UPDATED EVALUATION FOR THE CENTRAL TEXAS
– TRINITY AQUIFER –
PRIORITY GROUNDWATER MANAGEMENT AREA

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Priority Groundwater Management Area File Report

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EXECUTIVE SUMMARY

This report presents the updated priority groundwater management area (PGMA) study for the Central Texas - Trinity aquifer - area, including Bell, Bosque, Brown, Callahan, Comanche, Coryell, Eastland, Erath, Falls, Hamilton, Hill, Lampasas, Limestone, McLennan, Mills, and Somervell counties. The purpose of the study is to determine if all, part, or any of this area is experiencing or is expected to experience within the next 25-year period critical groundwater problems, and to recommend physically and economically feasible groundwater management solutions if shortages of surface water or groundwater are occurring or are expected to occur.

A 1990 study by the Texas Water Commission (TWC), a Texas Commission on Environmental Quality (TCEQ) predecessor agency, and the Texas Water Development Board (TWDB) determined that Central Texas Study Area did not meet the criteria to be designated as a "critical area" primarily because of the availability of surface water supplies to meet projected needs. However, the TWC recommended that progress toward the conversion from groundwater to surface water usage should be reinvestigated, and if conversion plans were not being implemented or if groundwater conservation districts were not being formed, designation consideration for the area may need to be reconsidered. At that time, three groundwater conservation districts existed within the study area, Clearwater UWCD (Bell County), Fox Crossing WD (Mills County), and Saratoga UWCD (Lampasas County). The Middle Trinity GCD was created in Comanche and Erath counties in 2001.

TCEQ efforts to reevaluate the study area were started again in 1998 and Texas Water Development Board (TWDB) and Texas Parks and Wildlife Department (TPWD) reports were completed in 1999. Shortly thereafter, the TCEQ chose to postpone the update effort until the 2001 Regional Water Plans and the 2002 State Water Plan were completed. State law was subsequently amended in 2001 to require TCEQ to complete this and several other similar update PGMA studies.

This study evaluates regional water resource issues, summarizes, and evaluates data and information that has been developed in the Central Texas study area over the past 15 years. This report relies primarily on the data and supporting information for the 2001 and the 2006 Brazos G, Region F, and Lower Colorado Regional Water Plans and the 2002 State Water Plan. The report also evaluates and uses information provided by stakeholders, other TWDB publications and data, data from the groundwater availability modeling for the Trinity/Woodbine aquifers, and natural resources issues identified by the Texas Parks and Wildlife Department. The report evaluates the authority and management practices of existing water management entities and purveyors within and adjacent to the study area, and makes recommendations on appropriate strategies needed to conserve and protect groundwater resources in the study area.

On October 18, 2004, TCEQ mailed a notice to approximately 532 water stakeholders within the study area to solicit comments and information about water supplies and groundwater availability, water level trends, quality, and management.

From 2000 to 2030, the population of the 16-county Central Texas study area is projected to increase from just over 771 thousand to just over 1.02 million residents. Likewise, the projected demand for water will increase from over 337 thousand acre-feet (acft) in 2000 to a projected demand of over 416.9 thousand acft by 2030. Municipal use presently accounts for about 43 percent of the total water use and is projected to account for 45.6 percent by the year 2030.

The Trinity aquifer is the primary groundwater resource in the study area, providing 52.9 percent of the groundwater, while the Brazos River Alluvium and the Woodbine aquifers provide significant

(26.2 percent) amounts of water in the eastern part of the study area. The Carrizo-Wilcox aquifer provides 15.6 percent of the groundwater in the area, but only in Falls and Limestone counties. Other aquifers supplying the area are the Edwards-Balcones Fault Zone (BFZ, Northern Segment), Ellenburger-San Saba, and Marble Falls. Together, these aquifers supply about five percent of the total water supply in the study area. Groundwater-level declines including the associated reduction of artesian pressure caused by the continued removal of water from aquifer storage is a regional problem. This problem was identified in 1975 and remains a significant groundwater problem today.

Regional water plan strategies to increase reliance on the Trinity aquifer have been adopted for many water user groups in the study area. Adding new wells or increasing existing well production are regional water plan strategies for six water user groups in Coryell, Eastland, Erath, Lampasas, and Mills counties.

The 2006 Brazos G Water Plans note that groundwater for mining in the study-area counties of Bosque, Comanche, Erath, Hamilton, Hill, and Somervell, is derived from the Trinity, Woodbine, and Brazos River Alluvium aquifers. The mining user group data in the regional water plans estimate the presently available water supply in these six counties for mining use is about 562 acft/yr.). Harden and Associates (2007) estimated a typical vertical well completion consumes approximately 1.2 million gallons (3.68 acft), and a typical horizontal completion 3.0 − 3.5 million gallons of fresh water (9.21 −10.74 acft) per well. Using this estimate, the current number of drilling applications in the six-county area would potentially represent about 2,148 acft of water use for this specific mining purpose. At present, the number of active drilling rigs appears to be the only limiting factor to the number of Barnett Shale gas wells that can be drilled each year.

More groundwater is being withdrawn than recharged to aquifers in most parts of the Central Texas study area. The continuing overdevelopment of the Trinity aquifer threatens water supplies for rural domestic, municipal, and small water providers who depend on groundwater resources. The water demands from the continued urbanization of the area, and more recently, the growing natural gas exploration activity are not expected to level out or to lessen over the next 25-year period.

Some groundwater users on the fringes of the Interstate 35 corridor, including many municipalities, will be converting to surface water sources over the next 10 to 20 years. However, increased groundwater pumpage to keep pace with the growth away from the corridor and the growing suburban cities is anticipated to continue. Historically, regional groundwater pumpage has not lessened when providers convert to surface water sources because those who develop next, just outside of the area that has recently converted to surface water, will look primarily to use the groundwater resources.

Preserving the ability to rely on the limited groundwater resource is and will remain a primary objective for remote rural water suppliers; individual businesses, industries, or homeowners; and, small municipalities. Protecting existing groundwater supplies is a critical issue for these groundwater users because the delivery of alternative surface water supplies is not projected to be economically feasible. For these reasons, it is recommended that the following counties be designated as the Central Texas (Trinity Aquifer) Priority Groundwater Management Area: Bosque, Coryell, Hill, McLennan, and Somervell. Critical groundwater problems are not presently occurring or projected to occur in Bell, Brown, Callahan, Comanche, Eastland, Erath, Falls, Hamilton, Lampasas, Limestone, or Mills counties within the next 25-year period and these counties should not be designated as part of the recommended Central Texas (Trinity Aquifer) Priority Groundwater Management Area.

The Brazos G regional water plan reports that Eastland County had a total water shortage of 9,140 acft in 2000 for the irrigation water user group. The report also projects an annual shortage of about

9,200 acft/yr through 2030 when the shortage is projected to be 9,224 acft. Strategies to meet these needs are conservation, weather modification, and brush control. There do not appear to be any long-term water level declines in the Trinity aquifer in Eastland County, which indicates that there has been no significant mining of the aquifer. Therefore, Eastland County is not being designated as part of the recommended Central Texas (Trinity Aquifer) Priority Groundwater Management Area.

One or more groundwater conservation districts (GCDs) created within Bosque, Coryell, Hill, McLennan, and Somervell counties would have the necessary authority to address the groundwater problems identified in the area. Financing groundwater management activities through a combination of well production fees and ad valorem taxes is concluded to be the most viable alternative. A regional groundwater conservation district for these counties would include the greatest areal extent of the Trinity aquifer experiencing supply problems and would be the most cost effective. From a resource protection perspective, this option would be the most efficient by allowing for a single groundwater management program that would assure consistency across the area, providing a central groundwater management entity for decision-making purposes, and simplifying groundwater management planning responsibilities related to Groundwater Management Area #8.

The remote rural water suppliers; individual businesses, industries, or homeowners; and, small municipalities of these counties would benefit from groundwater management programs for the Trinity, Brazos River Alluvium, and Woodbine aquifers. GCD programs with the following goals would benefit groundwater users in the area;

- manage groundwater withdrawals;
- quantify groundwater availability and quality;
- identify groundwater problems that should be addressed through aquifer- and area-specific research, monitoring, data collection, assessment, and education programs;
- quantify aquifer impacts from pumpage;
- establish a comprehensive water well inventory, registration, and permitting program; and
- evaluate and understand aquifer characteristics sufficiently to establish spacing regulations to minimize drawdown of water levels and to prevent interference among neighboring wells.

<u>It is recommended that a regional, combination fee and ad valorem tax funded groundwater conservation district for the preservation of the Trinity, the Brazos River Alluvium, and the Woodbine aquifers in Bosque, Coryell, Hill, McLennan, and Somervell counties represents the most feasible, economic, and practicable option for protection and management of groundwater resources</u>.

<u>Alternatively, it is recommended that two multi-county GCDs could be created based on local actions taken independently to create, subject to a confirmation election, the Tablerock GCD, Coryell County and the McLennan County GCD</u>. Each newly created District must add at least one adjacent county to their District before September 1, 2011.

It is also suggested that the landowners in Eastland County living and relying heavily on the Trinity aquifer would find it beneficial to join the existing Middle Trinity GCD.

The use and application of the permissive authority granted to municipal and county platting authorities to require groundwater availability certification under the Local Government Code can be an effective tool to help ensure that residents of new subdivisions with homes that will rely on individual wells will have adequate groundwater resources. It is recommended that local governments consider using this groundwater management tool to address water supply concerns in rapidly developing areas.

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INTRODUCTION

To enable effective management of the state's groundwater resources in areas where critical groundwater problems exist or may exist in the future, the Legislature has authorized the Texas Commission on Environmental Quality (TCEQ), with assistance from other agencies, to study, identify, and delineate Priority Groundwater Management Areas (PGMAs). If necessary, the TCEQ may initiate the creation of groundwater conservation districts (GCDs) within those areas.

In 1990 and 1991, the Texas Water Commission (TCEQ predecessor agency) completed 14 "critical area" studies (now PGMA studies) in various parts of the State to determine if these areas were experiencing or were expected to experience critical water problems in the next two decades. The Commission determined that four of areas had or were expected to have groundwater problems and designated them as Critical Areas, and that five of the study areas did not have and were not expected to have critical groundwater problems and no further evaluation or action was needed.

The Commission determined that the other five study areas did not meet the criteria to be designated as having critical groundwater problems; however, the Commission requested that these five areas be reinvestigated when more data became available. The Central Texas (Waco) area was one of these five study areas. Appendix 1 includes a reproduction of the technical summary for the Central Texas 1990 study and recommendations.

Purpose and Scope

This area was initially studied by the Texas Water Commission (TWC) in a report released in March 1990 (Nelson and Musick). The study was conducted under the guidance of the Critical Area Program in response to House Bill 2 passed by the 69th Texas Legislature in 1985. The purpose of the investigation was to determine if the area was experiencing, or was likely to experience in the next 20 years, critical groundwater problems and whether a groundwater conservation district should be created in order to address such problems. This study recommended that the Central Texas (Waco) study area not be designated as a Critical Area (now referred to as Priority Groundwater Management Area). The study concluded that available data and projections of water availability versus demand did not indicate that critical groundwater problems existed within the study area.

In 1997, the 75th Texas Legislature passed Senate Bill 1 (SB 1). This act requires the identification of PGMAs, which are defined as "those areas of the state that are experiencing or that are expected to experience, within the immediately following 25-year period, critical groundwater problems, including shortages of surface water or groundwater, land subsidence due to groundwater withdrawal, and contamination of groundwater supplies."

This report presents the updated priority groundwater management area study for the Central Texas – Trinity aquifer area, including all or part of Bell, Bosque, Brown, Callahan, Comanche, Coryell, Erath, Eastland, Falls, Hamilton, Hill, Lampasas, Limestone, McLennan, and Somervell counties. The purpose of the study is to determine if this area is experiencing or will experience critical groundwater problems within the next 25 years. Milam County, which was included in previous PGMA studies, was omitted from this report due to the small areal extent of the county within the study area, the limited use of groundwater, and the fact that it is part of the Post Oak Savannah GCD. Figure 1 shows the location of the study area and the extent of the urbanized parts of the area. This updated report serves as the basis of the Executive Director's recommendations to the Commission for action regarding designation of a PGMA, necessary management activities, and the need to create a groundwater conservation district.

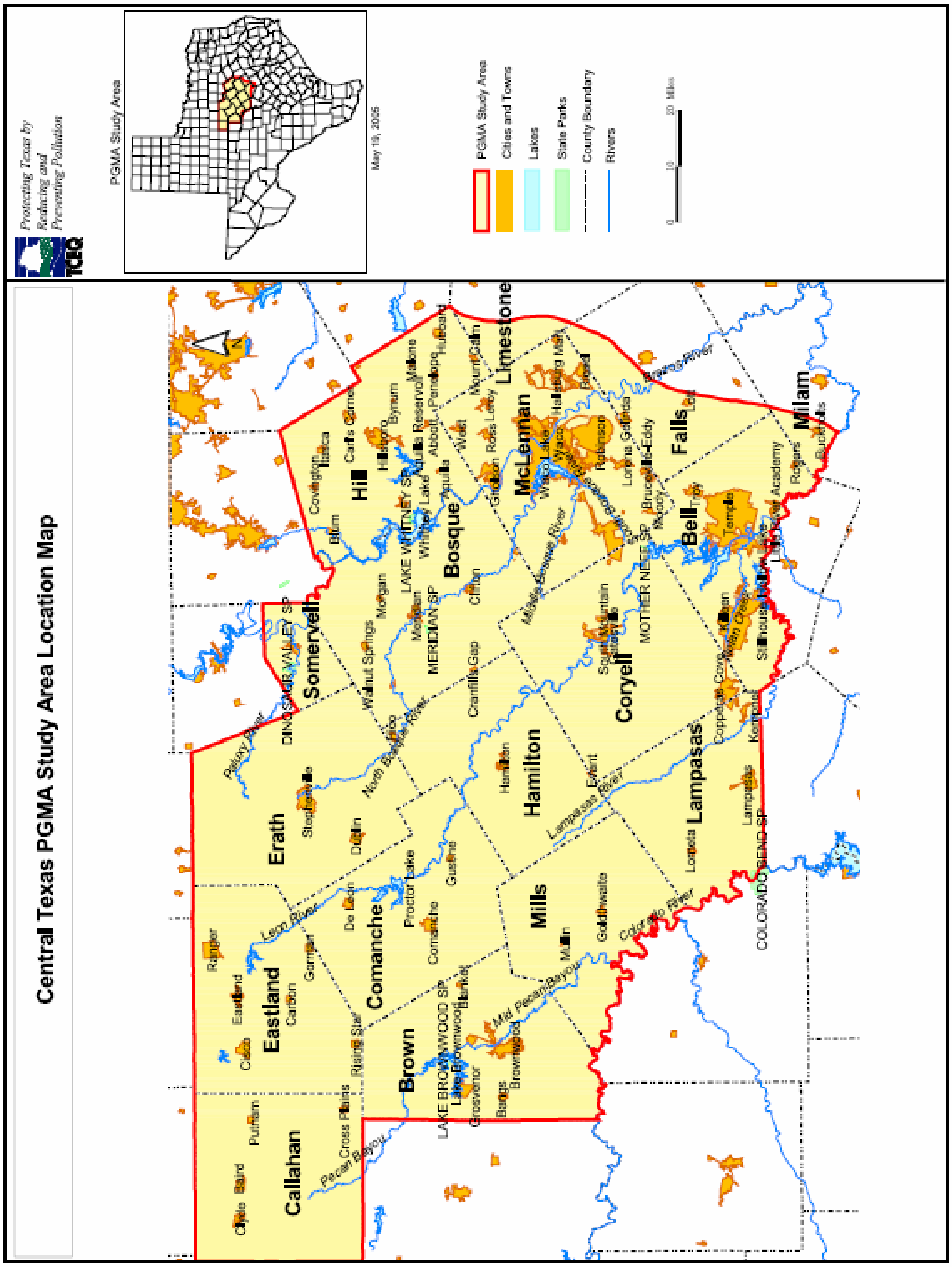


Figure 1. Location Map, Central Texas (Trinity Aquifer) PGMA Study.

Methodology and Acknowledgments

This report summarizes and evaluates data and information that has been developed in the Central Texas (Waco) area over the past thirteen years to determine if the area is expected to experience critical groundwater problems within the next 25 years. This report also evaluates the reasons and supporting information for or against designating all or part of the Central Texas study area as a PGMA. Based on this evaluation, the report provides conclusions and recommendations regarding PGMA designation, conservation of natural resources, and creation of GCDs and management of groundwater resources in the area.

The present report has been prepared using information contained in the following reports: Nelson and Musick, 1990; Bradley, 1999; and El-Hage and Moulton, 1999. Information was also taken from the Region F, Brazos G, and the Lower Colorado (Region K) Regional Water Plans, and the Trinity Groundwater Availability Model, 2004.). The locations of the regional water planning areas in relation to the study area are shown in Figure 2. Additionally, information provided by some of the major water-stakeholders in the area has also been used in the report. Although several aquifers exist in the study area, the report focuses primarily on the Trinity aquifer and secondarily on the Woodbine and the Brazos River Alluvium aquifers. The Trinity aquifer has the largest areal extent; however, the Woodbine and the Brazos River Alluvium aquifers are important locally.

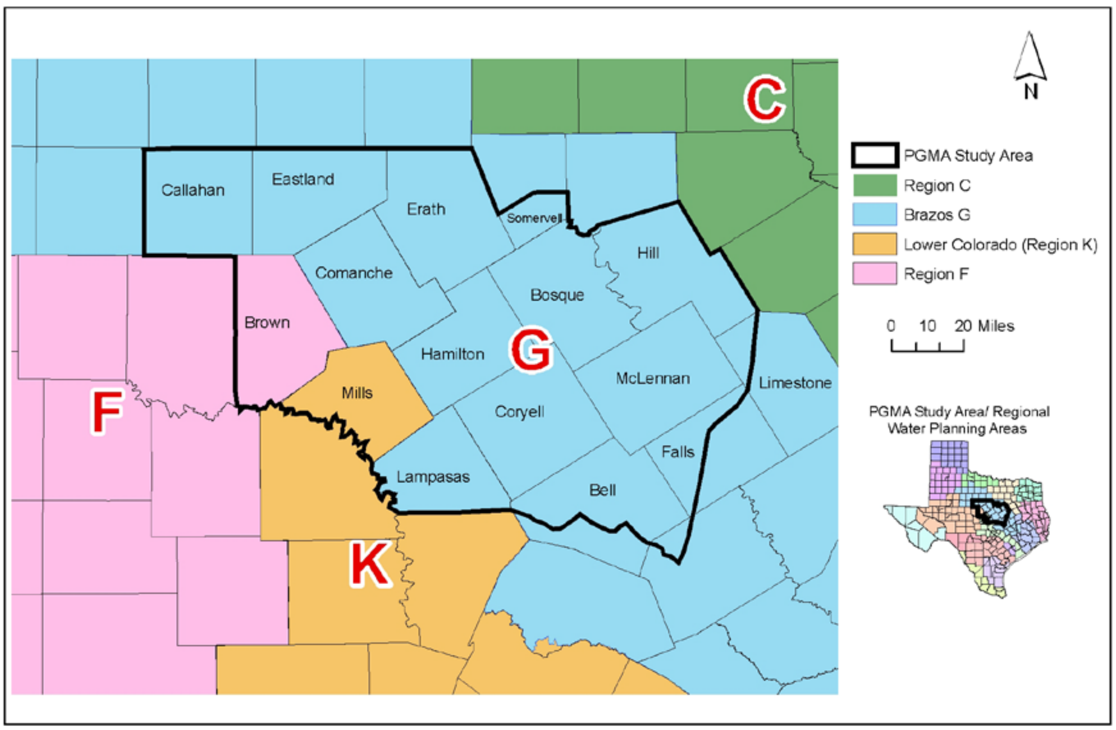


Figure 2. Regional Water Planning Areas, Central Texas (Trinity Aquifer) PGMA Study.

On October 18, 2004, TCEQ mailed stakeholder notice to solicit comments and to request data on water supply, groundwater availability, groundwater level trends, and groundwater quality. The writer acknowledges the stakeholders who met with him personally and provided written comments and data: the Brazos River Authority (BRA); the City of Waco; the Clearwater Underground Water

Conservation District (UWCD); the Middle Trinity Groundwater Conservation District (GCD); TXU Power; the Sierra Club, Lone Star Chapter; the City of Copperas Cove; Texas Parks and Wildlife; the Honorable Fred Cox, Hamilton County Judge; and Barbara Simpson, Coryell County Clerk on behalf of the Coryell County Commissioners Court.

Location, Climate, and Topography

The Central Texas (Waco) update study area is located in Bell, Bosque, Brown, Callahan, Comanche, Coryell, Erath, Eastland, Falls, Hamilton, Hill, Lampasas, Limestone, Milam, McLennan, and Somervell counties in central Texas (Figure 1). The study area extends over about 10,340 square miles within the Brazos, Colorado, and Trinity River basins. Consideration was given to only that portion of each county in which groundwater of usable quality is found. Usable quality groundwater is considered water containing less than 3,000 milligrams per liter (mg/l) total dissolved solids.

The climate of the study area is characterized by long, hot summers and short, mild winters. The average minimum temperature for January, the coldest month, ranges from 32°F (0°C) in the northwest to 39°F (4°C) in the southeast. The average maximum temperature for July, the warmest month, is 96°F (36°C) throughout most of the study area. The annual mean free air temperature for the period 1931-1960 ranged from 65°F (18°C) in the northwest to 68°F (20°C) in the east (Carr, 1987, Figure 3).

The average annual precipitation ranges from 24 inches in the northwest, Callahan County, to 36 inches in Hill and McLennan counties in the east. Figure 3 depicts the average annual rainfall for all of the study area. These figures are based on National Weather Service records for the 30-year period 1960-1990. The average annual gross lake-surface evaporation for the period 1940-1965 ranged from 80 inches in the northwest to 60 inches in the east (Kane, 1967).

Most of the land surface expressions in the study area are the result of stream erosion of relatively flat to gently eastward dipping sedimentary rock strata. Along the southern and eastern edges of the study area, topography exhibits gently rolling prairies with low relief and a well-developed, dendritic drainage pattern. Soils consist of dark calcareous clays, sandy loams, and clay loams in the uplands, while dark gray to reddish-brown calcareous clay loams and clays are found in the bottomlands. Vegetation in the uplands consists of tall bunch grasses and scattered mesquite, while elm, hackberry, and pecan are usually found in the bottomlands.

In the northwest, physical features consist of gently sloping prairies with moderate relief and a mature dendritic drainage pattern. The northeast has an irregular topography of high relief with erosional knobs, precipitous valleys, resistant outliers, and moderate to rapid surface drainage caused by major streams cutting across the various rock formations. Soils are usually light-colored, neutral to slightly acid sand, sandy loams, and loamy sands. Vegetation in the northwest and northeast part of the region consists of tall bunch grasses, mesquite, juniper, and scrub oak.

The central part of the region has moderately high relief with tabular divides, small limestone-capped mesas, sharp-cut valleys, and a thorough dendritic drainage pattern. The soils are dark, stony, shallow to deep calcareous clays in the uplands, and reddish-brown to dark gray clay loams and clays in the bottomlands. Tall bunch grasses, scattered mesquite, some live oak, and juniper grow in the uplands while oak and juniper are usually found in the bottomlands.

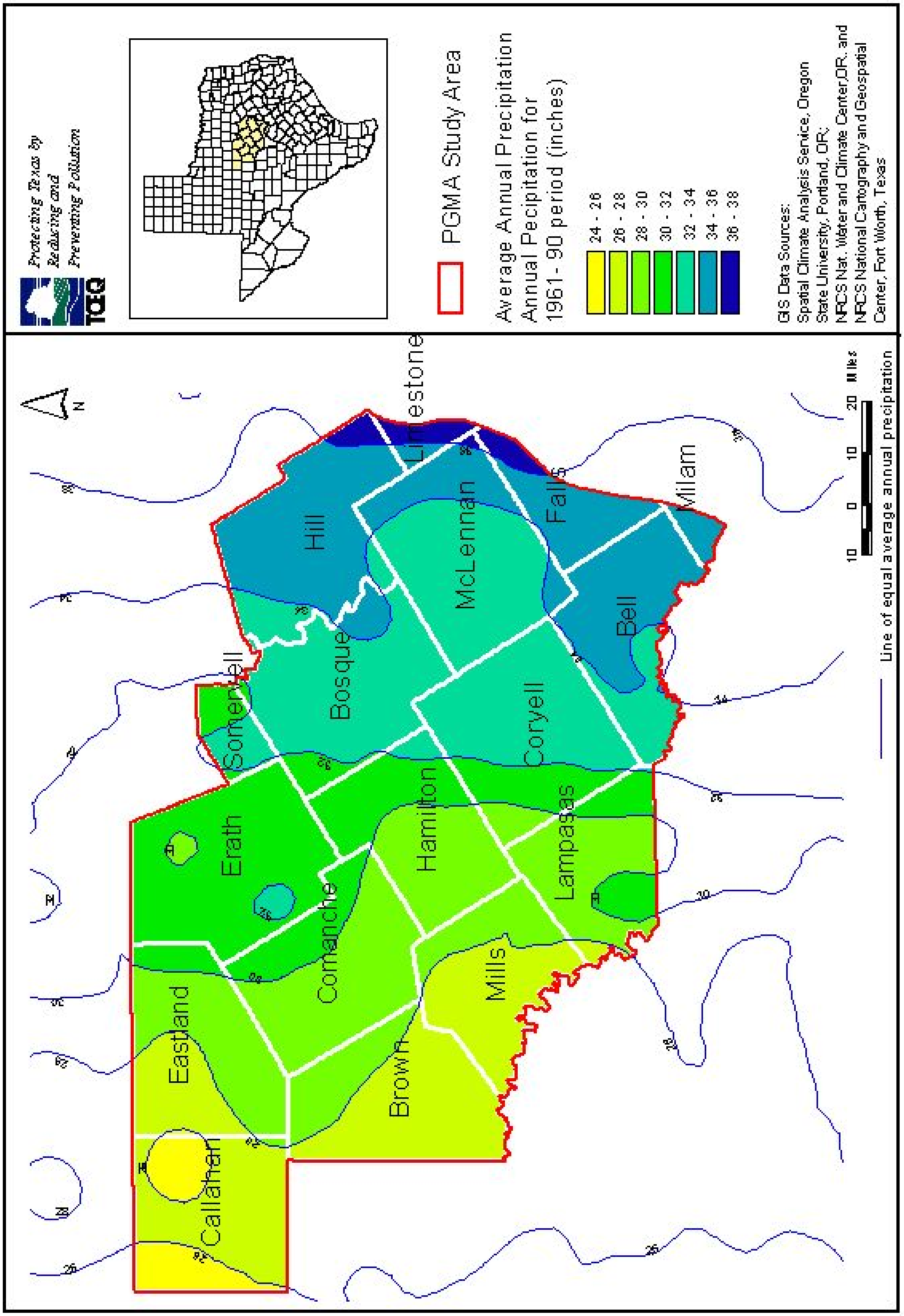


Figure 3. Average Annual Precipitation, Central Texas (Trinity Aquifer) PGMA Study.

