) delegation of responsibility for assessments to river authorities; (3) formation of river basin steering committees; (4) discharge permitting on a basin-wide basis; and (5) assessment fees charged to wastewater- and water-rights permittees.

The BRA is a partner with the TNRCC in the Clean River Program for the BGRWPA. The program provides funding for BRA staff to assess water quality in the Brazos River Basin and to document local problems. Also, the program provides fee payers with site-specific information on water quality such as receiving water assessments and flow data. The 1996 *Report*²⁴ for the Brazos River Basin provides an assessment of water quality for the basin, drawing attention to: (1) the need for more long-term data on water quality, (2) a continued emphasis on the Basin Steering Committee for direction and comment on the water quality assessment program, (3) continued assistance in water quality monitoring from local partners in the Basin Monitoring Program, (4) emphasis on assessing and maintaining data, and (5) development of a geographical information system for the basin. The 1996 *Report* provides detailed findings about water quality and related items for selected sub-watersheds of the basin. The findings most relevant to the BGRWPA were summarized in Section 1.7.2.

1.9.2 Clean Water Act

The 1972 Federal Water Pollution Control Act, which as amended is called the Clean Water Act, is the federal law with the most impact on water quality protection in the BGRWPA.

²⁰ Senate Bill 818, amending the Texas Water Code, Sections 5.103, 5.105, 26.011; T.A.C. Sections 320.1-320.9

²¹ TNRCC, Op. Cit., 1992.

²² TNRCC, Op. Cit., 1999.

²³ BRA, "Planning and Environmental Division", [Online] Available URL: <http://www.brazos.org/home.htm>, 1999.

²⁴ Brazos River Authority, 1999.

As amended in 1977 and again in 1987, the Clean Water Act: (1) establishes the framework for monitoring and controlling industrial and municipal point-source discharges through the National Pollutant Discharge Elimination System, (2) authorizes federal assistance for the construction of municipal wastewater treatment facilities, and (3) requires cities to obtain permits for stormwater or non-point-source discharges.²⁵ The Clean Water Act also includes provisions to protect specific aquatic resources. Section 303 establishes a non-degradation policy for high quality waters and provides for establishment of state standards for receiving water quality. Section 401 allows states to enforce water quality requirements for federal projects such as dams. Section 404 provides safeguards for wetlands and other waters from the discharge of dredged or fill material. Section 305 calls for the TNRCC to prepare and submit a water quality inventory to the U.S. Environmental Protection Agency.²⁶ Other provisions protect particular types of ecosystems such as lakes (Section 314), estuaries (Section 320), and oceans (Section 403).²⁷ Several of these provisions are relevant to specific water quality concerns in the BGRWPA.

1.9.3 Safe Drinking Water Act

The Safe Drinking Water Act, passed in 1974 and amended in 1986 and 1996, allows the U.S. Environmental Protection Agency to set standards for drinking water quality. These standards are divided into two categories: National Primary Drinking Water Regulations (primary standards that must be met by all public water suppliers) and National Secondary Water Regulations (secondary standards that are not enforceable, but are recommended). Primary standards protect water quality by limiting levels of contaminants that are known to adversely affect public health and that are anticipated to occur in water. Secondary standards have been set for contaminants that may affect cosmetic or aesthetic qualities of water (e.g., taste, odor, or color).

1.9.4 Water for Texas (1997)

Developed by the TWDB, *Water for Texas* is a comprehensive State plan that identifies current and prospective uses of water, water supplies and water users, necessary water-related

²⁵ 33 USCA, Sections 1251 through 1387.

²⁶ TWDB, 1997.

²⁷ Adler, R.W., Landman, J. and Cameron, D., *The Clean Water Act: Twenty Years Later*, Island Press, Washington D.C., 1993.

management measures, and facility needs and costs. The plan also recommends ways to better manage the State's water resources through the year 2050. Key management areas include:

- Water conservation
- Water reuse
- Expanded use of existing supplies
- Reallocation of reservoir storage
- Water marketing
- Subordination of water rights
- Yield enhancement measures
- Chloride control measures
- Interbasin transfers
- Development of new supplies

This plan offered several recommendations for the BGRWPA to aid the area in meeting future demand. Key recommendations include:

- Chloride control projects need to be constructed in the upper Brazos River Basin (Kiowa Peak, Dove, and Croton Brine Lakes) to reduce the salinity of downstream water supplies.
- Depletion of the Trinity Aquifer may require some entities to convert to surface water supplies.
- The City of Abilene will need to construct a pipeline to O.H. Ivie Reservoir to meet its projected needs in 2025.
- The Cities of Hamlin and Stamford may need to obtain water from either the West Central Texas Municipal Water District or the City of Abilene because sedimentation has severely reduced supply in Lake Stamford. Treatment facilities will need improvements in order to handle greater volumes of raw water.
- The Cities of Round Rock and Georgetown should consider participating in the construction of a pipeline from Lake Stillhouse Hollow to Lake Georgetown and possibly in the construction of the Lake Belton pipeline.
- The City of College Station should upgrade infrastructure to meet demand projected for year 2030.
- Paluxy Reservoir should be built by 2010 to meet the needs of the Cities of Glen Rose and Stephenville. At present, both cities fully depend on groundwater.
- The City of Cisco should consider contracting with the City of Abilene for water to supplement its current source, Lake Cisco. Current demands exceed Lake Cisco's dependable yield.
- Storage in Lake Whitney will need to be reallocated to consumptive use to meet projected demands in the BRA system.

The plan described above was adopted by the TWDB in August 1997, and it will be updated as prescribed by SB1 according to findings of this report. Since the completion of the 1997 plan, the following issues have arisen:

- It has been found that at this time, construction of the Paluxy Reservoir is not a viable option for meeting water needs in the region.
- The City of Stamford is pursuing obtaining water from Abilene as well as the possibility of diverting flow from California Creek to supplement its supply.
- The City of College Station has done studies to determine where upgrades are most needed and has begun upgrading its infrastructure.
- The Cities of Round Rock and Georgetown and the Jonah Special Utility District are constructing a raw-water pipeline from Lake Stillhouse Hollow to Lake Georgetown.