Elevations range from about 2,100 feet along the Callahan divide in the western part of the area to about 300 feet along the Brazos River near the Falls-Milam County line. Drainage is to the southeast, mainly by the Brazos River and its tributaries. The major tributaries include the Bosque, Paluxy, and Leon rivers and their respective tributaries. A small portion of northeast Hill County is drained by tributaries of the Trinity River, and to the southwest, tributaries of the Colorado River drain portions of northeast Brown, Mills, and southern Callahan counties.

Physiography

The central Texas study area lies within four major physiographic provinces (Figure 4). These include, from east to west, the Gulf Coastal Plains, the Grand Prairie, the Edwards Plateau, and the North Central Plains. The Gulf Coastal Plains include the Blackland Prairies and the Eastern Cross Timbers sub provinces. The Blackland Prairies have a gentle undulating surface, where chalks and marls weather to deep, black, fertile clayey soils. The blacklands have been cleared of most natural vegetation and cultivated for crops. The Blackland Prairie is bounded on the west by sandstones, which form the Eastern Cross Timbers.

The eastern Grand Prairie is developed on limestones where weather and erosion have left thin rocky soils. Streams dissect land that is mostly flat or gently sloping southeastward. Silver bluestem and Texas wintergrass is the flora of this grassland. Primarily sandstones underlie the western margin of the Grand Prairie where post oak woods form the Western Cross Timbers sub province.

The Lampasas Cut Plain is the modified northern extension of the great Edwards Plateau Province. It is a greatly dissected dip plain, recognized by the general level of its many remnantal summits, which dominate the country between the Western Cross Timbers and the Balcones fault zone. The Edwards Limestone capped, flat-topped buttes form the divides between the drainage valleys composed of thick, rich, arable soils formed generally upon the Walnut Formation.

The Rolling Plains Subprovince of the North Central Plains, consists of an erosional surface that developed on upper Paleozoic formations. In areas of hard bedrock, hills and rolling plains dominate. Local areas of hard sandstones and limestones cap steep slopes which are severely dissected near rivers. Rocks and soils on the eastern portion weather tan to buff colored. Live oak/ashe juniper parks grade westward into mesquite/lotebush brush.

The Central Texas Uplift (Llano Uplift) borders the study area to the southwest. Minor aquifers are formed from the outwash of the weathered and eroded igneous and metamorphic rocks of the uplift area (Figure 8).

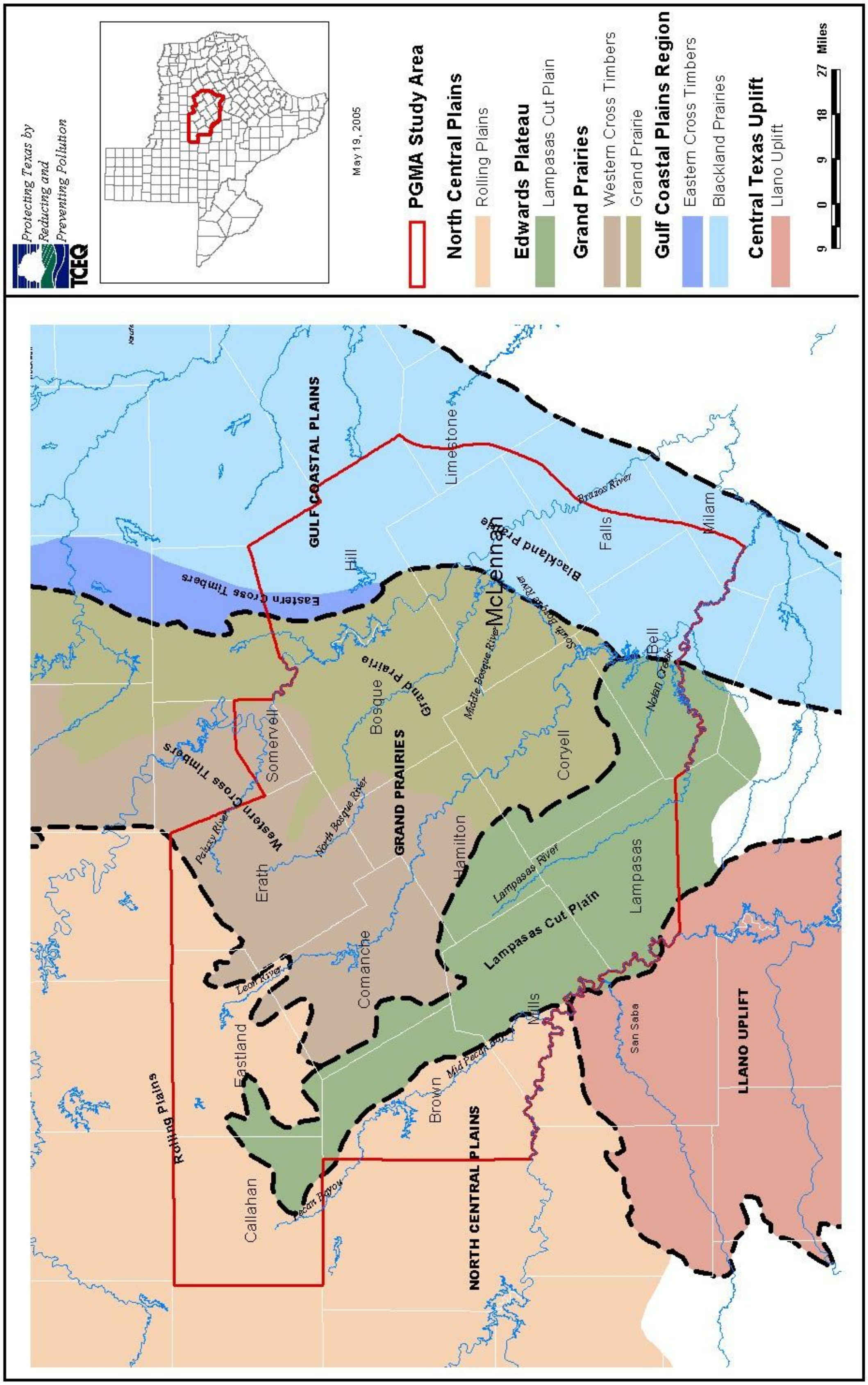


Figure 4. Physiographic Map, Central Texas (Trinity Aquifer) PGMA Study.

Geology and Groundwater Resources

Geologic formations underlying the study area range in age from Paleozoic rocks to Recent alluvium. The most important water-bearing units are Cretaceous age, specifically the Antlers, Travis Peak, and Paluxy formations, of the Trinity Group and the Woodbine Group.

The Cretaceous System is composed of two series, Gulf and Comanche, and each is divided into groups. The Gulf Series is divided into the following five groups: Navarro, Taylor, Austin, Eagle Ford, and Woodbine. The Comanche Series is divided into the following three groups: Washita, Fredericksburg, and Trinity. The Navarro, Taylor, Austin, ,and Eagle Ford groups consist predominantly of limestone, marl, and shale and yield only small amounts of water in localized areas. The Woodbine Group is the only important aquifer of the Gulf Series in the area covered by this report. It consists predominantly of sand and shale and is capable of yielding small to moderate amounts of water.

The Washita, Fredericksburg, and Trinity groups are the three major water-bearing units of the Comanche Series in the study region, and each of the three groups is divided into separate formations and members. The Washita Group is divided into the Buda, Del Rio, and Georgetown formations. The Buda and Del Rio are composed of limestone and shale, respectively, and neither is known to yield usable quality water in the region. The Georgetown Formation consists of limestone and usually yields small amounts of water.

Formations comprising the Fredericksburg Group are the Kiamichi, Edwards, Comanche Peak, and Walnut. The Kiamichi is composed of shale and is not known to yield water in the region. The Edwards is composed of limestone, often porous, and in some areas yields large amounts of good quality water. Comanche Peak and Walnut Formations consist of limestone and shale, and yield small amounts of water in some localized areas. The Edwards and Georgetown formations are hydrologically connected and are referred to as the Edwards and associated limestones.

The principal water-bearing group of rocks in the region is the Trinity Group (Figures 5, 6, and 7), which is divided into the Paluxy, Glen Rose, Travis Peak, and Antlers formations. The Paluxy formation consists of sand and shale and is capable of yielding small to moderate amounts of water. The Glen Rose is predominantly a limestone and yields only small amounts of water. The Travis Peak Formation is composed of limestone, sand, and shale. It is the principal water-bearing formation of Cretaceous age in the region and yields large amounts of good quality water. This Formation is divided into the following seven members: Hensell, Pearsall, Cow Creek, Hammett, Sligo, Sycamore, and Hosston. Northwest of where the Glen Rose pinches out in Brown and Eastland counties and the Paluxy and Travis Peak coalesce, these formations are collectively referred to as the Antlers Formation. Figure 5 shows the general relationships of these formations and their relative positions within the study area. The relationship, approximate maximum thickness, brief description of lithology, and summary of water-bearing properties of the stratigraphic units are shown in Appendix II. Areas of outcrop of the various formations are illustrated on Figure 6.

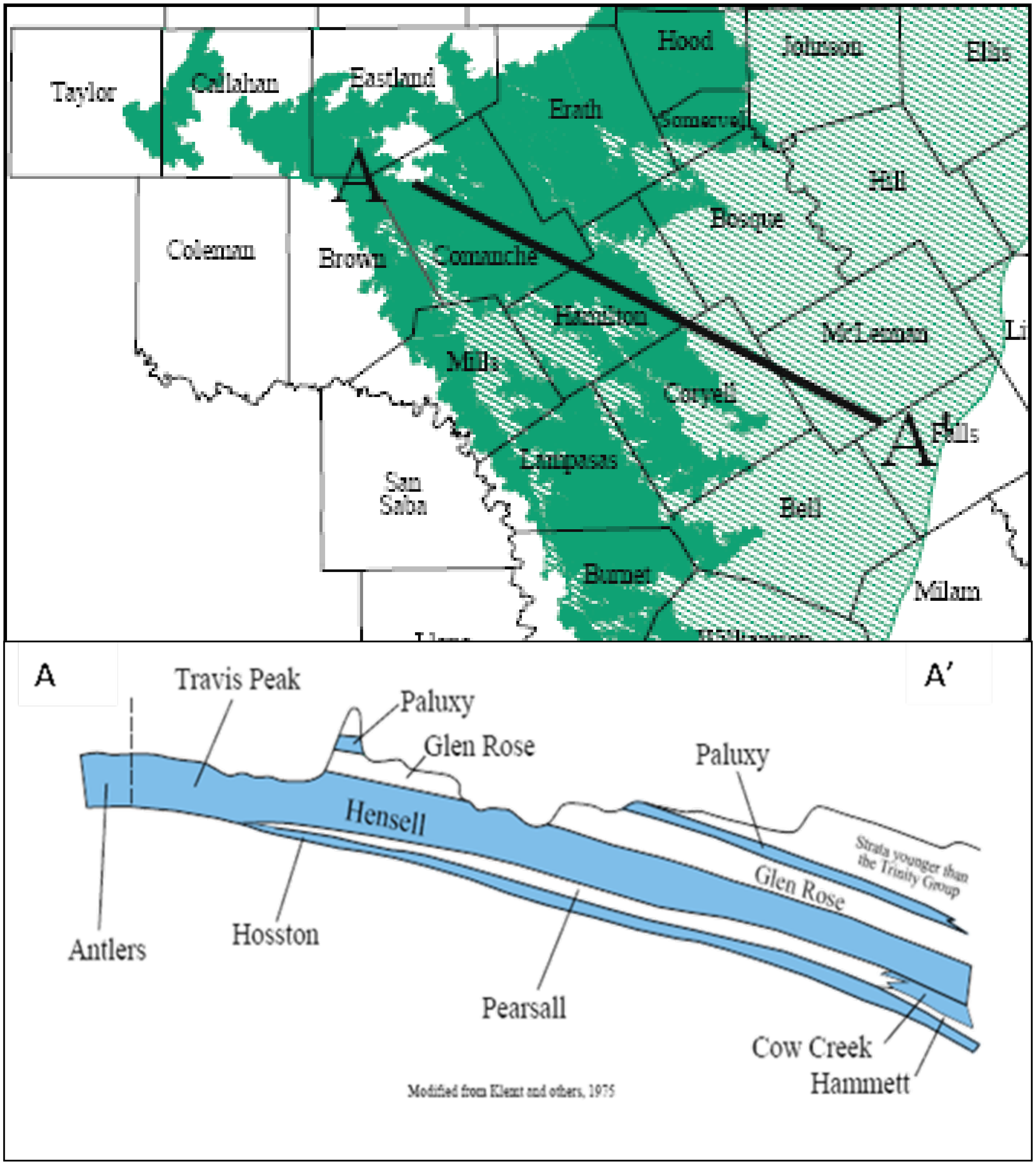


Figure 5. Generalized Cross Section,Trinity Group Aquifer in the Study Area.

Major Aquifers

Trinity Group Aquifer

The Trinity Group aquifer, the only major aquifer in the study area (Figure 7), consists of three hydrologic units. The lower Trinity unit contains the Hosston and Sligo members of the Travis Peak Formation. The middle Trinity hydrologic unit is composed of the Cow Creek limestone and Hensel sand members of the Travis Peak Formation and the lower member of the Glen Rose Formation. The upper Trinity hydrologic unit is composed of the upper member of the Glen Rose Formation and the Paluxy Formation (Figure 5).

The lower Trinity hydrologic unit consists of a lower calcareous conglomeritic section, a middle calcareous section, and an upper calcareous clastic section. Regionally, the lower unit of the Trinity Group aquifer dips east to southeast and ranges in thickness from 100 feet in the west to around 900 feet downdip. Between the lower Trinity hydrologic unit and the middle Trinity hydrologic unit, the Hammett shale member of the Travis Peak Formation acts as a confining bed. The Hammett shale is a fossiliferous, calcareous, and dolomitic shale interbedded with thin limestone and sand layers. The middle Trinity hydrologic unit consists of a lower calcareous section with intermittent gypsum or anhydrite beds, a middle calcareous conglomerate section, and an upper calcareous section. The upper Trinity hydrologic unit consists of the upper Glen Rose and the Paluxy formations. Stair-step topography typifies the upper Glen Rose Formation in outcrop due to erosional characteristics of the alternating marl and limestone beds. Gypsum and anhydrite beds, which are present in some areas, have often been dissolved leaving solution channels. The Paluxy Formation is composed predominantly of fine- to medium-grained sand with interbedded silty, calcareous, clay and shale.

Recharge to the Trinity Group aquifer is derived primarily from rainfall on the outcrop, underflow, vertical leakage, and seepage from lakes and streams. The Paluxy Formation, upper and lower members of the Glen Rose Formation and the Hensell Sand Member of the Travis Peak Formation crop out over the western portions of the study area; therefore, these units receive the maximum amount of recharge. The Hosston Member of the Travis Peak Formation probably receives very little recharge from rainfall because of its limited surface outcrop and the type of soils it produces.

Groundwater in the Trinity Group aquifer moves slowly downdip to the south and east-southeast. The direction of the groundwater movement is perpendicular to water level contour lines and toward lower elevations. A regional cone of depression exists in McLennan County, centered in the Waco metropolitan area. This appears to be the effect of localized cones of depression around the Waco area reported in Report 319 (Baker and others, 1990). Water levels show a general gradient of about 15 feet per mile from west to east across the study area. The steepest gradient of approximately 90 feet per mile occurs in McLennan County, along the southern edge of the cone of depression. Most of the discharge occurs from flowing wells and pumpage. Discharge from the middle and upper Trinity aquifers is from pumping and flowing wells and springs

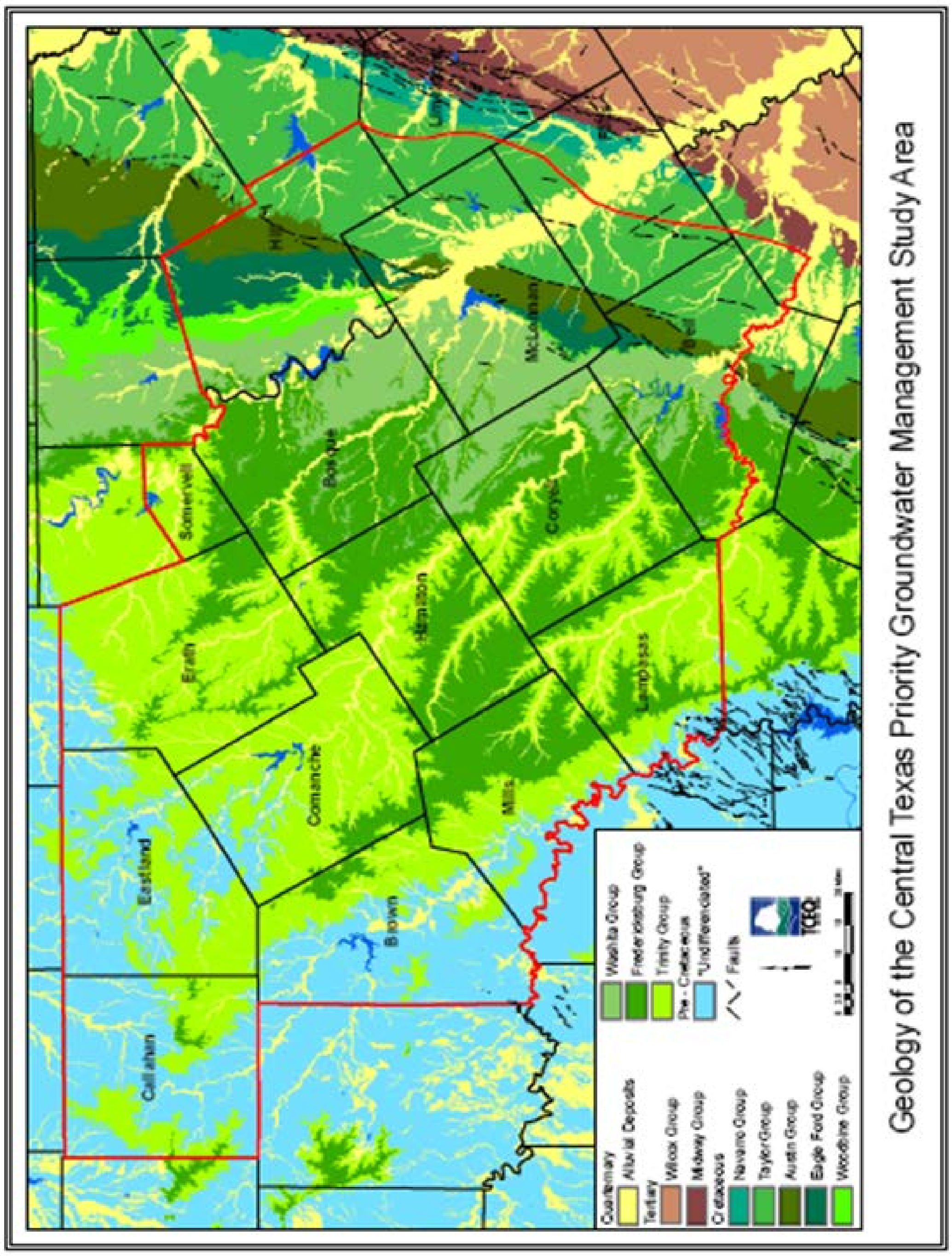


Figure 6. Geologic Map, Central Texas (Trinity Aquifer) PGMA Study.

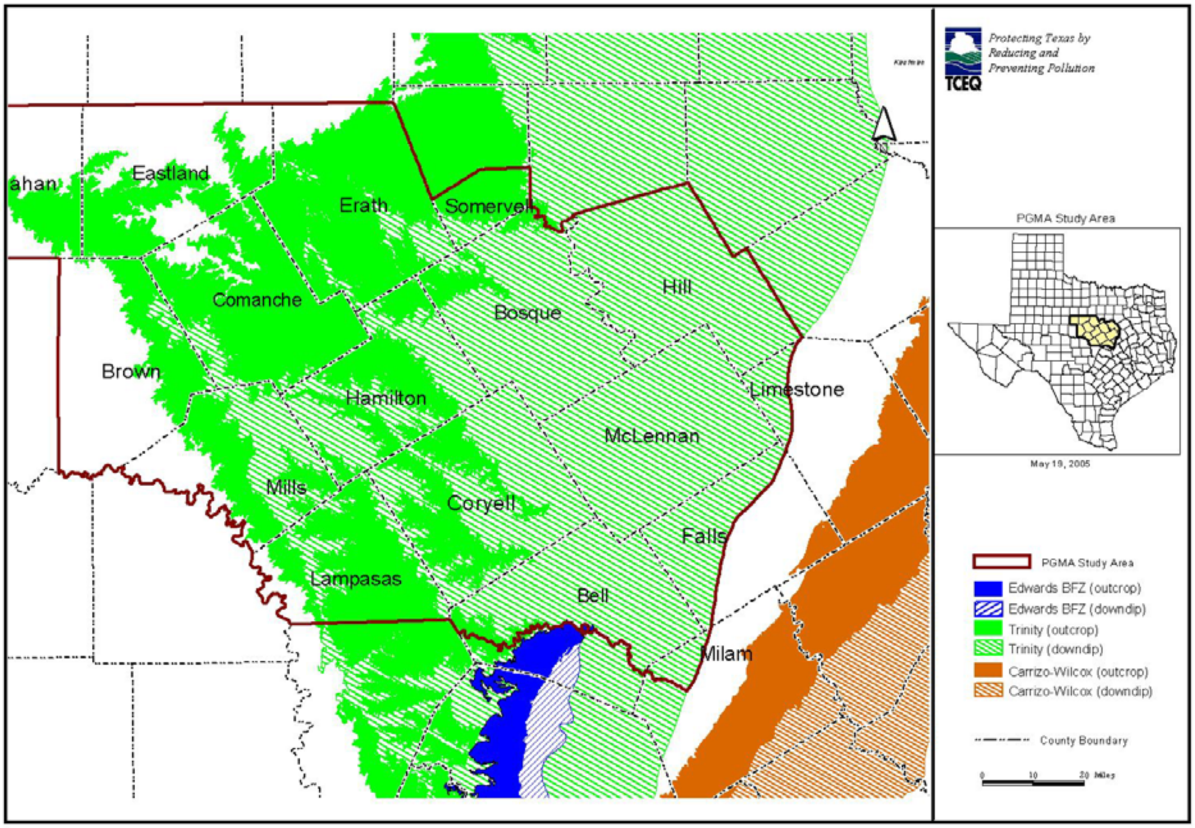


Figure 7. Major Aquifer Map, Central Texas (Trinity Aquifer) PGMA Study.

Minor Aquifers

Brazos River Alluvium

The Brazos River Alluvium aquifer occurs in parts of Hill, Bosque, McLennan, and Falls counties within the study area. It is limited to the valley area along the Brazos River (Figure 8). The alluvium forms the floodplain as a series of terraces contiguous to the river. Large amounts of water (250 to 500 gallons per minute) can be produced locally from this aquifer. The maximum saturated thickness of the alluvium is about 85 feet. Recharge occurs primarily by precipitation directly on the floodplain, groundwater discharge from adjacent aquifers, and return flow from irrigation water. Discharge occurs by seeps and springs along the Brazos River, evapotranspiration, and wells.

Woodbine Aquifer

The Woodbine Group exists as an aquifer only in the extreme northeast corner of the study area, with fresh to slightly saline water occurring only in Hill County. Recharge to the Woodbine occurs in the outcrop, which consists of a permeable, sandy soil conducive to infiltration of rainfall and seepage

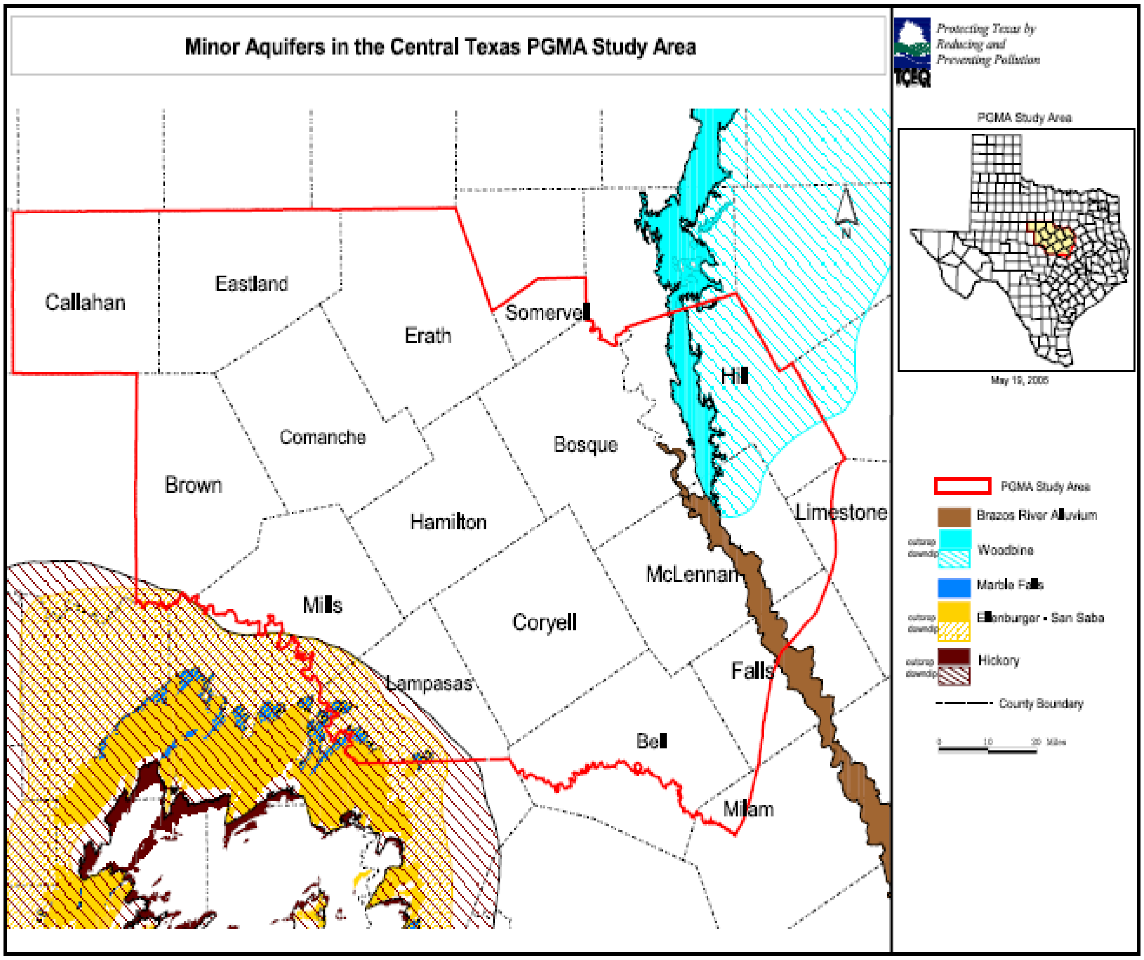


Figure 8. Minor Aquifer Map, Central Texas (Trinity Aquifer) PGMA Study.

from streams. From the outcrop the water-bearing sands dip eastward beneath younger strata. Water occurs in saturated sand beds under both water table and artesian conditions. The upper part of the Woodbine has distinctly poorer water quality. Total formation thickness ranges up to slightly over 200 feet and sand thickness in the study area up to 100 feet.

Other Minor Aquifers

Other aquifers, which produce small to moderate amounts of groundwater in the study area, are the Marble Falls, Ellenburger–San Saba, and Hickory (Figure 8). The Marble Falls Limestone aquifer is exposed along the northern and eastern flanks of the Llano Uplift in Lampasas County. This aquifer reaches a maximum thickness of 600 feet, with groundwater occurring in cavities and fractures in the Pennsylvanian-aged limestone (Muller and Price, 1979). The majority of the aquifer recharge is probably derived from inflow along cavities and fractures from the underlying strata (Brune, 1975), and infiltration of precipitation on the outcrop. Discharge occurs from large springs issuing from the limestone (Brune, 1975).

The Ellenburger Group (Cambrian and Ordovician age) and the San Saba Member of the Wilberns Formation (Cambrian age) are composed of marine limestones and dolomites. The Ellenburger Group and the San-Saba Member are considered as one aquifer due to their hydrologic interconnection and the difficulty in distinguishing the two stratigraphic units in the subsurface (Walker, 1979). The Ellenburger-San Saba aquifer crops out in a circular shape, which surrounds the Llano Uplift in Lampasas County and dips into the subsurface away from the Uplift in Brown, Lampasas, and Mills counties (TWC, 1989). The aquifer yields small to moderate supplies of water, is highly faulted in the surface and subsurface, and was eroded prior to being covered by Cretaceous sediments, causing a large variation in aquifer thickness (Walker, 1979).

The Hickory Sandstone aquifer crops out and dips into the subsurface in a radial pattern around the Llano Uplift. There are no outcrops of the Hickory Sandstone in the study area, however the formation is found in the subsurface in Brown, Lampasas, and Mills counties. The aquifer is principally composed of sand and sandstone of the Hickory Sandstone Member of the Riley Formation, Cambrian age (Muller and Price, 1979) and is the oldest aquifer in the study area. Extensively faulted in the outcrop and subsurface, the aquifer strata dip steeply away from the Llano Uplift. The Hickory was deposited upon an unevenly eroded metamorphic and igneous rock surface with a topographic relief in excess of 300 feet, which resulted in a wide variability in the accumulated thickness (Walker 1979; Black, 1988).

Other Groundwater Sources

The study area also gets groundwater supplies from minor widely scattered sources. Austin, Taylor, and Navarro groups produce small to moderate amounts of groundwater in the study area (Duffin and Musick, 1991).

In the Austin Chalk, groundwater usually occurs in the upper, weathered outcrop portion of the unit, which is the most permeable. The unit contains numerous fractures and joints throughout. It consists of a light gray chalk, limy marl, and chalky limestone. It has an extensive outcrop across Texas from northeast to southeast along the eastern portion of the study area. Water can also be present in the softer marls, which occur throughout the unit. Groundwater occurs primarily under water-table conditions in the unit.

In the Navarro and Taylor Groups, groundwater usually occurs in the upper, weathered outcrop portion, which is the most permeable. Groundwater occurs primarily under water-table conditions. Lithologically, the Taylor Group and overlying Navarro Group are very similar and are treated as a single hydrologic unit. They consist of massive beds of shale, siltstone, marl, and chalk with minor amounts of sand and clay. The unit is found east of the Balcones Fault Zone in Hill, McLennan, Falls, and Bell counties.

Surface Water Resources

Stream flow in the Brazos and Colorado Rivers and their tributaries, along with reservoirs in the Brazos and Colorado River Basins, comprise a vast supply of surface water in the study area. Diversions and use of this surface water occur throughout the entire area. Water rights provide authorization for an owner to divert, store, and use the water, however, they do not guarantee that a dependable supply will be available from the water source. Availability of water to a water right is dependent on several factors including hydrologic conditions (i.e., rainfall, runoff, spring flow), priority date of the water right, quality of authorized storage, and any special conditions associated with the water right (i.e., in stream flow conditions or maximum diversion rate). A summary of major water rights in the study area is presented in Table 1. Major water rights are defined as having an authorized diversion of greater than 10,000 acre feet/year (acft/yr) or 5,000 acre feet (acft) of authorized storage.

The study area contains parts of three river basins. The majority of the area is within the Brazos River Basin with a small portion of the Trinity River Basin in Hill County and a strip of the Colorado River Basin paralleling Pecan Bayou in Callahan, Brown, and Mills counties and the western part of Lampasas County. Eleven major reservoirs with an authorized storage capacity of 28,000 acft or more each are located within the study area (Figure 9). The only reservoir not located in the Brazos River drainage basin is Lake Brownwood, which is in the Colorado River drainage basin. The U.S. Army Corps of Engineers (USCOE) owns several of these reservoirs in the study area, including Lake Aquilla, Lake Proctor, Lake Somerville, Lake Belton, Lake Stillhouse Hollow, and Lake Whitney.

Table 1. Major Reservoirs, Central Texas (Trinity Aquifer) PGMA Study.

Reservoir	Stream (Basin)	County	Authorized Storage (acft)	Authorized Diversion (acft)	Water Right Owner
Aquilla	Aquilla Creek (Brazos)	Hill	52,400	13,896	Brazos River Authority
Belton	Leon River (Brazos)	Bell	469,600	112,257	Brazos River Authority
Brownwood	Pecan Bayou (Colorado)	Brown	131,430	67,390	Brown County WID
Cisco	Sandy Creek (Brazos)	Eastland	45,000	2,027	City of Cisco
Leon	Leon River (Brazos)	Eastland	28,000	6,300	Eastland County WSD
Proctor	Leon River (Brazos)	Comanche	59,400	19,658	Brazos River Authority
Squaw Creek	Squaw Creek (Brazos)	Somervell	151,500	20,780	Texas Utilities Elec Co.
Stillhouse Hollow	Lampasas River (Brazos)	Bell	235,700	67,768	Brazos River Authority
Tradinghouse	Tradinghouse Creek (Brazos)	McLennan	37,800	27,000	Texas Utilities Elec Co.
Waco	Bosque River (Brazos)	McLennan	192,062	79,870	City of Waco and BRA
Whitney	Bosque River (Brazos)	Hill	50,000	18,336	Brazos River Authority
TOTAL			1,452,892	435,282	

These reservoirs were built for the primary purpose of flood control; however, they also incorporate other benefits such as water supply. For purposes of water supply, the USCOE has contracted conservation storage in each reservoir to the Brazos River Authority (BRA). The BRA owns the water right permit for each reservoir and manages the water supply conservation storage in each reservoir. Other major reservoirs in the study area that provide municipal, industrial, and irrigation water supply are owned by the BRA, the City of Waco, Brown County Water Improvement District (WID) No. 1, and the City of Cisco, These reservoirs are listed in Table 1 along with their stream (basin), county location, storage capacity, authorized diversion amount, and water right owner. After 1992, the Lower Colorado River Authority (LCRA) began providing surface water to Brown County and to that part of Callahan County that is in the Colorado River Basin. The BRA and LCRA 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 (Brazos G Water Plan). There are no proposed major sites for man-made reservoirs in the study area, however there is a reservoir planned southeast of the study area in Milam County, Little River Reservoir. There are five minor reservoirs recommenced in the Lower Colorado Region K and the Brazos G Regional Plans for the study area. Three are proposed for Mills County (Goldthwaite Off-Channel, Goldthwaite On-Channel, and Mills County); one in Somervell County (Somervell County); and one in Bosque County (Meridian).

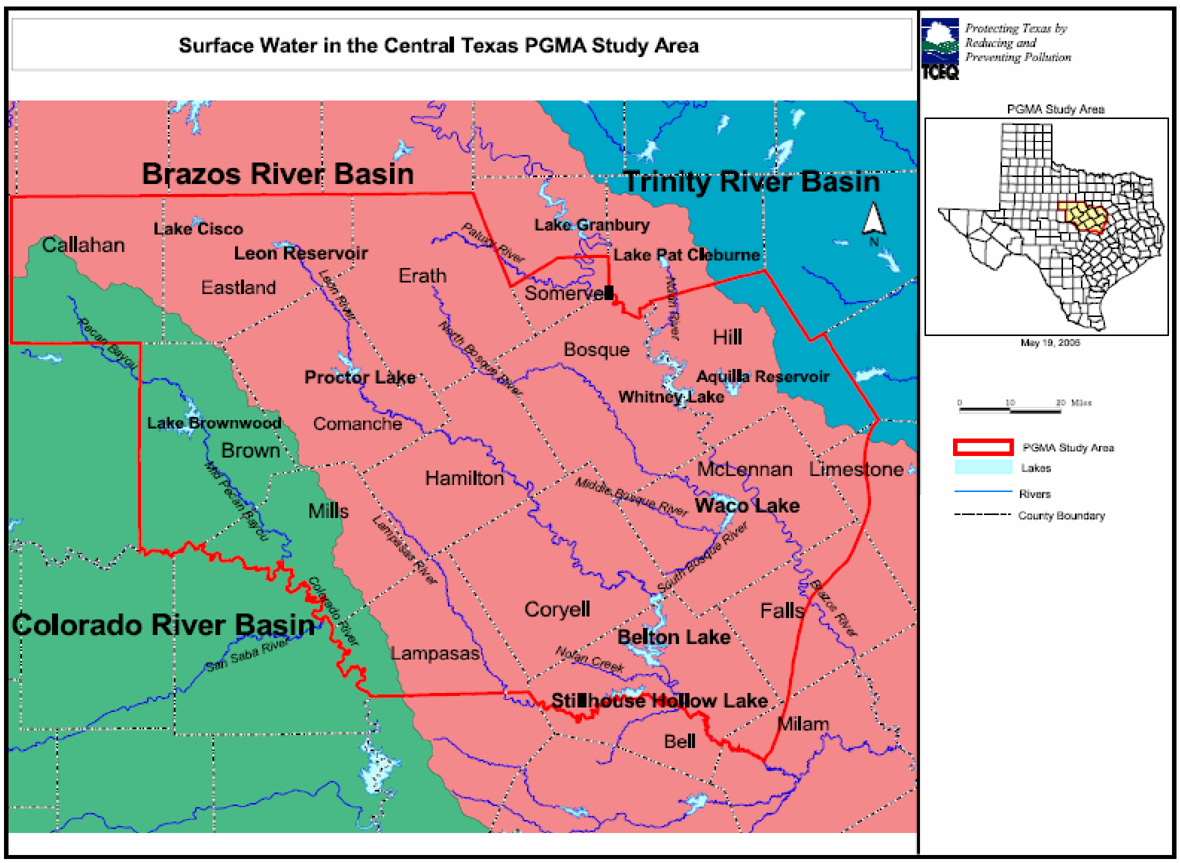


Figure 9. Surface Water Map, Central Texas (Trinity Aquifer) PGMA Study.

STAKEHOLDER RESPONSE

Opportunity for public participation in the PGMA study process was expanded by new requirements in Senate Bill 1 (75th Legislative Session, 1997). A brief description of the stakeholder's role in the PGMA process and a summary of comments received from stakeholders in the study area are presented below.

Stakeholder Notification

Senate Bill 1 (75th Legislative Session, 1997) provides stakeholders an opportunity to participate in the preparation of the TCEQ Executive Director's PGMA report. Accordingly, before initiating a PGMA study, the TCEQ is now required by statute (Section 35.007), Texas Water Code) to provide notice of the proposed study to stakeholders in the study area. By statute, stakeholders include the governing bodies of all counties, municipalities, and regional water planning groups within the study area. Also included are river authorities, irrigation districts, water districts, adjacent groundwater conservation districts, and other entities that supply public drinking water. Statute requires the Executive Director to evaluate and consider all relevant information submitted by the stakeholders in the preparation of the report.

Stakeholder Comments

In accordance with the criteria established in Chapter 35, Texas Water Code, notice for the Central Texas (Trinity Aquifer) Area PGMA study was sent to approximately 532 stakeholders in the study area on October 18, 2004. The purpose of the notice was to solicit comments, data, reports of existing studies, or any other pertinent information on the area's water supply, groundwater availability, aquifer water-level trends, and groundwater quality. The general categories of stakeholder interests to whom the notice was sent included area legislators, planning entities, county officials, municipalities, river authorities, groundwater conservation districts, water districts, entities supplying public drinking water, agricultural interest groups, selected federal and state agencies, and environmental interest groups. Stakeholder comments about the condition of study area water supplies and actions to meet future demands are summarized here.

Seven comments were received by the TCEQ in response to the October 18, 2004 notice. The respondents included TXU Power, Hamilton County, the Sierra Club, the Clearwater UWCD, Middle Trinity GCD, the Coryell County Clerk, and the City of Copperas Cove. Their responses are summarized below.

TXU Power

TXU Power response to the stakeholder notice included a table listing the power generation facilities located within the study area that use groundwater. There are three facilities, two in McLennan County, and one in Somervell County. The two in McLennan County have two water wells each and the one in Somervell County has five water wells. In addition, TXU Power has transmission and distribution facilities within the study area. These facilities could potentially affect groundwater due to the oil containing equipment necessary for their operations. Therefore, TXU is interested in the evaluation of regional water resource issues and has requested that information developed by the study be provided for their review and comment.

Hamilton County

A response from the Hamilton County Judge, Fred Cox, indicated that Hamilton County has no current groundwater or surface water shortages and none projected in the nest 25 years. Judge Cox further stated that even if the population of Hico and the rural population of Hamilton County doubled there would still likely be a groundwater surplus. According to local water well drillers, the vast majority of water wells drilled since 2001 in Hamilton County is replacement wells, which indicates there has been no significant increase in groundwater usage. A Hamilton County Commissioners Court Resolution requested that TCEQ "...recognize in its proposed study the uniqueness of Hamilton County (there are no indications that Hamilton County now has or will have groundwater problems within the next 25 years) and to set apart and remove Hamilton County from the Central Texas-Trinity Aquifer PGMA Study Area."

Sierra Club

The Sierra Club voiced concerns regarding increased pressure on the groundwater resource in the area both from the standpoint of quantity and quality. The large number of Concentrated Animal Feeding Operations (CAFOs) located in the study area may have an impact on groundwater samples exceeding the Maximum Concentration Levels (MCL) for Nitrate-N. The impact these CAFOs are already having on surface water could also affect the conversions from groundwater to surface water that are proposed for the area. Also of note are the naturally occurring saline groundwater problems in the western portion of the study area. Without adequate groundwater management, there is a potential for saline waters in the aquifer to contaminate fresh water. The Sierra Club also suggested that projected growth throughout the I-35 corridor will likely exert pressure to continue use of the Trinity/Woodbine aquifers at existing, or possibly greater, levels in the future. They support the designation of the area as a PGMA.

Clearwater Underground Water Conservation District

The Clearwater UWCD did not comment directly on the GCD creation issue. However, they did comment that recent studies indicate that the general direction of groundwater flow in the Trinity aquifer is from the northwest to the southeast, or from Coryell County into Bell County. Recharge of the Trinity aquifer may be limited in Bell County, and use of the Trinity aquifer is increasing. The district is concerned about the impact that groundwater use in counties to the northwest may have on Bell County, since many of these counties do not have a groundwater conservation district to manage these resources. The Clearwater UWCD commented that the effectiveness of their groundwater management measures might be lessened if surrounding areas are not likewise managing their groundwater, especially when existing users depend upon some of this water entering Bell County. Unregulated pumping of the Trinity aquifer in surrounding counties could have an impact on the availability of groundwater in Bell County.

Respondents with No Direct Comment

The Middle Trinity GCD, Coryell County Clerk, and City of Copperas Cove did not provide direct comment regarding their positions or preferences about groundwater supply and quality issues or GCD creation.

NATURAL RESOURCES

At the request of the TCEQ, an evaluation of selected natural resources in the study area was conducted by the Texas Parks and Wildlife Department (TPWD) in 1998. Most information presented in this section was obtained from TPWD's 1999 report prepared by El-Hage and Moulton (1999). The remaining information has been obtained from the Region F, Brazos G, and Lower Colorado Region K Regional Water Plans.

Texas Parks and Wildlife Department Regional Facilities

Within the study area, TPWD operates six state parks (SP). Dinosaur Valley SP, Lake Brownwood State Recreation Area (SRA), Lake Whitney SRA, Meridian SP, Mother Neff SP, and a small section of Colorado Bend SP (Figure 1). Dinosaur Valley SP is a 1,524.72-acre park in Somervell County. The park is on the Paluxy River with flora characteristic of the Cross Timbers and Prairie vegetation areas. Lake Brownwood SRA is a 537.5-acre park located in Brown County on the edge of a 7,300 surface-acre reservoir. The reservoir was constructed by the damming of Pecan Bayou, a tributary to the Colorado River. Lake Whitney SRA is a 1,280.7-acre park located on the east shore of Lake Whitney in Hill County. The lake, located in the Grand Prairie subregion of the Blackland Prairie natural region, was constructed by the damming of the Brazos River. Meridian SP is a 505.4-acre park in central Bosque County that contains 72-acre Lake Meridian, created by the damming of Bee Creek. Mother Neff SP contains 259 acres, the first dedicated state park in Texas, is located on the Leon River in eastern Coryell County. The only water related activity is fishing from the riverbank of the Leon River. Colorado Bend SP has 5,328.3 acres, but only a small section of it on the east side of the Colorado River is within the study area. Around 155 species of birds can be found in the park at different times. White bass from Lake Buchanan use the river upstream from the lake for spawning.

Rivers, Wetlands, Springs, and Fishes

Two major rivers cross the study area (Figure 9). The Brazos River is located on the east side and the Colorado River on the west side. Two major tributaries to the Brazos River are the Paluxy and the Bosque rivers. The Paluxy River, from its confluence with the Brazos River to 40 miles upstream, supports a striped bass (Morone saxatilis) spawning run. In addition, Dinosaur Valley SP, a national natural landmark and unique state holding, is on the Paluxy River. The Colorado River, between Colorado Bend State Park and Lake Buchanan, supports a white bass (Morone chrysops) spawning run and serves as a TPWD collection area (Bauer et al. 1991). The rivers and streams within the study area have a variety of fish species common to the Brazos and Colorado River drainages.

The U.S. Army Corps of Engineers defines wetlands as areas that, due to a combination of hydrologic and soil conditions, are capable of supporting hydrophytic vegetation. In the study area, wetlands are found primarily in narrow strips along rivers and streams. Wetlands are especially valued as natural resources, 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, sites for educational research, sites of historic and archaeological importance, and locations for conveying floodwaters. Wetlands provide high-quality habitats for wildlife, including foraging, nesting for birds and spawning/nursery areas for fish.

The study area rivers and streams contain a variety of native and introduced fish species. Water quality and habitat in the Bosque River drainage are adequate to support a diverse and healthy fish community. The Bosque River supports a significant recreational fishery. Spawning runs of white bass occur in the North Bosque River upstream of Lake Waco.

There are records of springs for all counties in the study area except for Erath and Hamilton counties (Heitmuller and Reece, 2003). There have been springs in the past that are now dry or are inundated. Springs in the study area emanate from the Cretaceous Trinity formations, Cretaceous Edwards and associated limestones, upper Cretaceous Austin Chalk, and Quaternary river terrace sand and gravel. The spring waters are chiefly of the calcium bicarbonate type, very hard, fresh and alkaline (Brune, 1981). As of 1980, according to Brune, the groundwater table had not been severely affected by man's activities, except in areas of heavy pumpage. The implementation of a PGMA in this region could prevent the lowering of groundwater tables through groundwater management. Most springs emanate from the top of the groundwater reservoir, so changes in the water table elevation generally have immediate impact upon spring discharge rates (El-Hage and Moulton, 1998).

Two area fish species reported on the Special Species List in Appendix III (Table III.1, Wildlife Diversity Program 1998) are the Guadalupe bass and the smalleye shiner. The Guadalupe bass is endemic to the streams of the northern and eastern Edwards Plateau including portions of the Brazos, Colorado, Guadalupe, and San Antonio river basins. It is also found in small numbers in the lower Colorado River. The Guadalupe bass is the official state fish of Texas. The smalleye shiner is endemic to the middle and upper Brazos River drainage. At Present, TPWD does not have any extensive information on the fish species living in other streams within the study area (El-Hage and Moulton, 1999).

Birds and Waterfowl

Many species of neotropical songbirds and wintering shorebirds stopover to feed and rest along the riverbanks and creek bottoms of the area. The trees and shrubs that grow along the rivers, streams, and lakes are of importance to nesting songbirds and raptors, such as the black-capped vireo and the zone-tailed hawk.

The county Special Species List for the study area includes 12 birds. Several of the birds listed in Table III.1 occur in the study area only as migrants (peregrine falcon and whooping crane). Migrating peregrines use wetlands because they prey mostly on ducks and shorebirds. Migrating whooping cranes would also use wetlands for feeding and roosting. The golden-cheeked warbler and black-capped vireo are upland nesters on the Edwards Plateau and are found in most of the study area.

Mammals, Amphibians, and Reptiles

There are at least 48 species of mammals, reptiles, and amphibians that are aquatic, semi-aquatic, or in some way wetland-dependent present in the study area (El-Hage and Moulton, 1999). There are no riparian or water dependent mammals on the Special species List. The Salado Springs salamander is listed on the Special Species List. Two reptiles are listed in the Special Species List (Table III.1), the Brazos water snake and the Texas garter snake.

In the study area, most of the snakes, lizards, and turtles are restricted to riparian habitat adjacent to the local rivers, springs, ponds, and wetlands. A good example is the Texas garter snake, which is usually found in riparian meadowland and juniper-wooded canyons along the eastern edge of the Edwards Plateau.

According to state law, a Regional Water Planning Group (RWPG) may recommend legislative designation of river or stream segments within the region as ecologically unique. The criteria that are to be applied in the evaluation of potential ecologically unique river or stream segments are:

- Biological Function
    - Quantity (acreage or areal extent of habitat)
    - Quality (biodiversity, age, uniqueness)
- Hydrologic Function
    - Water Quality
    - Flood Attenuation and Flow Stabilization
    - • Groundwater Recharge and Discharge
- Occurrence of Riparian Conservation Areas
- Occurrence of High Water Quality, Exceptional Aquatic Life or High Aesthetic Value
- Occurrence of Threatened or Endangered Species and/or Unique Communities

In 2000, Hicks & Company prepared a report for the Brazos G RWPG identifying 19 stream segments within the Brazos G Area meeting one or more of the criteria.. The Hicks analysis identified 11 segments that had already been identified by the Texas Parks and Wildlife Department in 2000, plus an additional eight segments. Table 2 lists those stream segments identified in the Hicks & Company report and by TPWD as candidates for designation that are located in the study area. The 2006 Brazos G Regional Water Plan states that the Brazos G RWPG has chosen not to designate any stream segments as having unique ecological value (HDR Engineering, Inc., 2006).

Table 2. Stream Segments in the Central Texas (Trinity Aquifer) PGMA Study Area Identified as Candidates for Designation as Unique Stream Segments.

Candidate Stream Segment	Source of Original Identification	Year Identified
Brazos River – Bosque & Somervell Counties	TPWD	2000
Colony Creek – Eastland County	TPWD	2000
Colorado River – Lampasas County	TPWD	2000
Cow Bayou – Falls & McLennan Counties	TPWD	2000
Lampasas River – Lampasas & Hamilton Counties	Hicks & Company	2000
Leon River – Coryell & Bell Counties	Hicks & Company	2000
Little River – Milam & Bell Counties	TPWD	2000
Neils Creek – Bosque County	TPWD	2000
Nolan River –Hill Counties	Hicks & Company	2000
North Bosque River – McLennan County	Hicks & Company	2000
Paluxy River – Somervell & Erath Counties	TPWD	2000
Steele Creek – Bosque County	TPWD	2000

Conclusions

While few species are directly dependent upon the groundwater resources of the study area, the springs that emanate from the groundwater reserves contribute to the surface water hydrology and have helped to shape the ecosystems that exist. Reduced spring flow can result from over pumping of the aquifers of the area, which can subsequently affect surface water flows. Long-term decreases in flow can exacerbate water quality problems and affect the species that are directly and indirectly dependent upon freshwater resources. In addition, human uses can be affected due to diminished recreational opportunities, increased levels of required water treatment, and decreased quantities of usable quality water. Reduced groundwater reserves and quality also has economic consequences.

There is a trend to less dependence upon groundwater from the confined portion of the Trinity Group aquifer, and more dependence upon surface water. However, surface water projects can have significant effects upon the natural resources of an area. For example, the proposed Paluxy Reservoir would have been approximately two miles upstream from Dinosaur Valley SP, a national natural landmark. The water rights permit application for this project was recently denied by TCEQ. Operation of the reservoir could have been potentially damaging to the dinosaur tracks in the Paluxy River streambed that require certain maintenance flows. The reservoir also would have inundated up to 3,848 acres including an estimated 566 acres of mixed riparian forest. In addition, the project would have reduced flows to downstream white bass spawning areas. Spotted bass and shad fisheries would have also been impacted. In addition, reduced base flows will influence aquatic habitats all the way to, and including, the Gulf of Mexico bays and estuaries.

El-Hage and Moulton (1999) suggested that declaration of the study area as a PGMA could lead to a more efficient use of the existing water resources in the area. It could also help protect the groundwater and surface-water quality of the region. At present, the unconfined portion of the Trinity Group aquifer is subject to contamination by oil and gas operations and confined livestock feeding operations. Surface resources are equally imperiled. For example, elevated fecal coliform levels occur in the Leon River downstream from Lake Proctor and in the North Bosque River. Elevated nutrient concentrations from several sources contribute to excessive planktonic and attached algal growth in the Bosque River.

Protecting the quality and quantity of the groundwater and surface water of the study area is an important goal. The implementation of protection and management strategies will ultimately safeguard other natural resources in the area that are influenced by groundwater, either directly or indirectly.

WATER USE, DEMAND, SUPPLY AND AVAILABILITY

Evaluations of historic water usage, population and water demand projections, current water supplies, and water availability are provided in this section. The evaluated data come predominantly from the 2002 State Water Plan, *Water for Texas −2002* (TWDB, 2002). Data from the Regions F, G, and Lower Colorado Region K 2006 Regional Water Plans have also been used. If not discussed here, the methodologies for development of the evaluated data may be referenced in the state and regional water plans.

The following definitions are offered for the convenience of the reader:

- **Water use** is defined as the quantity of raw water supplied to or pumped to an individual water user. This information is reported for municipal, manufacturing, irrigation, livestock, steam electric power generation, and mining uses.
- **Water demand** is the quantity of water projected to meet the overall necessities of a particular water user group in a specific future year.
- **Water supply** is the maximum amount of water obtainable from existing sources for use during drought of record conditions that is physically and legally accessible for use.
- **Water availability** is the maximum amount of water existing during the drought of record, regardless of whether the supply is physically or legally obtainable for use.

Water supplies from existing sources are the amounts of water that can be used if water rights, water quality, infrastructure limitation, and contract restrictions are taken into account. The total amount of water available for use, or water availability, is the amount of water that could be used if the infrastructure were built to transport that water to users. Groundwater availability represents the total amount of water available for use from an aquifer under a development scenario selected by a regional planning group. Most of the planning groups estimate groundwater availability using either recharge or systematic depletion. Groundwater supplies represent the amount of water that can be accessed with existing infrastructure, such as wells and pipelines. Surface water supplies represent the amount of water that can currently be used from rivers and reservoirs. A reservoir may have much more water available than can be currently used because of limited infrastructure (Table 1).

Historic Water Use

Water needs throughout the study area are primarily met with surface water (Table 3). However, almost constant quantities of groundwater are being used. There are several counties in the study area that used over 10,000 acft/year of groundwater from 1974 to 2000 (Table 4). Comanche County used 33,533 acft of groundwater in 1992 and decreased to 15,349 acft in 2000. Erath County shows the largest use of groundwater in 2000, using 13,544 acft in 1974, increasing to 23,008 acft in 1993, and dropping down to 19,182 acft in 2000. Bosque and Callahan counties used almost constant amounts of groundwater from 1974 to 2000, averaging about 3,700 and 1,569, respectively. In 1974, groundwater accounted for 30 percent of all water used in the study area. In 2000, groundwater accounted for about 22 percent (90,320 acft), and surface water accounted for 78 percent (325,113 acft) of water used in the study area. Surface water use essentially doubled over the same period.

Data from the 2006 Regional Water Plans were used for the following information. In 1974, the amount of water used for irrigation and municipal needs was almost the same, 91,636 acft and 96,303 acft, respectively. By the year 2000, irrigation dropped to 87,131 acft and municipal use increased to 146,384 acft. The production of power was the second largest consumer of water using 141,493 acft

Table 3. Historic Water Use, Central Texas (Trinity Aquifer) PGMA Study.

County	Year											
	1980	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Bell	31,507	35,866	31,598	34,676	36,813	37,368	38,235	43,202	41,540	42,791	46,131	49,886
Bosque	4,893	5,403	6,113	5,388	6,426	6,560	6,119	6,964	8,149	9,469	7,371	7,808
Brown	19,123	11,053	10,923	10,949	20,722	21,320	24,350	23,121	23,456	27,286	26,161	21,375
Callahan	3,608	3,396	3,488	4,012	3,728	3,802	3,702	4,100	3,520	4,196	3,104	3,378
Comanche	31,034	54,850	50,709	58,400	53,960	50,486	50,070	35,759	32,258	36,177	33,497	42,113
Coryell	11,898	11,202	10,472	11,761	12,747	13,335	13,211	15,114	12,591	13,606	14,084	18,044
Eastland	19,781	16,491	17,631	20,069	9,466	17,409	16,358	13,740	11,109	11,784	7,002	20,512
Erath	21,190	19,902	19,312	19,989	32,043	28,559	29,157	30,486	24,454	23,538	25,059	24,991
Falls	10,103	10,966	6,574	6,011	6,695	10,318	10,494	8,833	9,046	9,417	7,814	7,585
Hamilton	4,090	4,476	4,602	4,762	4,508	4,342	4,422	5,127	4,492	4,602	4,832	3,818
Hill	5,648	5,286	5,223	5,272	6,512	6,613	6,684	7,639	7,081	7,442	7,664	6,553
Lampasas	3,983	3,350	3,411	3,961	3,818	4,093	4,029	4,140	4,312	4,449	3,857	5,557
Limestone	4,800	9,766	22,966	24,293	25,403	26,795	24,113	22,866	24,384	23,521	23,397	27,494
McLennan	70,528	58,934	54,233	60,833	66,203	65,626	58,105	60,331	58,830	57,937	40,371	74,850
Mills	5,192	4,430	4,340	3,996	5,026	4,358	4,384	6,486	4,355	4,706	4,391	4,913
Somervell	1,578	11,424	6,328	6,541	9,701	6,690	5,832	8,147	5,597	6,072	6,106	20,101
Region Total	**248,956**	**266,795**	**257,923**	**280,913**	**303,771**	**307,674**	**299,265**	**296,055**	**275,174**	**286,993**	**260,841**	**338,978**

Source: 2006 Regional Water Plans from Region, F, Brazos G, and Lower Colorado Region K.

in 2000. Of the amount of water used for municipal purposes in 2000, 24,491 acft (22.8 percent) was supplied by groundwater sources and 67,145 acft (77.2 percent) was supplied from surface water sources. Sixty two percent of the water used in 2000 for municipal purposes (90,377 acft) was used in Bell (46,280 acft) and McLennan (44,097 acft) counties.

Manufacturing water user group accounted for 5,228 acft (1.26 percent) of the total water used in 2000, down by almost half from 1974 when manufacturing use accounted for 10,078 acft (4.26 percent) of the total water used. McLennan County used 2,804 acft of the water for manufacturing in 2000 and 4,775 acft in 1974.

Water for power generation, in 1974, was all taken from surface water (13,162 acft) and all of it was used in McLennan and Bell counties. By the year 2000 water used for power generation had increased by more the ten times (141,493 acft). Somervell County used 76,466 acft of surface water and 39 acft of groundwater, representing 54 percent of the total water used for power generation within the study area.

Most of the water used in the study area in 1974 was for irrigation purposes (96,303 acft) and over half (59,668 acft) of that water came from Brown, Comanche, Eastland, and Erath counties, with Brown County being the largest user of the four. By the year 2000, the amount of water used for irrigation had dropped to 87,131 acft and 84 percent (73,171 acft) came from the same four counties.

Mining use accounted for 2,344 acft (0.99 percent) of the total water used in 1974. Out of this amount, 51 percent came from groundwater. The amount almost doubled by 2000 with 4,442 acft being used for mining purposes. Brown County used 2,427 acft (54.63 percent) of total water use in 2000 for mining purposes and 2,274 acft (93.7 percent) was surface water.

Table 4. Historic Groundwater Use, Central Texas (Trinity Aquifer) PGMA Study.

County	1974	1980	1985	1990	1995	2000
BELL	3,407	3,463	1,803	1,618	2,549	3,331
BOSQUE	2,373	3,100	3,469	3,813	3,713	4,811
BROWN	2,032	1,049	1,210	1,611	2,502	2,788
CALLAHAN	1,846	1,546	1,637	1,315	1,500	1,599
COMANCHE	11,876	11,317	23,707	26,728	27,395	15,349
CORYELL	2,459	3,683	3,920	1,152	966	978
EASTLAND	9,373	10,156	12,855	8,685	9,398	12,504
ERATH	13,544	13,703	11,970	14,096	20,288	19,182
FALLS	5,947	4,113	3,399	5,889	4,974	2,732
HAMILTON	1,171	2,639	1,345	2,030	1,333	950
HILL	3,802	3,767	2,717	2,519	2,816	2,121
LAMPASAS	710	1,192	1,089	993	1,154	1,872
LIMESTONE	1,570	1,556	3,354	3,768	4,122	3,856
McLENNAN	9,472	13,017	14,125	12,588	13,863	15,760
MILLS	629	1,340	801	1,245	1,032	952
SOMERVELL	432	882	1,440	1,299	1,335	1,535
TOTAL	**70,643**	**76,523**	**88,841**	**89,349**	**98,940**	**90,320**

2006 Regional Water Plans

Water used for livestock accounted for 9.83 percent (23,281 acft) of all the water used in the study area in 1974. The majority of the water (18,614 acft) came from surface sources. In 2000, 30,755 acft or 7.4 percent of the water used in the study area was for livestock purposes. As in 1974, the major portion (21,299 acft) was from surface water supplies.

Population and Water Demand Projections

According to the Brazos G, Region F, and Region K Regional Planning Groups, the total population of the study area was 770,899 in 2000. This report uses the population projections developed for the regional and state water plans in 2006. The U.S. Census Bureau did not outline population projections based on Water User Groups (WUGs); therefore, this report did not use population projections from the Bureau.

The regional and state water plans project that between the years 2000 and 2030, total population within the study area will increase by approximately 32.5 percent (from 770,899 inhabitants in 2000 to 1,021,300 inhabitants in 2030). During that period, the population in some counties is projected to decrease (Callahan, Eastland, and Hamilton counties). Counties experiencing more than a 30 percent increase in population are Bell, Bosque, Coryell, Erath, and Somervell. Population projection data is shown in Table 5.

Table 5. Projected Population by County, Central Texas (Trinity Aquifer) PGMA Study.

County	Historical	Projections					
	2000	2010	2020	2030	2040	2050	2060
Bell	237,974	279,313	315,766	351,336	381,839	408,408	432,418
Bosque	17,204	19,831	22,646	24,622	25,364	25,667	26,032
Brown	37,674	39,324	40,602	40,958	40,958	40,958	40,958
Callahan	12,905	12,829	12,980	12,750	12,492	12,206	11,968
Comanche	14,026	14,273	14,721	14,860	14,816	14,503	14,045
Coryell	74,978	87,707	102,414	116,741	126,878	135,749	142,886
Eastland	18,297	18,336	18,382	18,061	17,566	16,989	16,226
Erath	33,001	36,666	40,609	44,160	47,734	57,200	63,155
Falls	18,576	19,600	20,884	22,196	23,350	24,267	25,346
Hamilton	8,229	7,790	7,681	7,596	7,624	7,512	7,504
Hill	32,321	33,416	34,947	36,679	38,407	40,252	42,300
Lampasas	17,762	20,114	22,596	24,396	25,731	26,606	27,160
Limestone	22,051	23,322	24,944	25,828	26,505	27,177	28,050
McLennan	213,517	231,882	250,398	266,002	284,217	292,449	307,378
Mills	5,575	5,708	5,898	6,021	6,074	6,129	ND
Somervell	6,809	7,542	8,393	9,094	9,554	9,740	9,804
Total	770,899	857,653	943,861	1,021,300	1,089,109	1,145,812	1,195,230

Projected water demand data, by county and category for the study area, are presented in Table 6. The Water User Groups (WUGs) have been identified by the Region F, Brazos G, and Lower Colorado River Region K Regional Planning Groups. The WUG projected water demand data (Appendix IV) include municipal demands for cities and towns, rural water supply demands for county-others uses, agricultural demands for irrigation and livestock, and other water demands for manufacturing, mining, and steam electric power generation.

Development of the demand projection data is detailed in the 2006 Regional Water Plans. The total projected water demand for the study area is expected to increase by 23.57 percent over the next 30-year period. The total water use for 2000 was 337,412 acft and the total projected demand for 2030 is anticipated to be 416,937 acft, an increase of 79,525 acft over the 30-year period (Figure 10).

Municipal need represents the largest demand for water in the study area. Municipal demand in 2000 was 145,281 acft and is projected to increase to 190,050 acft by 2030, approximately 44,769 acft (30.82 percent) over the 30-year planning period. Municipal use accounted for 43.06 percent of the total water use in the area in 2000 and increases to 45.58 percent of the total water demand in 2030.

Table 6. Total Water Demand Projections for 2000 - 2060 (in acre-feet).

Region	County	Historical	Projections					
		2000	2010	2020	2030	2040	2050	2060
G	Bell	52,271	62,039	75,246	82,101	87,796	93,122	98,575
G	Bosque	7,721	11,919	14,188	15,526	16,927	18,561	20,598
F	Brown	21,374	24,119	24,221	24,173	24,053	24,011	24,040
G	Callahan	3,376	3,321	3,284	3,207	3,141	3,079	3,047
G	Comanche	42,098	41,766	41,400	41,005	40,593	40,176	39,772
G	Coryell	14,730	17,217	19,429	21,542	22,997	24,305	25,488
G	Eastland	20,513	20,500	20,482	20,401	20,291	20,177	20,080
G	Erath	24,813	24,959	25,157	25,314	25,461	26,344	26,883
G	Falls	7,584	7,588	7,661	7,738	7,795	7,846	7,598
G	Hamilton	3,807	3,719	3,672	3,630	3,600	3,549	3,528
G	Hill	6,419	6,491	6,636	6,809	6,985	7,238	7,503
G	Lampasas	4,826	5,604	6,096	6,434	6,668	6,828	6,936
G	Limestone	27,144	27,540	27,970	31,867	36,539	42,328	49,395
G	McLennan	75,772	92,053	91,419	97,148	103,556	109,739	117,827
K	Mills	4,912	4,826	4,790	4,720	4,650	4,574	4,501
G	Somervell	20,052	25,221	25,276	25,322	25,341	25,341	25,340
Total		337,412	378,882	396,927	416,937	436,393	457,218	481,111

Source: 2006 Region F, Brazos G, and Lower Colorado K Regional Water Plans.

Irrigated agricultural use represented the second highest water demand in the study area in 2000, but is projected to decrease to third place in 2030. Water for irrigation accounted for 25.82 percent of the total water demand in 2000 and only decreases slightly to 20.90 percent of the total water demand in 2030. Decrease in irrigation water demand is associated with projected improvements in irrigation efficiency and reductions in irrigated acres due to forecasted unfavorable farming economics.

Steam electric demand for the study area is projected to increase by approximately 31,873 acft over the 30-year planning period, thus becoming the WUG with the second largest demand for water in the area. This water demand accounted for 19.26 percent of the total water use in 2000 and is projected to increase to 23.23 percent of the total water demand for 2030. Demands will grow from 64,998 to 96,871 acft.

Livestock demand represents the fourth highest demand for water in the study area. Water used for livestock accounted for 8.86 percent of the total water use in the study area in 2000. This demand is projected to remain almost the same for the next 30-year period, and would decrease to account for 7.21 percent of the study area total water demand in 2030.

Demand for manufacturing is projected to increase 57.84 percent (from 5,228 acft to 8,252 acft) between 2000 and 2030. This demand is mainly used by industries in producing products, as a cooling agent during manufacturing process, or for cleaning/wash-down of parts and/or products. McLennan County is responsible for more than half of the water demand for manufacturing in the study area. However, that demand was low, in 2000 (2,804 acft used for manufacturing) and the projected demand for 2030 is 4,577 acft.

Mining demand is projected to decrease slightly. In 2000, mining demand accounted for 1.45 percent of the total water demand in the study area (4,894 acft). This demand is projected to decrease to 4,595 acft) by 2030 and accounts for 1.10 percent of the total demand in the area.

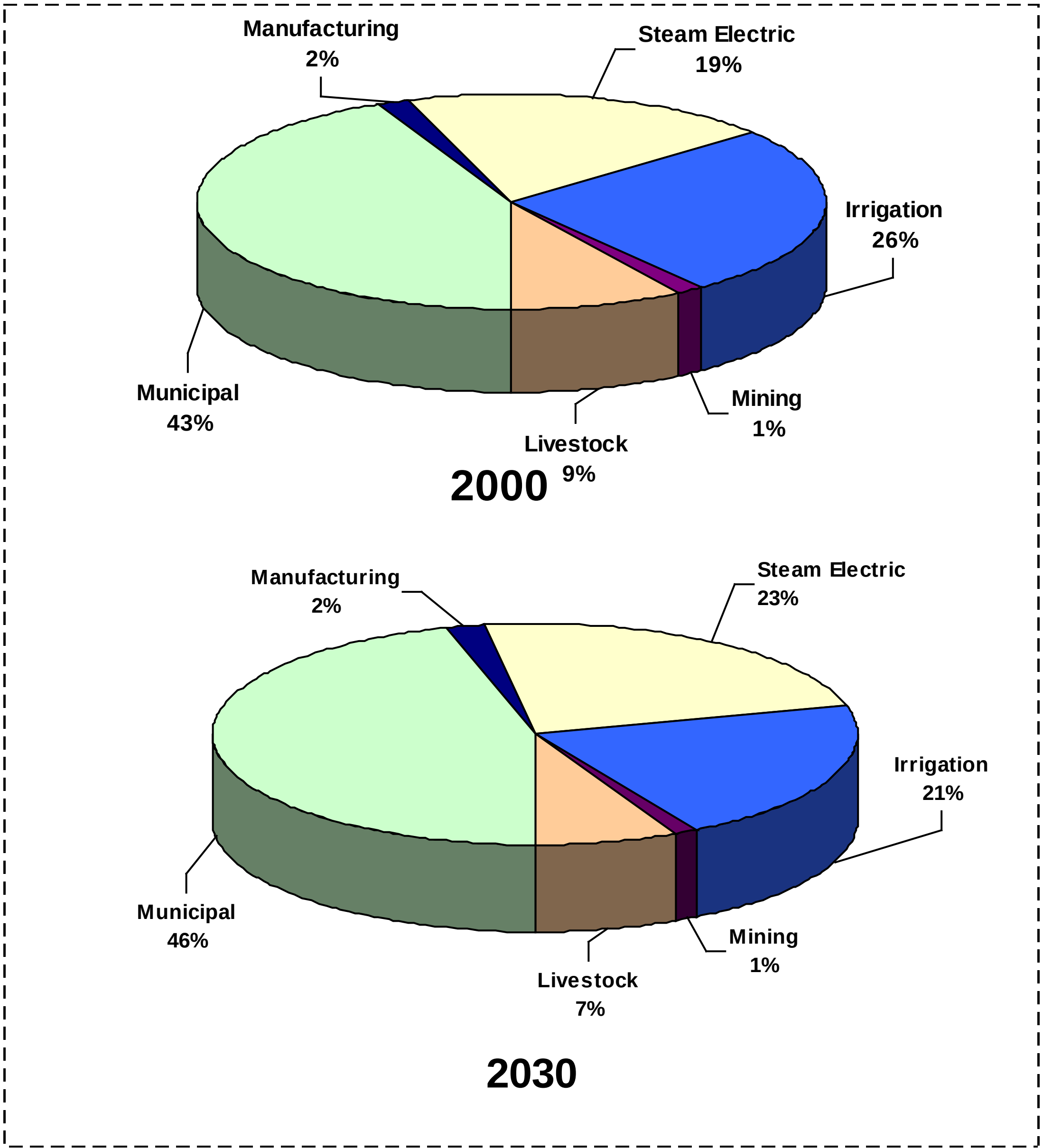


Figure 10. Total Water Demand for 2000 and Projections for 2030 (in acre-feet).

Water Supply

The projected population and water demand data combined with the estimates of groundwater and surface water availability is critical to project water supply shortfalls or surpluses for the study area. The regional water plan data describes current supplies and water user groups based on existing conditions and limitations. All water supplies that are presently available to a water user group are identified and quantified. These data are presented in Appendix V. Surface water supplies include rivers, streams, creeks, lakes, ponds, and tanks. These supplies belong to the state and are limited by water rights, contracts, or reservoir yields. Surface water supplied 457,506 acft in 2000 and is projected to supply 454,132 acft in 2030. Groundwater resources also supply water based on developed well fields and aquifer availabilities. Groundwater supplies in 2000 were an estimated 78,869 acre-feet (acft) and these supplies are projected to decrease slightly by 2030, to 76,357 acft (Table 7). The Trinity aquifer is the primary groundwater source in the study area. Groundwater is also supplied from the Carrizo-Wilcox aquifer, the Brazos River Alluvium aquifer, and the Woodbine aquifer. Water supply from the Trinity aquifer in the study area is projected to remain the same thorough 2030.

Current and projected water supply and demand data by county, WUG, and year for the study area are tabulated in Appendix V. The Trinity aquifer provides all of the groundwater in Callahan, Comanche, Coryell, Eastland, Erath, Hamilton, Mills, and Somervell counties. The major portion of groundwater used in Bell, Brown, and Hill counties is from the Trinity aquifer with Bell County using less than half from the Edwards-Balcones Fault Zone (BFZ, Northern Segment). Brown County uses small quantities from Other aquifer. Hill County receives about 18 percent of its groundwater from the Woodbine aquifer. Lampasas County's groundwater supply is predominantly from the Trinity aquifer (~96 percent) and the rest comes from the Marble Falls aquifer. Limestone County uses groundwater from the Carrizo-Wilcox aquifer. Groundwater supplied in Falls and McLennan counties comes primarily from the Brazos River Alluvium aquifer. Other aquifers that furnish water to these counties are the Trinity (Bosque County), Carrizo-Wilcox and Trinity (Falls County), and Trinity and Woodbine (McLennan County).

Surface water supplies include any water resource where water is obtained directly from a surface water body. The primary sources of surface water supply in the study area are from the Brazos River Authority (BRA) system (67,087 acft/yr) and Lake Waco (66,504 acft/yr). Water supply from Lake Waco is solely for municipal use, which is projected to increase by three percent between 2000 and 2030. In 2000, the BRA system supplied about 30 percent of the surface water supply in the study area. Most of the BRA system water is used for power generation purposes, about 36,000 acft in 2000 and is projected to increase to 49,342 acft in 2030. Municipal use accounted for about 28,070 acft in 2000 with minor amounts allotted to mining and manufacturing. These total surface water supplies are projected to increase by 0.36 percent between 2000 and 2030 in the study area (Appendix V).

Groundwater Availability

Water availability is the maximum amount of water available during the drought of record, regardless of whether the supply is physically or legally available for use. Groundwater availability in the study area involves consideration of issues such as demand, water level declines, spring flows, potential water quality deterioration, depletion of aquifer storage, and the availability of alternate surface-water supplies. It allows for some increase in groundwater development to meet a portion of future demands, but use available surface water to meet the majority of demands in order to minimize or eliminate negative effects on aquifer systems. Table 8 illustrates the total groundwater available in the study area.

Table 7. Total Water Supply Projections (ac-ft/yr), Central Texas (Trinity Aquifer) PGMA Study.

County	Supply	Historical	Projections				
		2000	2010	2020	2030	2040	2050
Bell	Groundwater	2,648	2,623	2,614	2,606	2,600	2,593
	Surface water	117,426	117,028	116,889	116,747	116,586	116,417
	Subtotal	120,074	119,651	119,503	119,353	119,186	119,010
Bosque	Groundwater	2,805	2,732	2,712	2,697	2,682	2,670
	Surface water	12,707	12,702	12,697	12,692	12,687	12,682
	Subtotal	15,512	15,434	15,409	15,389	15,369	15,352
Brown	Groundwater	2,788	1,893	1,876	1,870	1,870	1,864
	Surface water	18,586	17,314	17,404	17,407	17,366	17,378
	Subtotal	21,374	19,207	19,280	19,277	19,236	19,242
Callahan	Groundwater	1,973	1,971	1,962	1,952	1,941	1,930
	Surface water	2,196	2,195	2,195	2,195	2,194	2,194
	Subtotal	4,169	4,166	4,157	4,147	4,135	4,124
Comanche	Groundwater	21,002	20,772	20,567	20,366	20,167	19,970
	Surface water	25,873	25,949	25,947	25,931	25,905	25,878
	Subtotal	46,875	46,721	46,514	46,297	46,072	45,848
Coryell	Groundwater	477	485	488	490	492	494
	Surface water	26,790	26,988	26,935	26,889	26,846	26,809
	Subtotal	27,267	27,473	27,423	27,379	27,338	27,303
Eastland	Groundwater	4,853	4,853	4,853	4,853	4,852	4,852
	Surface water	8,983	8,978	8,976	8,969	8,963	8,957
	Subtotal	13,836	13,831	13,829	13,822	13,815	13,809
Erath	Groundwater	14,932	14,820	14,709	14,601	14,493	14,388
	Surface water	15,119	17,012	17,043	17,071	17,103	17,209
	Subtotal	30,051	31,832	31,752	31,672	31,596	31,597
Falls	Groundwater	1,863	1,794	1,752	1,713	1,675	1,639
	Surface water	14,944	14,924	14,903	14,883	14,863	14,842
	Subtotal	16,807	16,718	16,655	16,596	16,538	16,481
Hamilton	Groundwater	1,145	1,142	1,139	1,138	1,135	1,126
	Surface water	6,444	6,442	6,440	6,438	6,436	6,435
	Subtotal	7,589	7,584	7,579	7,576	7,571	7,561
Hill	Groundwater	2,244	2,226	2,222	2,220	2,218	2,216
	Surface water	9,079	8,545	8,011	7,478	6,944	6,412
	Subtotal	11,323	10,771	10,233	9,698	9,162	8,628
Lampasas	Groundwater	966	939	932	928	923	921
	Surface water	7,755	7,543	7,584	7,611	7,630	7,640
	Subtotal	8,721	8,482	8,516	8,539	8,553	8,561
Limestone	Groundwater	13,783	13,803	13,810	13,815	13,798	13,633
	Surface water	22,028	21,855	21,682	21,510	21,358	21,354
	Subtotal	35,811	35,658	35,492	35,325	35,156	34,987
McLennan	Groundwater	4,154	4,087	4,069	4,057	4,046	4,035
	Surface water	114,681	114,868	115,033	115,161	115,264	115,317
	Subtotal	118,835	118,955	119,102	119,218	119,310	119,352
Mills	Groundwater	2,003	2,003	2,003	1,818	1,818	1,584
	Surface water	4,524	4,524	4,524	2,837	2,837	2,837
	Subtotal	6,527	6,527	6,527	4,655	4,655	4,421
Somervell	Groundwater	1,233	1,233	1,233	1,233	1,233	1,232
	Surface water	50,371	50,352	50,332	50,313	50,293	50,274
	Subtotal	51,604	51,585	51,565	51,546	51,526	51,506
Groundwater Total		78,869	77,376	76,941	76,357	75,943	75,147
Surface water Total		457,506	457,219	456,595	454,132	453,275	452,635
Area Total		536,375	534,595	533,536	530,489	529,218	527,782

Source: 2006 Region F, Brazos G, and Lower Colorado K Regional Water Plans.

Table 8. Groundwater Availability in 2000, Central Texas (Trinity Aquifer) PGMA Study.

County	Aquifer	2000 Availability (acft)	
			Subtotal
Bell	Edwards-BFZ (Northern Segment)	2,500	
	Trinity	2,169	4,669
Bosque	Brazos River Alluvium	2,500	
	Trinity	1,718	4,218
Brown	Other	213	
	Trinity	2,026	2,239
Callahan	Trinity	3,787	3,787
Comanche	Trinity	21,976	21,976
Coryell	Trinity	1,791	1,791
Eastland	Trinity	4,853	4,853
Erath	Trinity	20,165	20,165
Falls	Brazos River Alluvium	15,600	
	Carrizo-Wilcox	1,000	
	Trinity	161	16,761
Hamilton	Trinity	2,146	2,146
Hill	Trinity	2,383	
	Woodbine	1,433	3,816
Lampasas	Ellenburger-San Saba	551	
	Marble Falls	4,183	
	Trinity	2,145	6,879
Limestone	Carrizo-Wilcox	20,000	
	Trinity	66	
	Woodbine	33	20,099
McLennan	Brazos River Alluvium	15,600	
	Trinity	1,718	
	Woodbine	100	17,418
Mills	Trinity	2,760	2,760
Somervell	Trinity	1,233	1,233
TOTAL			134,810

For purposes of estimating groundwater availability, the aquifer is divided between the outcrop area and the confined area. In the outcrop area, groundwater availability was estimated based on percent of rainfall that becomes effective recharge. This percent varies based on the relative amount of Antlers and Travis Peak formations that is exposed to the surface and the relative permeability of the major water-bearing zone in the county (Ridgeway and Petrini, 1999). After 2030, the aquifer supply would be based on the estimated effective recharge. The availability is also based on the areal extent of the downdip or artesian portion of the aquifer in the study area.

The Trinity aquifer supplies 52.9 percent of the groundwater available in the study area (Table 9). Although the Brazos River Alluvium aquifer is considered a minor aquifer, it supplies 25 percent of groundwater available to the study area. The Carrizo-Wilcox aquifer supplies 15 percent of the groundwater (20,000 acft in Limestone and 1,000 acft in Falls counties). The remainder of the groundwater available to the study area comes from the Edwards-BFZ (Northern Segment) aquifer in Bell County (1.85 percent); the Woodbine aquifer in Hill, Limestone, and McLennan counties (1.16

percent); and the Marble Falls (3.1 percent) and Ellenburger-San Saba aquifers (0.41 percent) in Lampasas County.

Table 9. Total Groundwater Availability by Aquifer, Central Texas (Trinity Aquifer) PGMA Study.

Aquifer	Availability (acft/yr)
Trinity	71,310
Brazos River Alluvium	33,700
Carrizo-Wilcox	21,000
Marble Falls	4,183
Edwards-BFZ (Northern Segment)	2,500
Woodbine	1,566
Ellenburger-San Saba	551
TOTAL	134,810

AREA WATER CONCERNS AND IDENTIFIED MANAGEMENT STRATEGIES

This section summarizes data and information with regard to water quality, water supply and identified needs, and identified water management strategies for the next 25 years. The discussions in this section rely primarily upon the Brazos G Regional Water Plan (HDR et al., 2006); the Region K Lower Colorado Regional Water Plan (Collie and Braden Inc., 2006); Water for Texas - 2002 (TWDB, 2002); Duffin and Musick, 1991; and Ridgeway and Petrini, 1999.

Groundwater Level Declines

More groundwater is being withdrawn than recharged to aquifers in the Central Texas study area. Historically, pumpage has exceeded recharge resulting in declining water levels, removal of water from aquifer storage, and possible deterioration of chemical quality in the Hensell and Hosston Members of the Travis Peak Formation, and the Paluxy Formation, the of the Trinity Group aquifer due to interformational leakage. Water-level declines and associated reduction of artesian pressure caused by the continued removal of water from aquifer storage are regional groundwater problems.

- Klemt, Perkins, and Alvarez (1975) indicated water-level declines in the Hensell and Hosston members of the Travis Peak Formation from 1900-1975 of more than 550 feet in the Waco, McLennan County area.

- The 1984 State Water Plan (Texas Department of Water Resources, 1984) recognized that overdrafts were occurring in the Trinity Group aquifer in Comanche, Coryell, Eastland, Erath, Hill, and McLennan counties.

- Baker, Duffin, Flores, and Lynch (1990) documented the following water-level declines from 1967-1988.
    - The Antlers Formation, the Travis Peak Formation, and the Hosston Member of the Trinity Group have experienced some water-level decline over almost 60 percent of the study area.
    - Forty percent of the area has declined 100 feet or more and declines of 200 feet have occurred in Bell, Bosque, Falls, Hill, and McLennan counties.
    - Declines of 300 feet occurred in Hill County and three areas in McLennan County; and over 400 feet southwest of Waco, McLennan County.
    - Water levels in the Hensell Member of the Travis Peak Formation have declined 100 feet or more over about 35 percent of the study area.

- Ashworth and Hopkins (1995) noted that the Trinity aquifer is extensively developed from the Hensell and Hosston members in the Waco area, where the water level has declined by as much as 400 feet.

- Bradley (1999) updated and evaluated water-level decline data from Report 319 (Baker and others, 1990).
    - The greatest water level declines are from wells completed in the Hosston Formation in the Waco metropolitan area in McLennan County with declines of over 400 feet.
    - The Hensell Formation has also recorded significant water-level declines in Central Texas with well over 200 feet of decline in Coryell County.
    - Wells completed in the artesian zone of the Twin Mountains Formation showed declines from 171 feet in Somervell County to 337 feet in Bosque County.

- Wells completed in the outcrop of the Twin Mountains Formation showed no long-term water-level declines.

- The 2001 Region G Water Plan (HDR Engineering, Inc., et al., 2001) notes that groundwater use exceeds long-term supply in the Trinity Group aquifer in Bell, Bosque, Comanche, Coryell, Eastland, Erath, McLennan, and Somervell counties.

- The 2004 Trinity-Woodbine aquifer groundwater availability model (GAM) report by Harden & Associates et al. (2004) notes that model runs predict future water-level drawdown and recovery in the study area. The model runs for the Paluxy layer of the Trinity aquifer predict up to 100 feet of drawdown to occur in Bosque, Falls, Limestone, and McLennan counties. Over the 40-year horizon, the model runs do predict that a gradual long-term water-level decline in the Paluxy will occur in the eastern part of the study area. Due to the predicted reduction in pumpage built into the regional water plans and the TWDB's data, the model runs for the Hensell and Hosston layers of the Trinity aquifer predicts water-level recoveries in McLennan and surrounding counties.

- The 2006 Brazos G Water Plan (HDR Engineering, Inc., et al., 2006) notes the present use of groundwater exceeds or is near the estimate of long-term reliable groundwater supply in many counties in the study area. The plan notes that groundwater pumpage from the Trinity aquifer in Bell, Bosque, Callahan, Coryell, Eastland, Erath, Falls, Hill, Lampasas, Limestone, McLennan, and Somervell counties is at or above the estimated long-term sustainable supply. The 2006 Brazos G Water plan also notes that overdevelopment of aquifers and resulting water-level declines pose a threat to small water suppliers and domestic user in rural areas.

- The Draft 2007 State Water Plan (TWDB, 2007) illustrates the most significant historic water-level declines in the state have occurred in the Trinity aquifer in the study area centered in McLennan County (Waco) and in Dallas, Ellis, Johnson, and Tarrant counties to the north. The report also illustrates localized water-level declines of between 50 and 250 feet from 1994 and 2004 in Bell, Bosque, Falls, Hill, and McLennan counties, and other localized water-level rises of up to 50 feet in Lampasas County.

Hydrographs of selected wells in the study area are exhibited in Appendix VI. Several wells in the area exhibit continued water-level declines within the past ten years (Table 10 and Figure 11). Major water-level declines occur in areas of high groundwater usage, usually corresponding to dense populations that rely on groundwater to meet all needs. As shown in Table 10, Figure 12, and Appendix VI however, these major water-level declines only occur in the confined portion of the Trinity aquifer and not in the outcrop or recharge zones of the aquifer. In the outcrop area the water levels fluctuate according to the amount of rainfall or lack thereof.

Table 10. Water-Level Differences of Selected Wells, Central Texas (Trinity Aquifer) PGMA Study.

Completion Formation	County	State Well Number	Measurement Period	Average Yearly Difference (feet)	Total Water-Level Difference (feet)
Hosston Member of the Travis Peak Formation	Bosque	40-05-701	1965-1994 1984-1994 1994-2004	-7.90 -3.30 ND	-228.20 -36.01 ND
	Falls	40-48-201	1964-2004 1984-1994 1994-2004	-7.35 -5.30 -6.01	-293.09 -53.01 -60.14
		40-64-101	1965-2006 1984-1993 1994-2006	-4.26 -5.30 -2.50	-174.81 -47.65 -30.02
	Hill	39-09-201	1960-2006 1984-1994 1994-2006	-8.55 0.40 -5.01	-350.46 4.42 -60.06
	McLennan	40-31-612	1964-1994 1984-1994 1994-2004	-13.30 -6.20 ND	-438.40 -61.90 ND
		40-31-802	1964-1996 1984-1994 1994-2004	-13.20 -12.30 ND	-420.95 -122.75 ND
Hensell Member of the Travis Peak Formation	Bosque	40-03-901	1965-2004 1984-1994 1994-2004	-5.75 -5.20 -4.99	-224.16 -51.73 -49.88
	Coryell	40-45-402	1966-1996 1984-1994 1994-2004	-7.80 -3.10 ND	-234.27 -31.10 ND
Travis Peak Formation	Bosque	40-05-903	1964-2002 1984-1994 1994-2002	-10.60 -8.80 -13.54	-402.88 -88.13 -108.35
	Brown	31-57-523	1963-2006 1984-1994 1994-2006	0.13 0.47 0.27	5.55 4.72 3.25
	Callahan	30-55-501	1966-2006 1984-1994 1994-2006	-0.10 0.85 -0.68	-3.89 8.50 -8.10
	Comanche	31-58-703	1965-2003 1984-1994 1994-2003	0.18 0.40 -0.06	6.73 4.35 -0.52
	Eastland	31-43-702	1965-2006 1984-1994 1994-2006	0.36 1.331 -0.45	14.65 13.30 -5.35
	Erath	31-55-803	1963-2004 1984-1994 1994-2004	-0.27 0.70 0.21	-10.98 7.43 2.12
	Somervell	32-43-406	1965-2004 1984-1994 1994-2004	-3.59 -5.30 -0.95	-140.20 -52.86 -9.50
Paluxy Formation	Coryell	40-26-401	1963-2006 1984-1994 1994-2006	-0.10 0.04 -0.03	-4.29 0.40 -0.39
	Hamilton	41-07-501	1967-1998 1984-1994 1994-2004	0.20 0.90 ND	6.82 9.94 ND
		41-31-603	1966-2006 1984-1994 1994-2006	0.06 0.10 0.05	2.39 0.92 0.55
Woodbine Formation	Hill	32-55-304	1966-1997 1984-1994 1994-2004	0.16 0.60 ND	4.98 6.26 ND

Adapted from Bradley, 1999, with additional data from 2006 TWDB http://wiid.twdb.state.tx.us

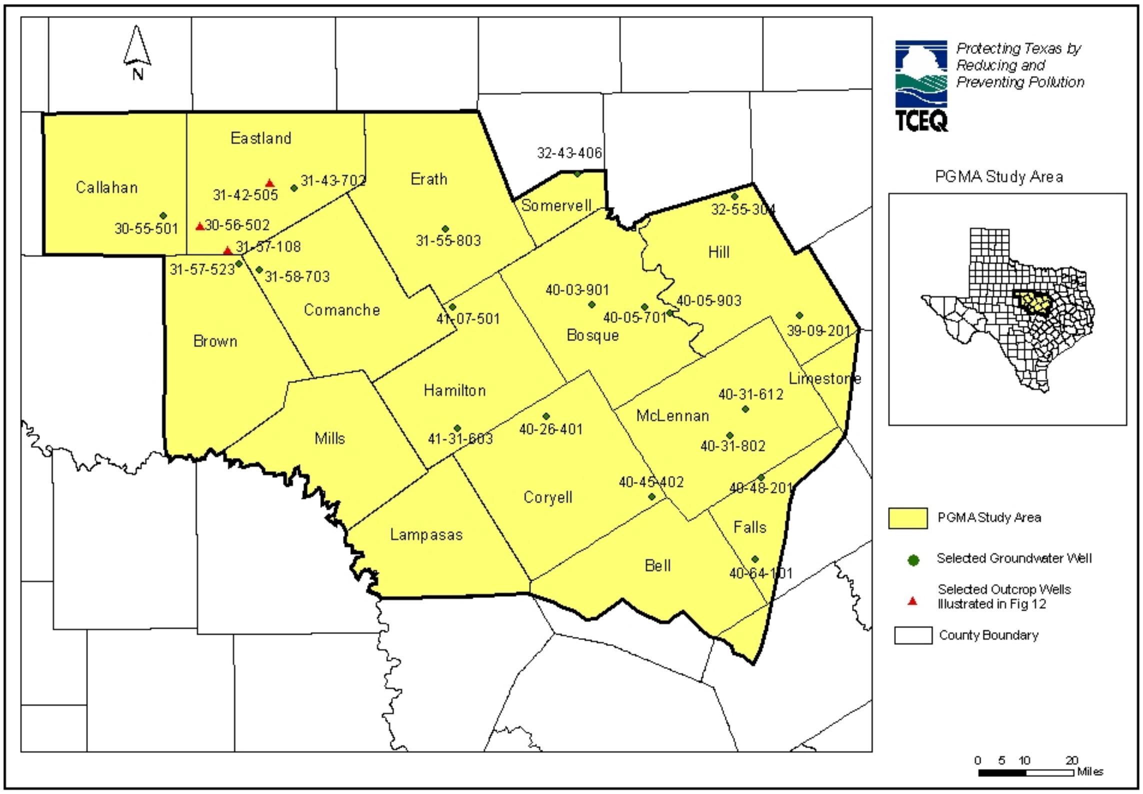


Figure 11. Location of Selected Groundwater Wells, Central Texas (Trinity Aquifer) PGMA Study.

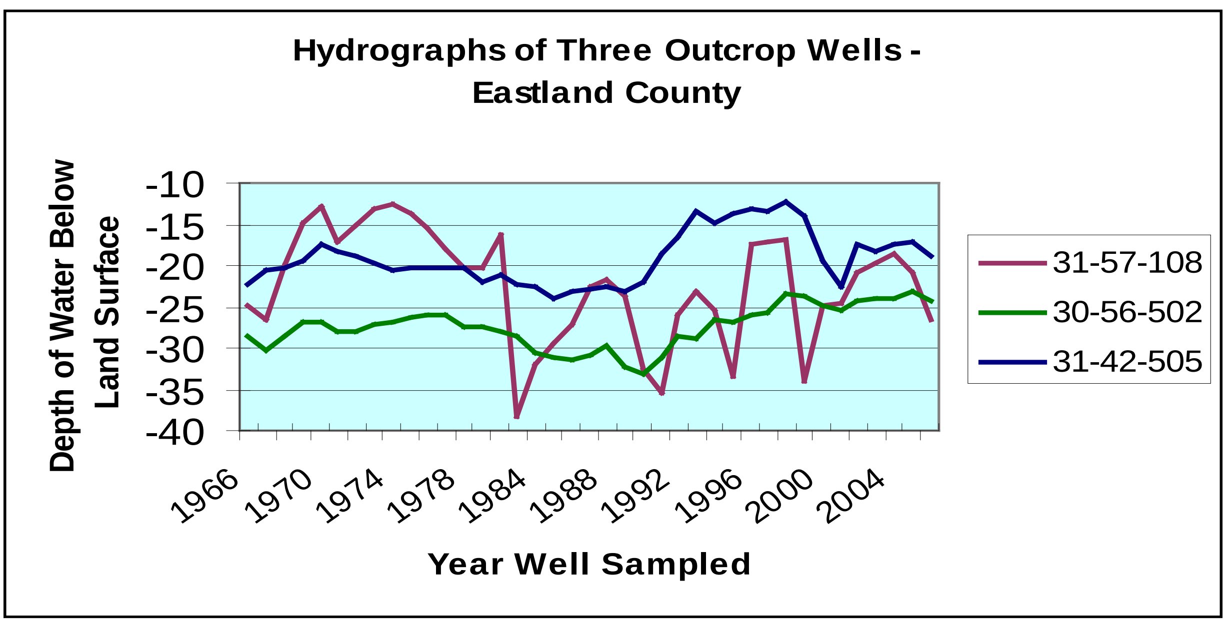


Figure 12. Hydrographs of Three Selected Water Wells Located in the Outcrop of the Trinity Aquifer, Eastland County.

Groundwater Quality Conditions

The geochemistry of the Trinity group aquifer in the western portion of the study can be characterized as calcium carbonate type water. This water becomes a sodium sulfate or sodium chloride type downdip (generally east of IH 35). It is usually of neutral pH and very hard and its quality ranges from fresh to slightly saline in most cases (Duffin and Musick, 1991). Down dip to the southeast of the study area, the water quality tends to decrease. Low permeability, restricted water circulation, and increase in temperature cause the groundwater to become more highly mineralized in the downdip portion of the aquifer.

Water quality in the Trinity aquifer is acceptable for most municipal and industrial uses. However, in some areas, natural concentrations of arsenic, fluoride, nitrate, chloride, iron, manganese, sulfate, and total dissolved solids (TDS) in excess of either primary or secondary drinking water standards can be found. Groundwater near the outcrop tends to be harder with relatively high iron concentration. Downdip, water tends to be softer, with concentrations of TDS, chlorides, and sulfates higher than on the outcrop. Groundwater contamination from anthropogenic sources is found in localized areas.

Water quality in the layers of the Woodbine aquifer used for public water supply is good along the outcrop with increasing concentrations of sodium, chloride, TDS, and bicarbonate in the downdip portions of the aquifer. High sulfate concentrations have been found in Hill County. Excessive iron concentrations also occur in parts of the Woodbine formation.

Where the Trinity aquifer is overlain by the Glen Rose Limestone the water chemistry exhibits a significant increase in sodium sulfate and chloride ions. This change in water chemistry is indicative of leakage through the Glen Rose into the Trinity aquifer. Heavy pumping of the Trinity aquifer, from parts of Bell, Bosque, Coryell, Hill, and McLennan counties is creating excessive drawdown beyond the recharge capacity of aquifer's ability to replenish water removed from storage. The leaky nature of the Glen Rose Limestone allows significant amounts of sulfate-rich water to be drawn into the depressed areas allowing degradation of the water quality of the Trinity aquifer (Rapp, 1988). The resulting water-level declines pose a threat to small water suppliers and to domestic water users in rural areas by increasing pumping costs and producing water of lesser quality.

The Texas Groundwater Protection Committee's Joint Groundwater Monitoring and Contamination Report – 2004 (TGPC, 2005) lists 119 groundwater contamination cases in the sixteen-county study area. These cases have predominantly been documented through regulatory requirements for compliance monitoring or through investigation in response to groundwater contamination complaints. Of these, 113 cases are related to activities under the jurisdiction of the TCEQ. The majority of the TCEQ-documented sites are contaminated by gasoline, diesel, or other petroleum products. Other documented contaminants under other TCEQ regulatory programs include, but are not limited to organic compounds, solvents, heavy metals, and pesticides. Nine counties – Bosque, Coryell, Falls, Hamilton, Hill, Lampasas, Limestone, Mills, and Somervell – have fewer than five contamination cases each, and Comanche County has nine contamination cases listed in the report. Four counties – Brown, Callahan, Eastland, and Erath – have reported contamination cases ranging from 11 and 19. Bell County has 26 and McLennan County has 41 reported contamination cases listed in the report.

Six cases listed in the Joint Groundwater Monitoring and Contamination Report – 2004 are related to oilfield activities under the jurisdiction of the Texas Railroad Commission. These cases document groundwater contamination in Brown County (salt-water seep, high in chlorides); in Eastland County (chlorides, hydrocarbons, and oil); and in Erath County (hydrocarbons).

In the study-area counties, an additional 12 groundwater contamination cases are reported as completed in the Joint Groundwater Monitoring and Contamination Report – 2004. Action on theses cases was considered complete when the desired remedy was achieved or when no further regulatory action was required. Five of the closed-case sites are in McLennan County.

The Barnett Shale Gas Exploration

The Barnett Shale is one of the largest and most active natural gas discoveries in the United States and may rival the Hugoton Field of southwestern Kansas as the largest onshore natural gas field in the nation. The Mississippian-aged Barnett Shale occurs at depths of 6,500 to 8,500 feet in the Fort Worth Basin of north Texas. It is bounded structurally to the east by the Ouachita Thrust-fold Belt and the Muenster Arch and to the west by the Bend Arch (Figure 13, from Givens and Zhao). The shale was deposited in an organic-rich, shallow epicontinental sea, and is now a productive gas reservoir due to high proportion of total organic carbon (TOC) that averages around 4.5 percent. The Barnett Shale is estimated to cover 5,000 square miles and contain 30 trillion cubic feet of natural gas. The majority of Barnett Shale production has been from the Newark East Field in portions of Denton, Tarrant, and Wise counties. Present production also occurs in Erath, Hill, Hood, Johnson, Palo Pinto, and Parker counties. Potential production from Bosque, Comanche, Cooke, Ellis, Hamilton, Jack, Montague, and Somervell counties is anticipated (Wikipedia, 2006, and Hayden and Pursell, 2005). The Barnett Shale is a very tight formation and must be hydraulically fractured to produce economic quantities of natural gas. Hydrofracturing is a process that involves injecting large volumes of water under high pressure through the well into the bedrock formation immediately surrounding the well bore. The desired result of this well stimulation is to widen existing fractures in the bedrock and/or extend them further into the formation. By enlarging the network of fractures, it is hoped to realize an increase in the release of gas trapped in the formation.

Hydrofracturing has been performed in the shale since 1997; however, recent technological advances in hydraulic-sand fracturing methods and horizontal drilling have led to increased drilling activity in the Barnett Shale. R. W. Harden and Associates (2007) reported that over 5,600 wells are producing gas from the Barnett Shale, with thousands more likely to be drilled in the next 20 years as the play expands out of its core area. Presently around 150 drilling rigs are active in the area and each can drill about 12 Barnett Shale wells per year or 1,800 wells per year (RCT personal communication, January 2006). In the study area counties of Bosque, Comanche, Erath, Hamilton, Hill, and Somervell, 175 Barnett Shale drilling applications have been filed with the Railroad Commission of Texas (RCT) since 2000 (Figure 14). According to a recent study by R. W. Harden and Associates (2007) 47 have been completed in the Barnett Shale within five counties of the study area (Table 11).

Millions of gallons of water are used in the stimulation of fractures and drilling wells in the Barnett Shale. The amount of water required for each well is highly variable depending on the depth of the well, the type of well, and any problems that may occur during the drilling of the well. One reported estimate for the quantity of water necessary for fracture stimulation was 90,706 barrels–the equivalent of about 3.8 million gallons or 11.7 acre-feet (acft). This well has a true vertical depth of 6,765 feet and reaches from 7,595 feet to 10,110 feet horizontally (Texas Drilling Observer, 2006). Harden and Associates (2007) estimated a typical vertical well completion consumes approximately 1.2 million gallons (28,642 barrels or 3.68 acft), and a typical horizontal completion 3.0 to 3.5 million gallons of fresh water (the equivalent of 71,600-83,540 barrels or 9.21 - 10.74 acft) per well. A query of online RCT data indicates that from the year 2000 through March 2006, 74 percent of the new Barnett Shale well applications are for horizontal wells.

As of the end of 2006, few if any horizontal well recompletions have occurred. It is uncertain whether any recompletions will occur in the future and if so, how often. Shirley (2002) suggested that re-fracing a well after approximately 5 years of production can be very beneficial. All wells completed before 2005 will have been re-hydro fractured by 2010. Nicot and Potter (2007) assumed that horizontal wells would not be restimulated.

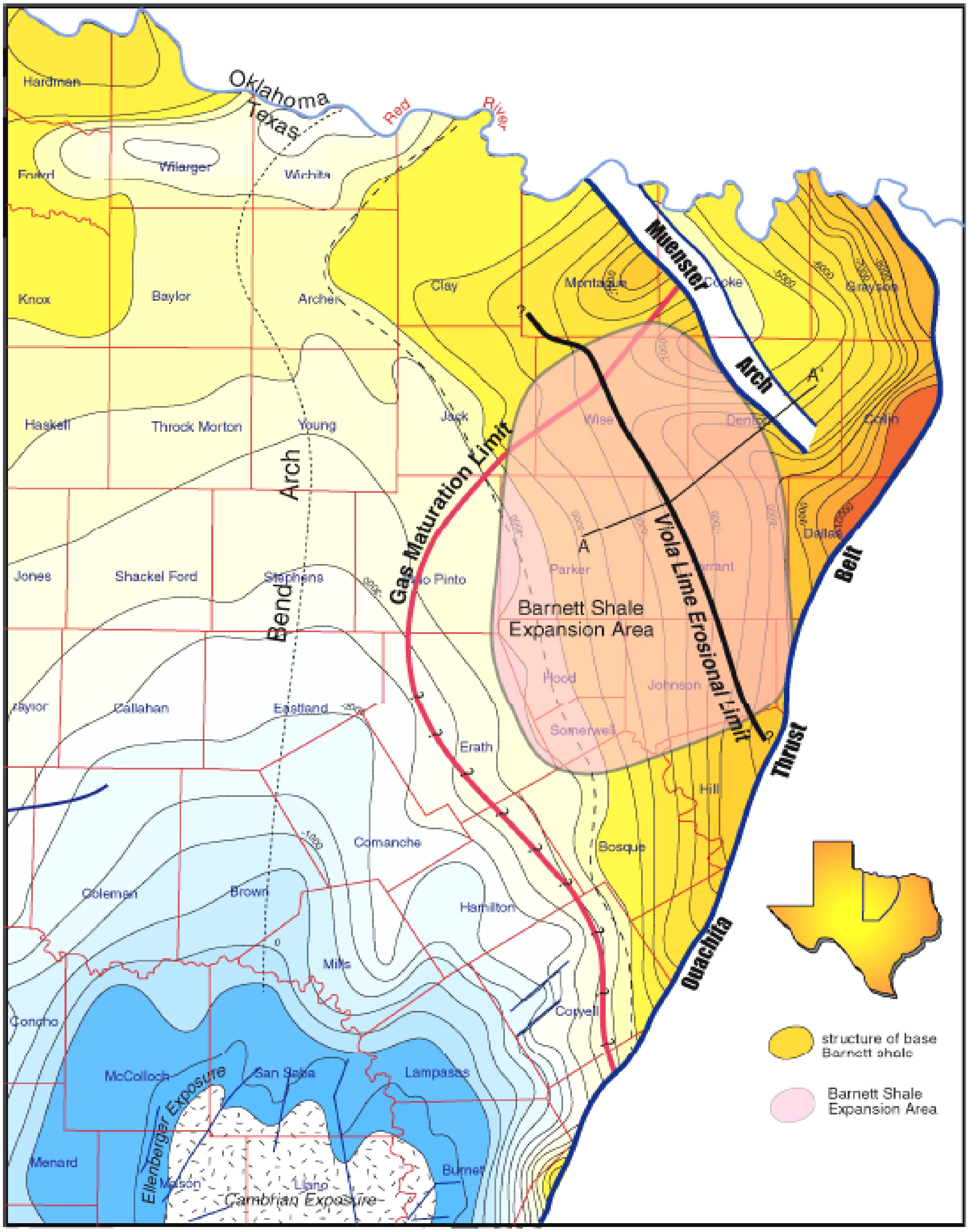


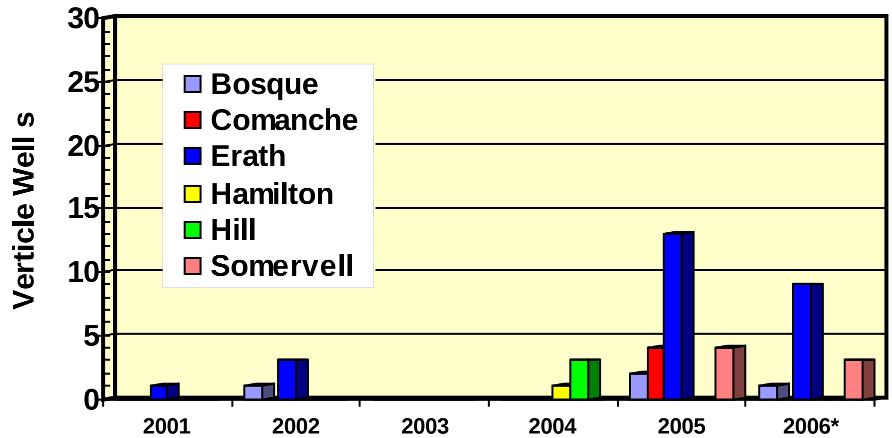
Figure 13. Fort Worth Basin showing the Barnett Shale Expansion area and the Structure of the Base of the Barnett Shale (from Givens and Zhao).

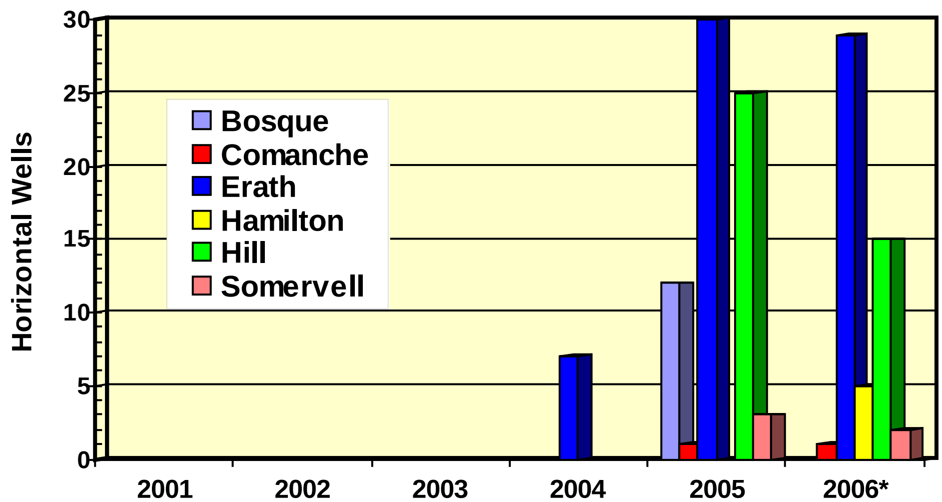
From 2001 through March 2006, drilling permit applications were sought for 175 Barnett Shale wells in the six counties listed in Figure 14. Understanding how much water will be needed for Barnett Shale well completion is difficult to characterize in water planning terms. If all of the drilling permits applied for in the study area from 2004 through the first quarter of 2006 were actually drilled, then it can be assumed that the following formulae would indicate the approximate amount of fresh water used for that particular mining purpose.

(10 acft per typical horizontal well)(130 wells)
= approximately 1,300 acft of fresh water used for horizontal well completion, and

(3.68 acft per typical vertical well)(40 wells)
= approximately 147.2 acft of fresh water used for vertical well completion.

This would potentially represent about 1,447.2 acft of fresh water use for this purpose from 2004 through March, 2006 in the six-county area.





* Only includes January, February, and March of 2006.

Figure 14. Barnett Shale Drilling Applications by Type of Well, Central Texas (Trinity Aquifer) PGMA Study.

Table 11. Barnett Shale Well Statistics by County.

County	2001	2002	2003	2004	2005	2006	Total by County
Bosque	0	0	0	0	1	2	3
Comanche	0	0	0	0	0	0	0
Coryell	0	0	0	0	0	0	0
Erath	0	0	0	1	9	21	22
Hamilton	1	0	0	0	0	0	1
Hill	0	0	0	0	0	19	19
McLennan	0	0	0	0	0	0	0
Somervell	0	0	0	0	1	1	2
Total	1	0	0	1	2	43	47

Adapted from: Appendix 2 Table 4, p. 2-26, R. W. Harden and Associates, 2007.

Table 12. Historical Water Use in the Barnett Shale (acft/yr).

County Polygon	2000	2001	2002	2003	2004	2005
Bosque	0	0	0	0	0	3.3
Comanche	0	0	0	0	0	0
Coryell	0	0	0	0	0	0
Erath	0	0	0	0	1.6	22.7
Hamilton	0	0	0	0	0	0
Hill	0	0	0	0	0	0
McLennan	0	0	0	0	0	0
Somervell	0	0	0	0	0	10.6
Total	0	0	0	0	1.6	33.3

Table 13. Estimated* Historical Groundwater Use in the Barnett Shale (acft/yr).

County Polygon	2000	2001	2002	2003	2004	2005
Bosque	0	0	0	0		2.0
Comanche	0	0	0	0	0	0
Coryell	0	0	0	0	0	0
Erath	0	0	0	0	1.0	13.6
Hamilton	0	0	0	0	0	0
Hill	0	0	0	0	0	0
McLennan	0	0	0	0	0	0
Somervell	0	0	0	0	0	6.4
Total	0	0	0	0	1.0	22.0

*Ground water use was estimated from total water use (Table 12).

Water use information is derived from Appendix 2, p. 21 and 22 of R. W. Harden and Associates. Water use in the Barnet Shale play has quickly increased from ~700 acft in 2000 to ~7,000 acft in 2005. The trend and partial numbers suggest an even higher water use in 2006. Tables 12 and 13 show the water use information for the Central Texas (Trinity Aquifer) PGMA Study Area Counties

The 2006 Brazos G Water Plan notes that mining water supplies in these counties are derived solely from groundwater from the Trinity, Brazos River Alluvium, and Woodbine aquifers. The mining user group data in the 2006, Brazos G Water Plans estimate the water supply in the six counties used for mining in 2010, 2020, and 2030 is 562, 533, and 517 acft/yr; and neither Erath nor Hamilton counties has a projected demand or supply for mining water use. Projected 2010, 2020, and 2030 demand for the mining user group for the six-county area is 558 acft/yr, 631 acft/yr, and 611 acft/yr, respectively. If the Barnett Shale exploration continues to increase, the future demand for water for hydrofracturing will also increase which will ultimately create a shortage for the mining water user group. Table 14 summarizes data from the mining water user group for the eight study-area counties where Barnett Shale natural gas exploration is ongoing or anticipated.

Various companies and government entities are investigating a few water conservation initiatives. In February 2005, the RCT approved a pilot study for the recycling of water used during drilling and water fracturing activities (RCT News Release, 2005). The study is ongoing and the results of the study are not yet available. Most of the hydrofracture fluid that cannot be reused is hauled to one of the Class II underground injection control disposal wells in the area. Fountain Quail Water Management LLC was the first oil field service company in the area to use mobile evaporator technology to distill on-site return water for reuse at other wells. The wastewater service company Aqua-Pure Ventures, Inc. purchased the remaining shares of Fountain Quail in April 2006, and is presently refining the mobile evaporator technology. This process shows the potential to treat up to 85 percent of the wastewater stream for reuse, and the remaining concentrate (brine) will require disposal. Aqua-Pure Ventures, Inc. is also presently working on a plan to use the heavy concentrate as kill fluid to hold gas pressures down when working on a well. In addition to three mobile purification units operated by Devon Energy in Tarrant County, Aqua-Pure Ventures, Inc. plans to add six more mobile purification units to operate in the area in 2006. These companies anticipate that the nine units in the area will be able to produce about 18,000 barrels (756,000 gallons or ~2.3 ac/ft) of distilled water per day. The purification units are fueled by on-site natural gas. This new process should turn at least some wastewater liabilities into fresh water assets (Scott, 2006).

Knowledgeable RCT staff is of the opinion that there could be over 50,000 wells in the Barnett Shale before the play is completed. Well spacing in the Barnett Shale can be very tight (i.e., 500 feet apart for horizontal wells or every 30 acres) and no decline in the annual number of wells that can be placed is expected. The number of active drilling rigs appears to be the only limiting factor to the number of wells that can be drilled each year (RCT personal communication, January 2006).

Surface Water Quality Conditions

The Brazos G Water Availability Model (WAM) addresses the quantity of water available to existing water rights in the Brazos River Basin. However, water quality issues for some sources of water for existing water rights and contracts may limit the availability of water for certain beneficial uses. Water quality that does not meet criteria for designated uses such as public water supply, contact recreation, and aquatic life support is a concern to water supply considerations.

Dissolved oxygen (DO) is an indicator of surface water quality along with the associated biochemical oxygen demand (BOD). DO is a measure of the amount of oxygen that is available in the water for metabolism by microbes, fish, and other aquatic organisms. BOD is a measure of the amount of organic material, containing carbon and/or nitrogen, in a body of water that is available as a food source to microbial and other aquatic organisms, which require the consumption of dissolved oxygen from the water to metabolize the organic material.

The basin-wide concentrations of DO that have existed in the past were indicative of relatively unpolluted waters; however, as populations and urban development continue to increase so do the levels of DO. The primary manmade sources of BOD in bodies of water are the discharge of municipal and industrial wastewater, as well as nonpoint source pollution from urban and agricultural

Table 14. Mining Water Use Planning Data for Barnett Shale Counties.

County	Planning Data	2010 [1]	2020 [1]	2030 [1]	Water Management Strategy [2]
Bosque	Groundwater (Brazos River alluvium)	210	197	189	No projected need.
	Surface Water	0	0	0	
	Total Water Supply	210	197	189	
	Total Water Demand	210	197	189	
	Surplus (Shortage)	0	0	0	
Comanche	Groundwater (Trinity aquifer)	54	51	50	No projected need
	Surface Water	0	0	0	
	Total Water Supply	54	51	50	
	Total Water Demand	54	51	50	
	Surplus (Shortage)	0	0	0	
Erath	Groundwater (Trinity aquifer)	0	0	0	No projected demand or supply
	Surface Water	0	0	0	
	Total Water Supply	0	0	0	
	Total Water Demand	0	0	0	
	Surplus (Shortage)	0	0	0	
Hamilton	Groundwater (Trinity aquifer)	0	0	0	No projected demand or supply
	Surface Water	0	0	0	
	Total Water Supply	0	0	0	
	Total Water Demand	0	0	0	
	Surplus (Shortage)	0	0	0	
Hill	Groundwater (Woodbine aquifer)	100	96	94	No projected need
	Surface Water	0	0	0	
	Total Water Supply	100	96	94	
	Total Water Demand	100	96	94	
	Surplus (Shortage)	0	0	0	
Somervell	Groundwater (Trinity aquifer)	198	189	184	Conservation and redistribution from Steam Electric.
	Surface Water	0	0	0	
	Total Water Supply	198	189	184	
	Total Water Demand	304	287	278	
	Surplus (Shortage)	(106)	(98)	(94)	

1. All tabulated values in acft/yr.
2. Adopted regional water plan strategies to address projected shortages.

Source: Brazos G Regional Water Planning Group et al., 2006, 4C.16.8, 4C.17.20, and Table C-33.

runoff. The presence of excess amounts of BOD allows increased rates of microbial and algal metabolism, which in turn depletes the dissolved oxygen concentrations in the water. Without sufficient levels of DO in the water, other aquatic organisms such as fish are impacted.

There are concerns throughout the Colorado River Basin regarding surface water quality. These concerns include aquatic life use, nutrient enrichment, algal growth, sediment contaminants, public water supply, and narrative criteria. Under normal hydrologic conditions, there are 11 classified stream segments in Region K with all or part of the stream segment exceeding the State Water Quality Criteria, based on data reported for 2002. The data also indicate that there are five classified stream segments with a concern for DO, based on the State Water Quality Criteria in the Lower Colorado Regional Water Planning Area (Region K) and the Region F Planning Area. The segments of concern in the study area are the Upper Pecan Bayou above Lake Brownwood, Brown County, and Middle Pecan Bayou in Brown and Mills counties. No known point sources of water pollution within these segments could be responsible for the problem. Low oxygen levels may be due to natural conditions and/or agricultural non-point source pollution. The TCEQ has not given this a priority ranking on the 303(d) list, instead stating that more data will be collected before a TMDL is scheduled. No impairment to water use because of the water quality has been reported.

A number of stream segments and lakes in the Brazos G Regional Water Planning Area do not meet water quality standards due to point and/or non point source pollution. The TCEQ and USEPA (40 CFR 130.7) have the responsibility to identify water bodies that do not meet, or are not expected to meet, applicable water quality standards for designated uses. These stream segments and lakes are identified in Section 303(d) list as impaired or threatened water bodies (TCEQ, 1999). The TCEQ has the responsibility to identify and prioritize water bodies that may require a Total Maximum Daily Load (TMDL) allocation to address the cause and source of water quality impairment. TMDL studies of bacteria are currently underway for the Leon River below Lake Proctor (segment 1221). Goose Branch in Erath County (and associated tributary) has been identified with a low priority for a TMDL study. These water quality issues are beyond the scope of regional water planning activities (TCEQ, 2005).

On the main stem of the Brazos River, the Draft 2004 Texas Water Quality Inventory includes a list of water bodies in Brazos G with water quality concerns. The largest impacts in terms of quantity of supply are associated with Possum Kingdom Lake, Lake Granbury, and Lake Whitney. These reservoirs have a combined 2060 firm yield of 312,298 acft/yr. Other surface water supplies with water quality concerns include the Brazos River above the Navasota River. Some of the water right and contract holders that divert water directly from these reservoirs in order to meet drinking water standards are utilizing advanced treatment. Other contract holders divert stored water released from these reservoirs at locations farther downstream, at which point the water quality is improved as it blends with downstream tributary stream flow (BRA, 2005).

Several special water quality studies are on going in the Brazos River Basin as described in the Brazos River Authority's 2005 Basin Highlights Report. A brief summary of these projects follows:

- In May 2002, a study of *Escherichia coli* for Lake Granbury commenced and included 53 monitoring locations. The objective of the program was to assess potential impacts of on-site sewage facilities. By 2004, several areas had been identified with failing on-site systems or improperly maintained systems. In August 2004, the monitoring program was revised and twelve sites were eliminated from future sampling.

- In October 2003, the TCEQ conducted an investigation of rock mining operations and determined that two operations in the Brazos River below Possum Kingdom Lake (Segment 1206) were noncompliant in controlling storm water runoff. A target-monitoring program was established to assess impacts of these operations on water quality.

- In September 2000, the Texas Soil and Water Conservation Board initiated the Dairy Manure Export Support (DMES) project to remove a large portion of dairy waste from the North Bosque River Watershed. From 2000 through 2003, nearly 64 percent of dairy manure produced was hauled to composting facilities. A monitoring program consisting of seven sites was established in the North Bosque River Watershed that demonstrated statistically significant water quality improvement with declines in phosphorous levels. A pilot project to use a digester pond to convert manure slurry to methane gas for electricity is located near Hico, Hamilton County.

- The Brazos River Authority, Texas State Soil and Water Conservation Board (TSSWCB), and United States Environmental Protection Agency (EPA) engaged in an effort to identify pollution prevention projects for the North Bosque River watershed through March 2006.

- Several agencies are compiling a reference library to profile bacterial sources for Lake Waco and Lake Belton, as well as source waters for those reservoirs.

- In October 2004, the Brazos River Authority funded a test pilot program to use alum to "fix" phosphorous in a flood control reservoir north of Stephenville. The process binds orthophosphate phosphorous to alum in an insoluble form.

- The Brazos Navasota Watershed Management Project, funded by the EPA and managed by the Brazos River Authority, is a multiple-phase approach to water quality management which includes creation of a stakeholder group, development of a water quality database, water quality monitoring, evaluation of poultry production practices, and recommendations of specific management techniques to protect water quality.

Concentrated Animal Feeding Operations

Background

Farming in the Central Texas -Trinity Aquifer- Study area dates back to the late 1800s. Ranchers were attracted to the land for livestock grazing. When railroads came, commercial farming and trade became the focus. In the early 1900s, cotton was a major source of income for farmers but after problems with soil exhaustion, drought, and boll weevil infestations, the agricultural focus returned to livestock and feed crops. In the 1930s, the dairy industry began changing rapidly as national companies such as Borden established processing plants and distribution centers in Texas. McLennan County led Texas in milk production in the 1980s with Erath County being second. Between 1940 and 1970, agriculture became more mechanized. The number of farms decreased while the number of animals produced increased (U.S. Census Bureau, 2004). Agricultural livestock production moved from farms to larger, more industrial type facilities known as concentrated animal feeding operations (CAFOs). The CAFOs typically contain large numbers of animals such as cattle, swine, horses, sheep, poultry, or ducks.

CAFOs are defined as "…a lot or facility (other than an aquatic animal production facility) where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and the animal confinement areas do not sustain crops, vegetation, forage growth, or post harvest residues in the normal growing season" (http://www.tceq.state.tx.us/). Operations defined as CAFOs are required to obtain permits. The type and number of animals on site determine how an Animal Feeding Operation (AFO) is categorized under the rules:

CAFOs feeding the following number of animals are classified as Large and require a permit:

- 1,000 veal calves and cattle other than mature dairy cattle
- 700 mature dairy cattle
- 2,500 swine weighing over 55 pounds
- 10,000 swine weighing less than 55 pounds
- 5,000 ducks (liquid manure handling system)
- 30,000 ducks (not using liquid manure handling system)
- 500 horses
- 10,000 sheep or lambs
- 55,000 turkeys
- 82,000 laying hens or broilers (not using liquid manure handling system)
- 30,000 laying hens or broilers (liquid manure handling system)
- 125,000 chickens (other than laying hens, if not using liquid waste handling system)

An AFO with the following number of animals that is located in the Dairy Outreach Program Area (Erath, Bosque, Hamilton, Comanche, Wood, Rains, and Hopkins Counties) is a medium CAFO:

- 300 to 999 veal calves and cattle other than mature dairy cattle
- 200 to 699 mature dairy cattle
- 3,000 to 9,999 swine weighing less than 55 pounds
- 750 to 2,499 swine weighing over 55 pounds
- 10,000 to 29,999 ducks (not using liquid manure handling system)
- 1,500 to 4,999 ducks (liquid manure handling system)
- 150 to 499 horse
- 3,000 to 9,999 sheep or lambs
- 16,500 to 54,999 turkeys
- 25,000 to 81,999 laying hens or broilers (not using liquid manure handling system)
- 9,000 to 29,999 laying hens or broilers (liquid manure handling system)
- 37,500 to 124,999 chickens (not laying hens and not using liquid waste handling system)

Any AFO may be designated a small CAFO by the executive director because it is a significant contributor of pollutants into or adjacent to water in the state. Any AFO that is designated a small CAFO must obtain written authorization from the TCEQ. Other operations can be designated CAFOs by the TCEQ, and are require to obtain a permit, if they are a significant contributor of pollutants into or adjacent to waters of the state.

Water quality concerns

Manure and wastewater from CAFOs have the potential to contribute pollutants such as nitrogen and phosphorus, organic matter, sediments, pathogens, heavy metals, hormones, antibiotics, and ammonia to the environment. Excess nutrients in water (i.e., nitrogen and phosphorus) can result in or contribute to low levels of dissolved oxygen (anoxia), eutrophication, and toxic algal blooms. These conditions may be harmful to human health and, in combination with other circumstances, have been associated with outbreaks of microbes such as <u>*Pfiesteria piscicida*</u>. Decomposing organic matter (i.e., animal waste) can reduce oxygen levels and cause fish kills. Pathogens, such as Cryptosporidium, have been linked to impairments in drinking water supplies and threats to human health. Pathogens in manure can also create a food safety concern if manure is applied directly to crops at inappropriate times. Nitrogen in the form of nitrate can contaminate drinking water supplies drawn from groundwater (USEPA AFO/CAFO FAQ).

Concerns about surface water quality in the study area are largely associated with animal feeding operations, though discharges from other agricultural uses and urbanized areas are also matters of concern. Many bodies of water in the study area have been placed on the Draft Texas 303(d) List for impairments resulting from elevated bacteria and depressed dissolved oxygen, along with concerns for nutrient enrichment. Other segments are listed for or exhibit concerns for some or all of the following: elevated bacteria, nutrient enrichment, Nitrate+Nitrite nitrogen, chloride, sulfate, total dissolved solids, pH, and depressed oxygen levels. (TCEQ, 2004, 303(d))

Currently there is no conclusive data showing that groundwater quality has been affected by CAFOs. TCEQ rules, 30 TAC Chapter 321, Subchapter B include provisions that are specifically related to groundwater protection, such as lining requirements for retention control structures and agronomic rates for waste and wastewater that are applied through an approved nutrient management plan (NMP). During the development of technical data to support CAFO permits, these rules require an evaluation of potential groundwater impacts from the facility and the waste management procedures that will be used for the operation. The pollution prevention plan regulatory requirements also include provisions for groundwater protection.

Regulations for CAFO

House Bill 2699 of the 77th Legislature, passed in 2001, mandated some specific monitoring and reporting activities by the TCEQ within the North Bosque River watershed. The bill directed the TCEQ to establish water quality monitoring sites in the North Bosque watershed, collect samples, and report the results on a quarterly basis. The bill further specified a list of parameters to be analyzed and reported, including orthophosphate-phosphorus (PO4-P). The legislation stated that the TCEQ is allowed to prescribe additional water quality control practices for AFOs by rule or general permit or to include additional provisions in an individual or general permit as necessary to protect water resources in the North Bosque River watershed.

The TCEQ adopted the current version of the CAFO rules on June 23, 2004. The primary purpose of the revision was to implement the new federal CAFO Regulations and Effluent Guidelines, also to implement the National Pollutant Discharge Elimination System (NPDES) CAFO Program under the Texas Memorandum of Agreement with the EPA regarding delegation of the federal NPDES program. In addition, the adopted rules addressed the North Bosque River Total Maximum Daily Load (TMDL) Implementation Plan to significantly reduce the amount of phosphorous (and other pollutants) discharged to waters in the state from dairy CAFO sources.

The composting program provides the primary means for trying to remove approximately 50% of CAFO manure from the North Bosque River watershed. Participation in the compost program will be voluntary, but may provide the most efficient way for some facilities to meet individual regulatory requirements. Agriculture permits for some facilities may require participation in the compost program or individual arrangements to accomplish the same result.

Bosque, Comanche, Erath, and Hamilton counties are involved with TCEQ's Dairy Outreach Program. This area of the state that has been identified as having water quality problems and concerns resulting from point and nonpoint source pollution from animal feeding operations. TCEQ rule Chapter 321, Subchapter B requires that CAFO operators within this area must complete an eight-hour course on animal waste management within 12 months of authorization, and an additional eight hours of training in animal waste management in each subsequent 24-month period. The Texas Cooperative Extension and the TSSWCB to address waste management issues and practices provide continuing education for agricultural producers in the area.

Perchlorate in Surface Water

The TCEQ's interim action level for perchlorate, the level that triggers an investigation but which is well below levels of health concern, is 4 ppb. Level of concern may be at rates at least ten times greater than the interim action. The health implication of perchlorate ingestion is also under investigation. The National Academy of Science (NAS) studies on health effects of perchlorate reported that the chemical, in high doses, can decrease thyroid function in humans, and that the chemical is present in many public drinking water supplies. The report also said daily ingestion of up to 0.0007 milligrams per kilogram of body weight could occur without adversely affecting the health of even the most sensitive populations. That amount is more than 20 times the "reference dose" proposed by EPA in recent draft risk assessment (Theodorakis, *et al*, 2006).

Perchlorate contamination was detected in the environment on and near the Naval Weapons Industrial Reserve Plant in McGregor, McLennan County, Texas. Perchlorate, a known thyroid endocrine disruptor, contaminates surface waters near military instillations where solid fuel rocket motors are manufactured or assembled. To assess potential perchlorate exposure to fish and the human population that may feed on them, fish were collected around the Naval Weapons Industrial Reserve Plant, and analyzed for the presence of the perchlorate anion. The sampling sites included Lake Waco and Belton Lake, and several streams and rivers within their watersheds. The general tendency was that perchlorate was only found in a few species sampled, and was not detected in every individual within these species. When detected in the fish, perchlorate tissue concentrations were greater than that in the water. This may be due to highly variable perchlorate concentrations in the water coupled with individual-level variation in elimination from the body, or to routes of exposure other than (Theodorakis, *et al*, 2006).

Water Supply and Identified Management Strategies

Water Supply Concerns This chapter summarizes data and information to evaluate whether the study area is experiencing or is expected to experience critical groundwater problems within the next 25-years. Discussions in this chapter address water supply concerns and environmental obligations. These discussions rely primarily upon work of the Region F, Brazos G, and Lower Colorado Region K Water Planning Groups; and information from the TWDB, TCEQ, and TPWD.

The study area was separated into two regions based on climatic conditions and location primarily on the Trinity aquifer outcrop or confined portion. The western region is composed of Brown, Callahan, Comanche, Eastland, Erath, Hamilton, Lampasas, and Mills counties. The eastern region is composed of Bell, Bosque, Coryell, Falls, Hill, Limestone, McLennan, and Somervell counties. Of all the counties in the planning areas, only Comanche and Hamilton, in the western region, are not projected to have water supply shortages in 2030.

Western Region

Recommended strategies to meet projected water supply shortages in Brown, Callahan, Eastland, Erath, Lampasas, and Mills counties (HDR, et al., 2005) are conservation, purchase from other entities, voluntary redistribution, additional Trinity aquifer development, brush control, and weather modification. It is anticipated that groundwater usage will remain constant in these counties through 2030. Table 15 summarizes water supply shortages and recommended actions to alleviate these shortages for the year 2030. A detailed description of shortages and recommended strategies by water user groups is presented in Appendix VII.

As indicated in Table 15, Eastland County is projected to have a substantial shortage of water in 2030. The majority of the water (9,224 acft) is used for irrigation, primarily on the outcrop of the Trinity aquifer, which covers 37.3 percent of the county. Based on current usage, about 66 percent of the irrigation water is from groundwater sources (Appendix V). Recommended actions to mitigate this shortage are conservation, brush control, and weather modification. After conservation figures are applied, the shortage is 8,079 acft and it is difficult to determine how brush control or weather modification can effect water consumption. There do not appear to be any long-term water level declines in the Trinity aquifer in Eastland County (Figure 12), which indicates that there has been no significant mining of the aquifer (Appendix V1, Hydrographs 31-51-205 and 31-43-702).

Table 15. Identified Water Supply Needs and Strategies to Address Needs, Western Region.

County	Region	2030 Shortage Ac-ft/yr	Recommended Actions
Brown County	F	(2,386)	Conservation and Purchase water from Brown County WID
Callahan County	G	(45)	Purchase water from Lake Coleman.
Eastland County	G	(9,439)	New Trinity aquifer supply, Connect to Westbound WSC, Purchase additional water from Eastland County WSD ,Conservation, Brush control, and Weather Modification
Erath County	G	(16)	Conservation and Additional Trinity aquifer development
Lampasas County	G	(862)	Conservation, Additional Trinity aquifer develop ment, and Purchase water from City of Lampasas.
Mills County	K	(618)	Conservation, Additional groundwater development, and Voluntary Redistribution from WUGs with surplus

Eastern Region

Recommended strategies to meet projected water supply shortages in Bell, Bosque, Coryell, Falls, Hill, Limestone, McLennan, and Somervell counties (HDR, et al., 2005) are conservation, voluntary redistribution, aquifer development (both the Trinity and Carrizo-Wilcox aquifers), purchase from other entities, and reuse. It is anticipated that groundwater usage will increase in these counties through 2030. Table 16 summarizes water supply shortages and recommended actions to alleviate these shortages for the year 2030. A detailed description of shortages and recommended strategies by water user groups is presented in Appendix VII.

Table 16. Identified Water Supply Needs and Strategies to Address Needs, Eastern Region.

County	Region	2030 Shortage Ac-ft/yr	Recommended Actions
Bell	G	(1,895)	Increase contracts with Central Texas WSC and Bluebonnet WSC, Conservation and Voluntary Redistribution from City of Temple.
Bosque	G	(5,713)	Conservation, Purchase water from City of Clifton through the Bosque County Regional Project, and BRA System Operation Supply to Bosque County
Coryell	G	(2,172)	Conservation, Additional Trinity aquifer development, and Increase Contract with Central Texas WSC
Falls	G	(483)	Purchase water from the City of Waco and Additional Carrizo-Wilcox aquifer development.
Hill	G	(528)	Conservation and BRA System Operation.
Limestone	G	(44)	Conservation and Development of the Carrizo-Wilcox aquifer.
McLennan	G	(32,444)	Conservation, Purchase water from City of Waco or from BRA System Operation, and/or reuse water from WMARSS.
Somervell	G	(329)	Conservation, Off-channel reservoir, Purchase water from City of Glen Rose, and Voluntary Redistribution from Steam-Electric

Wholesale Water Providers

The TWDB's definition of a Wholesale Water Provider (WWP) is: "… any person or entity, including river authorities and irrigation districts, that has contracts to sell more than 1,000 acft of water wholesale in any one year during the five years immediately preceding the adoption of the last Regional Water Plan. The Planning Groups shall include as wholesale water providers other persons and entities that enter or that the Planning Group expects or recommends to enter contracts to sell more than 1,000 acft of wholesale water during the period covered by the plan." Under this definition, the list of WWPs for the Central Texas study area is as follows:

Aquilla Water Supply
Bell County WCID No. 1
Bluebonnet WSC
Brazos River Authority
Brown County WID No. 1
Central Texas WSC
City of Waco
Eastland County Water Supply District
Lower Colorado River Authority
Upper Leon Municipal Water District

The RWPGs are required to prepare estimates of the water available to the Wholesale Water Providers within each region. For each WWP with a projected shortage, a water supply plan has been developed and is presented in Appendix VIII. For convenient reference, Table 17 shows which WWPs are projected to have shortages in 2030 and summarizes recommended actions to alleviate these shortages. Summaries for each WWP, including a brief description, contracts for water sales, and supplies are provided in Appendix VIII. Projected demands are total contracts or projected demands of customer entities, whichever is greater, and demands to be met from water management strategies recommended for that WWP.

Table 17. Identified Wholesale Water Provider Surplus/(Shortage).

Water User Group	Region	Surplus/ Shortage) 2030 (acft/yr)	Strategies to Meet Projected Shortages
Brown County WID No. 1	F	14.646	Projected surplus
Brazos River Authority (Lake Aquilla System)	G	(1,884)	BRA System Operation Surplus water supply from the Main Stem/Lower Basin
Brazos River Authority (Little River System)	G	(5,329)	Alternative: Additional Groundwater Development Alternative: Millican-Bundic Reservoir Alternative: Little River Off-Channel Reservoir
Brazos River Authority (Main Stem System)1	G	(207,433)	The BRA applied to the TCEQ for an additional appropriation of water to be developed by using its system of reservoirs to firm up uncontrolled runoff entering the basin below its reservoir system
Aquilla Water Supply District	G	(1,561)	BRA will increase supplies to Lake Aquilla through BRA System Operations
Bell County WCID No. 1	G	(275)	Purchase additional water supplies through an existing contract with BRA
Bluebonnet WSC	G	4,417	Projected surplus
Central Texas WSC	G	954	Projected surplus
Upper Leon MWD	G	975	Projected surplus
Eastland County WSD	G	2,980	Projected surplus
City of Waco	G	25,638	Projected surplus
LCRA (Supplies water to Lometa, Lampasas County, Region G)	K	882	Projected surplus

1 Does not include Region H portion.

Natural Resource and Habitat Loss Concerns

Overall, the strategies recommended in the 2006 Regional Water Plans will have limited negative effects on the environment. Many of the supply strategies rely on the Brazos River Authority System Operations, which has a permitted request for more than one million acre-feet. Removal of that amount of water has the potential of significantly altering flows in the Brazos River. However, at present, limited specific information is available related to the management of the System Operations, making it difficult to assess any ecological impact.

Water-related concerns for natural resources in the study area are primarily related to water purveyors using existing reservoirs or developing new reservoirs to meet future needs. The largest localized impacts will be from new reservoirs. The Wheeler Branch Off- Channel Reservoir, the only new reservoir recommended as a strategy in the 2006 Brazos G Plan, will inundate less than 169 acres,

reducing wildlife habitat, bottomland hardwood forestland, and cultivated farmland. However, permitting for this project will require mitigation land of at least equal ecological value, reducing the negative environmental consequences of the projects.

For the 2001 Regional Plan, the Lower Colorado Region K water-planning group passed a resolution "supporting the efforts of residents in Mills County and adjoining areas to construct water supply projects involving dams and reservoirs for water supply and the construction of pipelines and other facilities related thereto". There are three preliminary projects under development by the Fox Crossing Water District and Donald G Rauschuber & Associates. These sites include off-channel reservoir alternatives for Pompey Creek and Bennett Creek that will inundate 765 acres, and an in-channel reservoir alternative on the Colorado River (size is undetermined). To date, there are no engineering technical reports evaluating these locations other than a site map created by the Natural Resources Conservation Service (NRCS).

These strategies raise concerns about changes to historic reservoir levels, changes to natural flow conditions and water quality, and inundation of valuable land and limited habitat. Regional water plan strategies to increase use of some reservoirs may lower lake levels during severe drought. This will not have any additional adverse impact on the water resources or on parks and public lands beyond that which has already been allowed in their existing water rights permits.

Long-term decreases in flow can exacerbate water quality problems and affect the species that are directly and indirectly dependent upon freshwater resources. The TCEQ has documented concerns over water quality impacts to aquatic life or fish consumption in a number of surface water reaches in the study area. In general, these concerns are due to low dissolved oxygen levels or levels of pesticides or other pollutants that can harm aquatic life or present a threat to humans eating fish in which these compounds tend to accumulate.

Reservoir development, groundwater drawdown, and return flows of treated wastewater have greatly altered natural flow patterns in the study area. Since the late 1880's, spring flows in the study area have diminished and many springs have dried up because of groundwater development. The resulting water-level declines have reduced groundwater discharge flows to many tributary streams. While few species depend directly on groundwater resources, the springs from groundwater discharge contribute to the surface water hydrology thus helping shape study-area ecosystems.

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WATER PLANNING AND REGULATION

State law requires this report to consider the need for groundwater management by a groundwater conservation district (GCD). Part of this consideration is to understand the groundwater planning and regulatory functions of existing entities. An understanding of the roles, responsibilities, relationships, and abilities of existing entities in effective groundwater resource management must be acquired. Entities that may be involved with groundwater management activities include local municipalities; counties; state and federal government; regional planning authorities and commissions; regional surface water and groundwater management authorities; regional, municipal, and private water suppliers; and major agricultural, industrial and commercial water users. Water planning and regulatory functions of existing entities and GCDs are described in this chapter.

State and Regional Water Planning

Water planning efforts at the state level are the responsibility of the Texas Water Development Board (TWDB) that prepares a statewide water plan using information provided by regional stakeholders and other state water agencies. State law directs the TWDB to coordinate a regional water planning process and to develop a State Water Plan that incorporates regional water plans, resolves interregional conflicts, provides additional analysis, and makes policy recommendations to the Texas Legislature. State and regional water planning is a dynamic process with each type of plan updated on a five-year cycle.

There are 16 TWDB-delineated regional water planning areas covering the state, and a regional water-planning group (RWPG) for each of these areas. The RWPGs consist of members representing the public, counties, municipalities, industry, agriculture, environmental groups, small business, electric generating utilities, river authorities, water districts, and water utilities. The RWPGs are required to develop a regional water plan, establish policies, make decisions, and consider interest groups in the development of the plans consistent with Texas Water Code requirements. The development of a regional water plan includes studies, decisions, and recommendations on water supply needs. The purpose of the plan is to identify and recommend methods or strategies to conserve water supplies, meet future water supply needs, and respond to future droughts in the region.

The Central Texas (Trinity) area is divided among the 37-county Brazos G Regional Water Planning Area, the 14-county Lower Colorado Region K Water Planning Area, and the 32-county Region F. Each of the three study-area RWPGs adopted and submitted their initial regional water plans to the TWDB in January 2001. The 2001 regional water plans were incorporated into the 2002 State Water Plan that was adopted by the TWDB on December 12, 2001 (TWDB, 2002). The second round of regional water plans were adopted and submitted to the TWDB in January 2006. The TWDB has approved the 2006 regional water plans for the three RWPGs area study. The TWDB adopted the 2007 State Water Plan on November 14, 2006.

In addition to its water planning responsibilities, the TWDB collects and analyzes data to support its planning functions, and administers water development funds under state and federal programs. Water development funds generally are available as low interest loans and some as grants to local and regional governments for water supply and wastewater planning, feasibility studies, and infrastructure development. TWDB financial assistance may be provided only to water supply projects that meet needs in a manner that is consistent with an approved regional water plan.

Groundwater Conservation District Management Planning

Groundwater conservation districts are statutorily charged and authorized to manage groundwater resources by providing for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater resources within their jurisdictions. In addition to groundwater management planning as outlined below, GCDs also manage groundwater resources by adopting necessary rules. These rules are used to implement management plans; require permits for drilling, equipping, or completing wells that produce more than 25,000 gallons per day or for alterations to well size or well pumps; and require records to be kept of the drilling, equipping, and completion of water wells, as well as on the production and use of groundwater resources.

Every GCD in Texas is required to develop, in coordination with surface-water management entities, a comprehensive management plan that addresses the groundwater management goals of the district. Texas Water Code, Chapter 36 outlines the general contents of a groundwater management plan and the requirements for its adoption by the GCD's governing board of directors and approval by the TWDB. These GCD plans must include specific groundwater management goals to address:

- the most efficient use of groundwater,
- control and prevention of waste of groundwater,
- control and prevention of subsidence,
- conjunctive surface water management issues,
- natural resource issues that impact the use and availability of groundwater and which are impacted by the use of groundwater,
- drought conditions,
- conservation and specific conservation practices, and
- desired future conditions of groundwater resources.

GCD management plans must be developed by the district using the best available data and forwarded to the regional water planning group(s) for use in their planning process. The plans must identify management objectives and performance standards under which the district will operate to achieve management goals. The GCD management plans must also consider the water supply needs and water management strategies included in the adopted State Water Plan. The GCD management plans take effect on approval by the TWDB. The GCDs must readopt management plans with or without changes at least once every five years.

Groundwater conservation districts are authorized to manage groundwater resources by adopting rules and permit requirements for the spacing of water wells, regulating the production of wells, and for transferring groundwater out of the district. New GCDs may not adopt rules limiting the production of wells until their management plan has been approved by the TWDB. GCDs may also undertake projects to recharge aquifers; survey, monitor, evaluate, and research groundwater quantity and quality; and protect groundwater quality by adopting well construction standards more stringent than state standards and requiring the closure of abandoned water wells. No other such entities are authorized with these broad powers to manage groundwater resources. Four GCDs have been established in the study area.

With the passage of Senate Bill 714 (80^{th} Legislature, Regular Session) by Senator Troy Fraser, GCDs are authorized effective September 1, 2007, to adopt rules that require the owners or operators of water supply wells for oil and gas drilling or exploration to report groundwater usage to the district.

Joint GCD Management Planning in Groundwater Management Areas

In accordance with Texas Water Code, Chapter 35, the TWDB has delineated 16 Groundwater Management Areas (GMAs) for the state. A GMA is the delineated area that is suitable for groundwater management. State law requires GCDs in a common GMA to conduct joint planning for the common groundwater resources. The study area is included in GMA #8 for the Trinity aquifer and there are presently four GCDs in the southern part of GMA #8 (Figure 15). Bell County makes up the Clearwater UWCD, Comanche and Erath counties make up the Middle Trinity GCD, Lampasas County makes up the Saratoga UWCD, and Mills County makes up the Fox Crossing WD (Figure 15). Also included in GMA #8 are two GCDs that are not included in the study area, Burnet County makes up the Central Texas GCD and Milam County is part of the Post Oak Savannah GCD.

The presiding officer or the presiding officer's designee of each GCD located in whole or in part in a GMA must meet at least annually to conduct joint planning with the other districts in the management area and to review the management plans and accomplishments for the management area. The districts are required to consider the goals and effectiveness of each management plan and each management plan's impact on planning throughout the management area. Before September 1, 2010, and every five years thereafter, the GCDs in the GMA must consider groundwater availability models and other data and establish the desired future conditions for relevant aquifers within the GMA. Desired future conditions are the desired, quantified conditions of groundwater resources (such as water levels, water quality, spring flows, or volumes) at a specified time or times in the future or in perpetuity. In essence, a desired future condition is a management goal that captures the philosophy and policies addressing how an aquifer will be managed. Different desired future conditions may be established for each aquifer, subdivision of an aquifer, or geologic strata; or each geographic area overlying an aquifer or subdivision of an aquifer. Each GCD must then ensure that its management plan contains goals and objectives consistent with achieving the desired future conditions of the relevant aquifers as adopted in this joint planning process. Through these cooperative efforts, local GCDs can effectively provide coordinated regional management of a shared groundwater resource.

The TWDB will provide each GCD and RWPG in the GMA with the managed available groundwater in the GMA based on the established desired future conditions for the groundwater resources. The state law includes provisions for mediation and court appeal processes for cases of regional water plan - GCD management plan conflict and TWDB management plan approval - GCD disagreement. Regarding joint GCD management planning, a GCD or a person with a legally defined interest in groundwater in the GMA may petition the TCEQ for a review panel inquiry if a GCD does not join in the planning process or if the process failed to result in adequate planning, including the establishment of the desired future conditions of the aquifers.

GCD management plans adopted after the joint planning process has been completed will include the new management goal to address in a quantified manner the desired future conditions of the groundwater resources. The management plan must also include an estimate of managed available groundwater in the district based on the desired future condition established under a new coordinated GCD management planning process. Because managed available groundwater is defined by the desired future conditions, groundwater conservation districts, working collectively within each GMA, define groundwater availability for the regional water planning process.

At present, the statute does not provide representation to areas in a GMA that lie outside of a GCD; therefore, any area outside of a GCD does not have representation in GMA matters. GCDs in some GMAs are including nonvoting representation from areas without GCDs. This is an important issue to

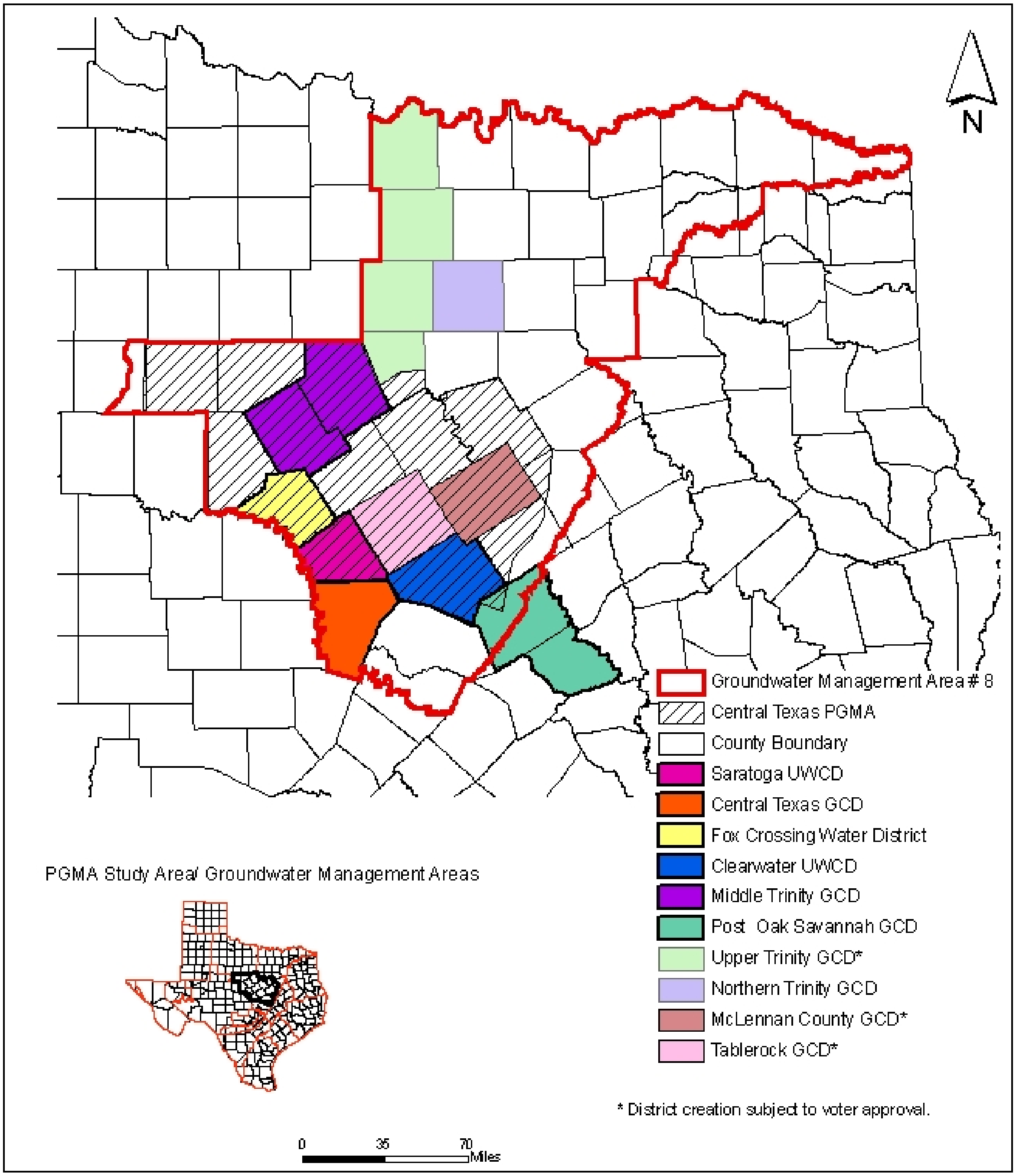

Figure 15. Groundwater Management Area #8 and Groundwater Conservation Districts, Central Texas (Trinity Aquifer) PGMA Study.

note because the desired future condition statements that will be used to calculate managed available groundwater for the entire GMA, including areas with no GCDs. These managed available groundwater determinations will be used by RWPGs in their plans. (TWDB Web Page at http://www.twdb.state.tx.us/GwRD/GCD/faqgma.htm#gma1 , accessed April 12, 2006).

Federal Regulatory Agencies

The U.S. Environmental Protection Agency (USEPA) and the U.S. Nuclear Regulatory Commission are federal agencies responsible for enforcing numerous federal laws for protecting groundwater resources. Generally, these agencies have delegated the administration of federal regulatory programs to individual states, or occasionally to local authorities. For example, the USEPA that has authority over the Resource Conservation and Recovery Act; the Comprehensive Environmental Response, Compensation, and Liability Act; the Clean Water Act; and the Safe Drinking Water Act has delegated administration of these programs in Texas to the TCEQ.

The U.S. Fish and Wildlife Service (USFWS) is a bureau within the Department of the Interior that works to conserve, protect, and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people. Among its key functions, the USFWS enforces federal wildlife laws, protects endangered species, manages migratory bird habitat, restores nationally significant fisheries, and conserves and restores wildlife habitat.

The U.S. Army Corps of Engineers (USCOE) mission is to provide quality, responsive engineering services to the nation including: planning, designing, building and operating water resources and other civil works projects (navigation, flood control, environmental protection, disaster response, etc.); designing and managing the construction of military facilities for the Army and Air Force. (Military Construction); and, providing design and construction management support for other Department of Defense and federal agencies. The study area is located in the USCOE's Southwestern Division in the Fort Worth District. The USCOE oversees six reservoirs in the study area including Lake Aquilla, Lake Proctor, Lake Somerville, Lake Belton, Lake Stillhouse Hollow, and Lake Whitney.

The U.S. Department of Agriculture (USDA) administers numerous programs at the local level to protect and conserve water resources. The USDA Farm Service Agency's Conservation Reserve Program (CRP) undertakes programs to reduce soil erosion and sedimentation in streams and lakes, improve water quality, establish wildlife habitats, and enhance wetland resources. The CRP encourages farmers to convert highly erodible cropland or other environmentally sensitive areas to vegetative cover such as native grasses. The USDA Natural Resource Conservation Service (NRCS) provides technical assistance to landowners, communities, and local governments in planning and implementing conservation programs. The USDA/NRCS's national Farm*A*Syst and Home*A*Syst programs promote voluntary assessments to prevent pollution. Systematic worksheets allow individuals to apply site-specific management practices to their property.

State Regulatory Agencies

State agencies do not have authority to manage or regulate groundwater resources. The roles of state agencies in addressing the problems and concerns identified in the study area are limited to water quality protection. Groundwater quality protection is managed primarily through the regulation of waste management or implementation of best management practices (BMPs), water resource planning, and project funding, and facilitation of groundwater management activities through the creation of GCDs. State law does not provide any state agency the authority to control groundwater pumpage or use.

The TCEQ is the state's primary environmental regulatory agency. TCEQ administers the supervision program for public drinking water systems and has primary responsibility for public water system aspects of the federal Safe Drinking Water Act. TCEQ also implements state and federally delegated programs. Among its other regulatory authorities are surface water rights permitting; creation and supervision of water districts; industrial, municipal and hazardous waste management; and water quality protection. In relation to water planning, the TCEQ cannot issue a water right for municipal purposes unless it is consistent with an approved regional water plan.

Other state agencies such as the Texas Parks and Wildlife Department (TPWD), Railroad Commission of Texas (RCT), Department of State Health Services (DSHS), Texas Department of Agriculture (TDA), Texas Department of Licensing and Regulation (TDLR), and the Texas State Soil and Water Conservation Board (TSSWCB) have management or regulatory responsibilities for some activities related to environmental protection. The TPWD is the state agency with primary responsibility for protecting the state's fish and wildlife resources. The TDLR licenses water well drillers and pump installers while also enforcing water well construction, water-quality protection, setback rules, and well plugging rules. The TSSWCB administers the Texas Soil Conservation Law and offers a technical assistance program to the state's 216 soil and water conservation districts (SWCDs). The TSSWCB is the lead agency for the planning, management and abatement of agricultural and silvicultural (forestry) nonpoint source pollution (TGPC, 2005).

Local Government and Regional Councils

Counties and municipalities typically carry out public health programs such as disposal of municipal solid waste; production, distribution, and protection of public drinking water supplies; and treatment and discharge of municipal wastewater. Local government can also accomplish other activities such as regulating underground storage tanks, implementing wellhead and source-water protection programs, inspecting and regulating septic tanks, and public-health administration. Texas Water Code, Section 26.177 governs the duties of cities in the area of water pollution control and authorizes cities to adopt and implement water pollution abatement plans.

The Local Government Code, §§212.0101 and 232.0032 provide groundwater availability certification authority to all municipal and county platting authorities in the state. Under this statute, a municipal platting authority or county commissioner’s court may require a person submitting a plat for the subdivision of a tract of land for which the intended source of water supply is groundwater under that land to demonstrate adequate groundwater is available for the proposed subdivision. If the local platting authority under the Local Government Code requires groundwater availability certification, the plat applicant must evaluate groundwater resources and prepare the availability certification pursuant to TCEQ rules. The rules in Title 30, Texas Administrative Code, Chapter 230 establish the appropriate form and content of a groundwater availability certification. Exercising this authority under the Local Government Code can be an effective groundwater management tool in areas undergoing significant growth and development. This tool, however, is limited because it can only be used to address site-specific cases of land subdivision and does not allow for aquifer-wide or regional considerations. Daniel B. Stephens & Associates, Inc. (2006) report that Comanche, Coryell, Erath, Falls, Hamilton, McLennan, and Mills counties do not exercise this authority in their plat application processes, and TCEQ staff are unaware of any local government in the study area presently exercising this authority.

Regional councils or councils of governments (COGs) are voluntary associations of local governments formed under Texas law. These associations deal with the problems and planning needs that cross the boundaries of individual local governments or that require regional attention. Regional services offered by councils of governments are varied. Services are undertaken in cooperation with member governments, the private sector, and state and federal partners, and include:

- planning and implementing regional homeland security strategies;
- operating law enforcement training academies;
- providing cooperative purchasing options for governments;
- managing region-wide services to the elderly;
- maintaining and improving regional 9-1-1 systems;
- promoting regional economic development;
- operating specialized transit systems; and
- providing management services for member governments.

In addition, Texas' regional councils of governments are responsible for regional planning activities that may differ from region to region, but typically include planning for economic growth, water supply and water quality, air quality, transportation, emergency preparedness, and the coordinated delivery of various social services. Many councils of government establish and host region-wide geographical information systems (GIS) as well as databases on regional population, economic, and land-use patterns (Texas Association of Regional Councils, 2006). State law mandates that COGs have primary responsibility for the development of regional municipal solid waste plans. Regional solid waste plans must conform to the state plans and be adopted by TCEQ rule.
The four COGs represented within the study area and the representative counties are as follows:

- Central Texas Council of Governments (Bell, Coryell, Hamilton, Lampasas, and Mills);
- Heart of Texas Council of Governments (Bosque, Falls, Hill, Limestone, and McLennan);
- North Central Texas Council of Governments (Erath and Somervell); and
- West Central Texas Council of Governments (Brown, Callahan, Comanche, and Eastland).

Water Purveyors

Wholesale and retail public water suppliers are of the utmost importance as water management entities because of their responsibilities to provide safe, reliable water to their customers. These water purveyors (Figure 16) can include municipalities, water supply corporations, water supply districts, investor-owned utilities, and water conservation and irrigation districts. In accordance with TCEQ rules (Title 30, Texas Administrative Code, Chapter 288), all public water suppliers are required to develop and implement water conservation plans, and wholesale and retail public water suppliers serving more than 3,300 connections and irrigation districts are required to develop drought contingency plans and to submit the plans to the TCEQ. Retail public water suppliers serving less than 3,300 connections are also required to develop drought contingency plans but are only required to submit them to the TCEQ upon request.

A water conservation plan is basically a strategy or combination of strategies for reducing the volume of water withdrawn from a water supply source, for reducing the loss or waste of water, for maintaining or improving the efficiency in the use of water, for increasing the recycling and reuse of water, and for preventing the pollution of water. Quantified five- and ten-year targets for water savings must be included in all water conservation plans. Water conservation plans help suppliers determine how much water they and their customers can save, what actions they can take to help save water, and what educational efforts are needed to encourage conservation.

The next required revision of the water conservation plans must be submitted to the TCEQ no later than May 1, 2009 to coincide with the regional water planning process. In addition to the revised water conservation plans, implementation reports of a water conservation plan must be submitted to the TCEQ no later than May 1, 2009. The implementation reports should describe measures that have been taken, whether targets have been met, and provide data about actual quantities of water saved.

A drought contingency plan is defined as a strategy or combination of strategies for temporary supply management and demand management responses to temporary and potentially recurring water supply shortages and other water supply emergencies. Unlike water conservation, which focuses on the ongoing maintenance and efficiency of the water supply system and customers' water-use habits, drought contingency is triggered by cases of extreme drought, periods of abnormally high usage, supply contamination, or extended reduction in ability to supply water due to equipment failure.

Any entity applying for a new water right or an amendment to an existing water right must prepare and implement a water conservation/drought contingency plan and submit the plan with the application. The TCEQ is required to determine whether requested appropriations of state water are reasonable and necessary for the proposed use(s), and that the water rights applicant will conserve and avoid wasting water.

A TCEQ issued certificate of convenience and necessity (CCN) defines a water purveyor's service area. The purveyor's system might not extend to the limits of this service area, but other utility service providers generally may not encroach upon the service area. If anyone in this area applies for service, the supplier generally must serve the applicant. Water purveyors may use one or more systems to serve their area. Counties within 50 miles of the Mexican border, investor-owned utilities, or water supply corporations must obtain a CCN. Cities, districts, and other counties are not required to obtain a CCN. TCEQ rules regarding CCNs are found in Title 30 Texas Administrative Code, Chapter 291. An April 2006 query of the TCEQ water utilities database indicated there are 190 active public water supply systems using groundwater sources in the 16-county study area.

The 2006 Regional Water Plans identify 10 regional wholesale water providers in Region G and one regional wholesale water provider in each of Region F and Region K. The regional wholesale water providers supply large amounts of water to several customers that include:

City of Waco,
Bell County WCID No. 1,
Bluebonnet WSC,
Central Texas WSC,
Aquilla WSD,
Upper Leon MWD,
Eastland County WSD,
Brazos River Authority (Lake Aquilla System),
Brazos River Authority (Little River System),
Brazos River Authority (Main Stem System),
Brown County WID No. 1, and
Lower Colorado River Authority (Supplies water to Lometa, Lampasas County, Region G)

The Texas Water Conservation Implementation Task Force (created by the 78th Legislature, Senate Bill 1049) identified 22 best management practices (BMPs) to conserve water resources that can be effectively administered by public water suppliers, and an additional 33 BMPs that can be exercised by industrial and agricultural water users. The Task Force uses a working definition of conservation as those practices, techniques, programs, and technologies that will protect water resources, reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses. The BMPs and cost effectiveness considerations are identified for the state's regional water planning groups, water providers, and water users as tools for planning and designing effective conservation programs. Each BMP is organized to be of assistance in conservation planning, program development, implementation, and evaluation (TWDB, 2004). As of May 1, 2006, one public water system in the study area suggested that customers voluntarily limit water use to avoid shortages, one system was restricting water use, and one system was prohibiting outdoor watering (http://www.tceq.state.tx.us/permitting/water_supply/pdw/trot/droughtw.html).

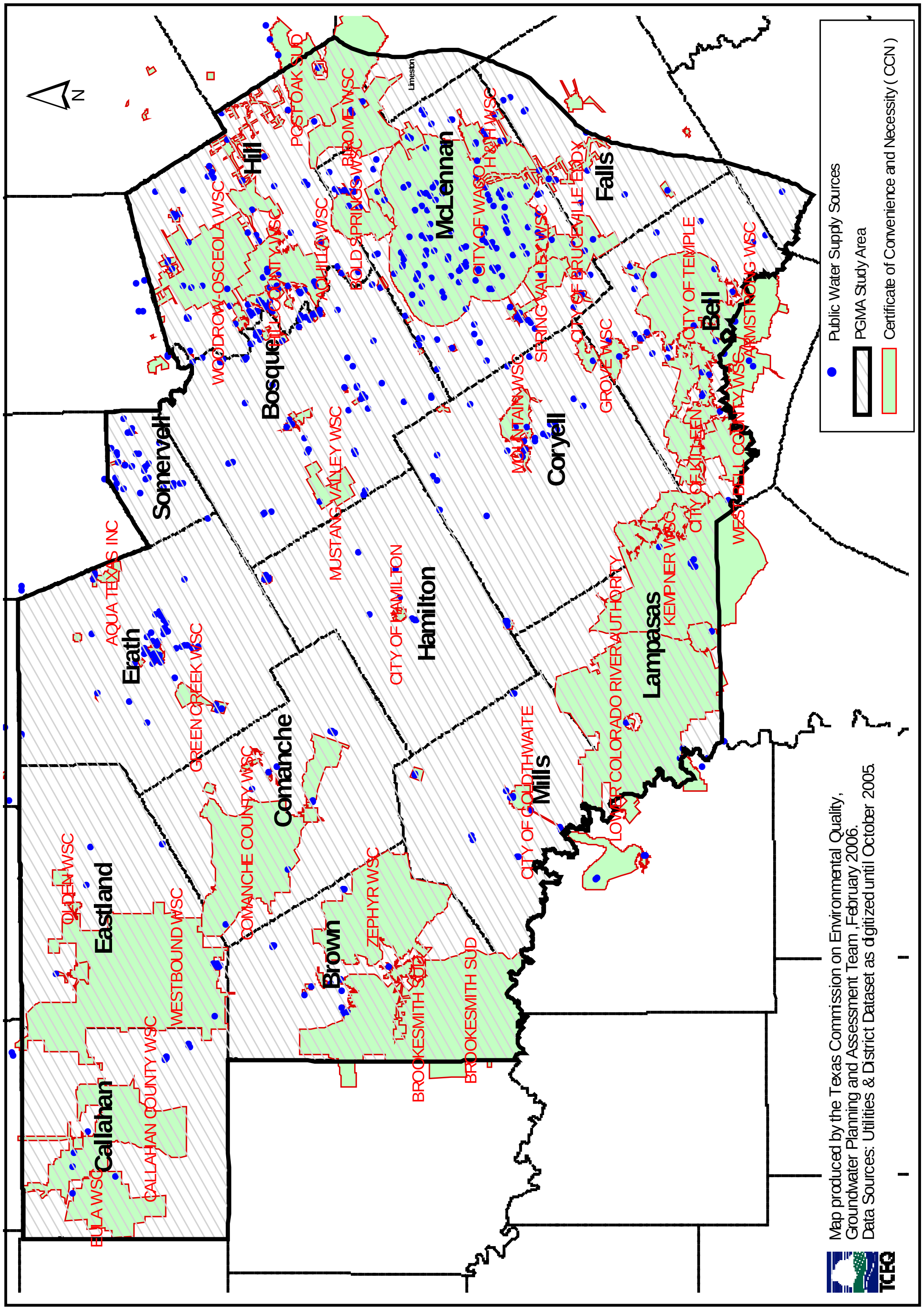

Figure 16. Public Water Supply Wells and Certificates of Convenience and Necessity, Central Texas (Trinity Aquifer) PGMA Study Area.

ADMINISTRATIVE FEASIBILITY OF GROUNDWATER MANAGEMENT

In the study area there are all or part of five groundwater conservation districts leaving all or part of eleven counties with no means of groundwater management. Therefore, the feasibility of managing groundwater resources within the study area is presented within this section. Groundwater management approaches that can be used by groundwater conservation districts are evaluated. Area-specific groundwater management strategies, economic and financial considerations, and available district-creation options are discussed below.

Groundwater Management Approaches

Various mechanisms are available for protecting groundwater resources in an area. They range from imposing restrictions on groundwater withdrawals to developing alternate supplies, to conjunctively using both surface water and groundwater. The water suppliers in the study area are implementing the latter two measures.

Local or regional groundwater conservation districts (GCDs) are the state's preferred method of managing groundwater resources. They are the only entities in Texas explicitly granted the power to regulate groundwater withdrawals. These districts are charged with managing groundwater by conserving, preserving, protecting, recharging, and preventing wastage of the groundwater resources within their jurisdiction. Managing groundwater is accomplished using the following approaches or techniques:

- water resource planning;
- groundwater resource assessment and research;
- monitoring of water levels, water quality and land subsidence;
- well inventory, registration, permitting and closure;
- limiting withdrawals and well interference through well spacing or setback requirements;
- well pumpage or use limitations; and
- use of engineered structures or injection wells to enhance natural recharge or artificially recharge groundwater aquifers.

Through groundwater monitoring (both quantity and quality) and assessment functions, a GCD can quantify groundwater resources, study and investigate aquifer characteristics, and identify groundwater problems that need to be addressed. Planning functions outline appropriate management objectives and goals for the district to preserve and protect groundwater resources and GCD rules are adopted to achieve the management planning objectives and goals.

Groundwater conservation districts are required to establish a water well permitting and registration program, and through this program can quantify aquifer impacts from pumpage. An efficient program for water well inventory, permitting, and registration allows a GCD to establish an overall understanding of groundwater use and production within the district. Permits must be obtained from a GCD to drill, equip, or complete nonexempt water wells, or substantially alter the size of wells or well pumps. Certain types of water wells are exempted from GCD permitting by state law, and each district is authorized to provide exemption for other wells through their rulemaking procedures. Wells exempted from regulation by statute or by district rule must be registered with the district before being installed and be completed and maintained in accordance with the district’s rules regarding prevention of waste and pollution of the groundwater. The wells that are exempt from GCD permitting by state law generally include (1) domestic or livestock wells incapable of producing 25,000 gallons per day located on tracts of land larger than 10 acres and (2) wells supplying water for exploration, production, and other activities permitted by the Railroad Commission of Texas (RCT). If the use of an exempted well changes from its original purpose, it must then obtain a permit consistent with all other like-use wells in the GCD. Also, an entity holding a surface-mining permit issued by the RCT that authorizes the drilling of a water well can be required to make monthly reports to a GCD about the total amount of water withdrawn during the month, the quantity of water necessary for mining activities, and the quantity of water withdrawn for other purposes. With the passage of Senate Bill 714 (80^{th} Legislature, Regular Session) by Senator Troy Fraser, GCDs are authorized effective September 1, 2007, to adopt rules that require the owners or operators of water supply wells for oil and gas drilling or exploration to report groundwater usage to the district.

Groundwater conservation districts may also adopt rules to regulate the spacing and production of water wells. Spacing regulations are generally adopted by a district to minimize drawdown of water levels (both water table and artesian), control subsidence, prevent waste, and prevent interference from nearby wells. Spacing and production regulations are commonly based on the following criteria:

- minimum distances from other wells or property lines,
- maximum number of wells in a specified area (e.g., ¼-section, ½-section, or full-section), and
- maximum allowable production per a given unit of land (e.g., 5 gallons per minute per acre or one acre-foot of production per year per acre of land).

The next three considerations go hand-in-hand: district size, representation on the district's board of directors, and funding for district operations. Regarding district size, eight of the first ten GCDs created in the state included multiple counties, and additional territory and counties have been added to five of these eight districts over the ensuing years. Starting in the mid 1980s and with few exceptions prior to 2001, single-county groundwater conservation districts became the predominant choice of Texas citizens. Multi-county GCDs covering larger portions of aquifers have increased in popularity this decade and represent about 30 percent of the new districts created since 2001.

State law was amended in 2005 to require coordinated groundwater management planning by GCDs in a common groundwater management area (GMA). Groundwater management areas such as GMA #1 for the northern part of the Ogallala aquifer and GMA # 10 for the San Antonio and Barton Spring segments of the Edwards aquifer are predominantly covered by larger, multi-county GCDs that exercise consistent regulation and effective conservation and management planning on a large or even aquifer-wide scale. Greater coordination and effort is required to achieve GMA planning objectives when multiple single-county GCDs or a few multi-county GCDs are created within the same groundwater management area and each district operates under its own rules and regulations to manage the groundwater resource. Because these GCDs share common groundwater resources, state law requires coordination of their efforts to manage the resource. This law is discussed further in the section on District Creation Options.

The board of directors for most GCDs ranges from five to 11 members, and under general law, they are elected to serve staggered four-year terms. Most single-county GCDs have five directors although some have as many as nine directors. At this size, board members are normally chosen either, from five single-member precincts within the county or from four county commissioners' precincts with one elected from the county at-large. The largest GCD in the state, the High Plains Underground Water Conservation District No. 1, comprises all or part of 15 counties and has five directors. The High Plains district and a few others use County Committees to review water well permit applications, make recommendations to the board for approval or denial of these permits, make recommendations to the board concerning programs and activities that the committee believes will be beneficial for the county they serve, and advise the board and district staff on water-related issues in their county that require district attention. GCD directors are not entitled to receive a salary; however, they may receive fees of office of not more than $150 a day for each day the director spends performing district duties. These fees of office are limited by state law not to exceed $9,000 a year. GCD directors are also entitled to receive reimbursement of actual expenses incurred while engaging in activities on behalf of the district.

Last of all, considerations must be made to determine the most feasible way to finance GCD operations – through taxes paid by all residents or through fees paid by large groundwater users. Local leadership and interested citizens must make realistic estimates for revenue that will be needed to fund meaningful groundwater management activities and determine which finance method would be most acceptable to the area residents.

Other types of regional, county, or local governments do not have the statutory authority to regulate groundwater production. Municipal platting authorities and county commissioners' courts have permissive authority to require plat applicants to demonstrate that sufficient supplies are available to support groundwater-dependent subdivisions when fully developed. Municipalities and water purveyors can indirectly limit groundwater withdrawals by implementing and enforcing water conservation measures. Municipalities, water supply districts, and river authorities play key roles in the development of alternative supplies such as surface water reservoirs or reuse systems that can reduce dependence on groundwater. Public water suppliers are required to prepare drought contingency plans and to implement the plans during times of water shortages and drought. These drought contingency plans generally call for mandatory water conservation and address options for alternate supplies during times of shortage.

The RWPGs and regional water plans support the creation of local groundwater conservation districts (GCDs). The plans support the philosophy of the creation of groundwater conservation districts that consider developing multi-county districts, or single-county districts with shared management and costs. The Brazos G Regional Water Plan notes that GCDs are created in part to manage competing interests in groundwater supplies (Brazos G Regional Water Planning Group et al., 2006). Hydrological impacts of the competing interests should be considered during the creation of GCDs in order to provide for the conservation, preservation, protection, recharging, and prevention of waste of groundwater.

The regional water plans are required to consider current water availability and use, existing water supply plans, and drought contingency plans during the development of their regional water plans. The regional water planning groups are charged to include potentially feasible water management strategies, including groundwater strategies, within their regional water plans. The regional water planning groups are also designed to involve the stakeholders and the public in water issues both at a local and regional level. Such participation should improve the development of management, conservation, and reclamation practices for those lives and livelihoods that depend on protection of their common water resources.

Groundwater Management Strategies

The 2006 Brazos G Regional Water Plan suggests that specific data, analyses, and tools are needed to make major improvements in the accuracy and reliability of determining groundwater availability estimates. Included in these suggestions are the following functions commonly administered by GCDs:

- frequent measurements at dedicated wells to document long-term water level trends,
- infrequent or annual water-level measurements from a network of wells to construct accurate water level or potentiometric surface maps to show regional flow patterns and the extent of and influences of pumping,

- data collection from a precipitation gauge network and shallow water-level monitoring wells in outcrop areas to better estimate recharge,
- collection of data for gain-loss studies though monitoring networks to measure state and discharge of streams and water levels in nearby shallow wells,
- collection of accurate well pumpage data,
- refinement of aquifer-wide Groundwater Availability Models (GAMs),
- annual sampling and analyses from a network of wells to understand baseline ambient water quality and trends in water quality, and
- targeted sampling and analyses in areas where groundwater quality is vulnerable to contamination from anthropogenic activities.

Several water supply problems were identified in the study area. These include lack of drought-reliable groundwater supplies for both short-term drought and long-term economic development, lack of firm supplies for municipal and mining use, water-level declines in the Trinity aquifer wells due to low permeability and excessive pumping, potential groundwater impacts from new mining or industrial well development, and mining of groundwater from aquifer storage to meet future demands. Opportunities for the study area include participation in regional water planning and cooperation with local water supply, conservation, and education entities. The following management strategies are suggested for the area to address identified problems and issues:

- quantify groundwater availability and quality, understand aquifer characteristics, and identify groundwater problems that should be addressed (both quantity and quality) through aquifer- and area-specific research, monitoring, data collection, and assessment programs;
- quantify aquifer impacts from pumpage and establish an overall understanding of groundwater use through a comprehensive water well inventory, registration, and permitting program;
- establish programs that encourage conservation of fresh groundwater and the use of poorer-quality groundwater when feasible and facilitate such transitions;
- evaluate and understand aquifers sufficiently to establish spacing regulations to minimize drawdown of water levels and to prevent interference from neighboring wells;
- establish educational programs, for school children and for the general public, to increase awareness of the limited water resources and actions that can be taken to conserve the resources;
- protect water quality by requiring water well construction to be protective of fresh-water zones and by administering a program to locate and plug abandoned water wells; and
- participate in the regional water planning process, refining of groundwater availability models, and regional groundwater management/protection programs with other central Texas GCDs and existing water supply entities.

The study area could benefit from GCD monitoring, assessment, planning, and permitting programs as well as water well spacing and well closure programs for the Trinity aquifer. Implementation of any or all of the above management programs would benefit the study area by protecting groundwater resources. These programs could best be implemented by a GCD that could benefit the study area by implementing groundwater management strategies as authorized by Texas Water Code, Chapter 36.

Financing Groundwater Management Programs

Obtaining alternative sources of water for an area is often cost prohibitive because either new or additional surface water rights must be acquired or infrastructure constructed to deliver surface water or groundwater from outside sources. The economic impacts of managing groundwater resources through a groundwater conservation district include both benefits and costs. For example, managing an area's groundwater resources can increase the value of land in the area by extending the economic life of the aquifer(s), limiting the possible encroachment of salt-water, and reducing other water quality impacts. Indeed, one of the greatest benefits of a GCD is to extend groundwater supplies equitably for future use and economic development through its assessment and monitoring, planning, permitting, and other conservation programs. GCDs also benefit the area by developing and implementing regulations for adequate well spacing, water well construction, pollution prevention through the plugging of abandoned wells, and by providing public education outreach programs.

While a district may provide many benefits to those living within its boundaries, there is a cost for the groundwater management programs and activities that are provided. To finance its operations, a GCD must generate revenue that is generally done either through property taxes collected from all residents within the district or from well production fees collected from major water users. Collection of tax to operate a district places an additional financial burden on all property owners within the district, and the collection of well production fees adds a financial burden to the users of water with permitted wells. The scale of cost for residents is dependent upon many factors including the size and total tax base of the district or the quantity of water that is subject to production fees, and the scale and scope of the programs undertaken by the district. Additionally, a GCD being a political subdivision adds an additional layer of local government that may not be welcomed by all residents.

Groundwater conservation districts are required to operate from an annual budget with spending limited to budgeted items. Present budgets for existing, operational GCDs range from slightly over $100,000 for some single-county districts with limited permitting and monitoring programs to over several million dollars for special-law type, multi-county districts with specific statutory groundwater management responsibilities such as restricting production to protect spring-flow or to cease subsidence caused by groundwater withdrawal. Present budgets for GCDs that include three- to four-counties range from about $150,000 to about $425,000 (TCEQ personnel communication, 2003).

TCEQ staff estimate a minimum of about $250,000 in revenue must be generated annually to operate a single-county district and fund meaningful groundwater management programs. For the purposes of this report, this estimate will be considered the lowest amount of revenue needed to finance a functional GCD. This estimate is based on review of GCD financial audits records that have been filed with the TCEQ, review and consideration of Texas Alliance of Groundwater District (2004) and State Auditor’s Office (2000 and 2001) report information, personal communication with existing GCD managers and board members, and other considerations of best professional judgment.

Under Texas Water Code, Chapter 36, a GCD may levy an ad valorem tax at a rate not to exceed 50 cents per $100 assessed valuation to pay for maintenance and operating expenses. In fact, most GCDs have lower ad valorem tax caps established either by their enabling legislation or by voters. After the voters have approved a tax cap, a GCD may not exceed the cap unless the voters subsequently authorize the GCD to do so at election. Most existing groundwater conservation districts currently have tax rates ranging from $0.004 to $0.0775 per $100 assessed valuation (or, $4.00 to $77.50 annual tax paid on property valued at $100,000) (TAGD, 2004). Single-county districts generally tend to have higher tax rates than multi-county districts that typically have tax rates averaging around $0.01 per $100 assessed valuation. One partial-county GCD with a small tax base presently has a tax rate of $0.231 per $100; this is the highest GCD tax rate in the state (Personal communication, Randy Barker, Hudspeth County UWCD No. 1).

Table 18 lists all of the counties in the study area along with the tax rate that would be required to raise $250,000 for each county. The figures clearly show the financial advantage of having multiple county GCDs. The total appraised value (Texas Association of Counties, 2003) for county taxation in selected counties in the study area is as follows:

- Bosque–$874,114,136;
- Coryell–$1,227,277,285;
- Falls–$391,894,432;
- Hill–$1,203,922,061;
- Hamilton–$1,203,922,061;
- McLennan–$7,089,194,736; and
- Somervell–$1,779,706,924.

For this seven-county area, the total appraised value is approximately $13,770,031,635. If a GCD was created that covered all seven counties, a tax rate of $0.005 per $100 (or five dollars on $100,000 of property) would annually generate about $688,502, and a tax rate of $0.01 per $100 (or ten dollars annual tax on $100,000 of property) would annually generate around $1,377,003.

Groundwater conservation districts may also generate revenue through the assessment and collection of well production fees on permitted wells. Unless otherwise addressed by a district's enabling legislation, the production fees are capped by state law at $1 per acre-foot/year for agricultural use, and $10 per acre-foot/year for other uses. Table 19 lists, by county, the amount of 2000 Trinity, Woodbine, Brazos River Alluvium, and Carrizo-Wilcox aquifer use and the estimated amount of revenue that could be generated in each county at the maximum well production fee rates for GCDs authorized by state law. Based on year 2000 supply data provided by TWDB (2003b), and assuming that county-other, livestock, and mining uses would be exempt from potential regulation and fees, about 40,000 acre-feet of water was produced for irrigation and about 17,528 acre-feet of water was produced for non-agricultural purposes (municipal, manufacturing, steam electric) in the study area.

Potential production fee revenues do not appear to be sufficient for any of the study area counties to fund a single-county GCD. Making the same assumption that a GCD was created that included the seven contiguous counties in the center of the study area, and using the maximum statutory well-production fee rates ($1 per acre-foot/year for agricultural use and $10 per acre-foot/year for other uses), it is estimated that only about $70,374 could be generated. This amount is well below the estimated minimum ($250,000) for financing a viable GCD.

In addition, GCDs may issue and sell tax bonds for capital improvements such as building dams, draining lakes and depressions, installing pumps and equipment, and providing facilities for the recharge of aquifers. Such tax bonds are subject to voter authorization, TCEQ review, and the State Attorney General's approval. The taxing rate is not capped for the repayment of bond indebtedness. GCDs may impose an export fee on water transferred out of the district. Unless specified in the legislation creating the district, the export fee is based on the district's existing tax or production fee rates or is negotiated with the transporter. GCDs are allowed to charge a 50 percent export surcharge in addition to the production fee charged for in-district use.

To a lesser extent, GCDs may also recover costs by assessing fees for administrative services such as processing permits or groundwater transport applications, performing water quality analyses, providing services outside of the district, and capping or plugging abandoned wells. These fees must be reasonable for services provided. GCDs may also apply for and receive grants, loans, and donations from governmental agencies, individuals, companies, or corporations for specific conservation projects or research.

Table 18. Appraised Value for County Taxation in the Eleven Counties not in a GCD, Central Texas (Trinity Aquifer) PGMA Study.

County	2003 Appraised Evaluation for County Taxation*	Revenue Generated@ $0.01/$100	Needs More Than $0.01/$100	Tax Rate Needed to Generate $250,000
Bell[1]	NA	NA	NA	NA
Bosque	$874,000,000	$87,400	Yes	$0.028600
Brown	1,336,000,000	$133,600	Yes	$0.018713
Callahan	$314,000,000	$31,400	Yes	$0.079618
Comanche[2]	NA	NA	NA	NA
Coryell	$1,227,000,000	$122,700	Yes	$0.020375
Erath[2]	NA	NA	NA	NA
Eastland	$551,000,000	$55,100	Yes	$0.063776
Falls	$392,000,000	$39,200	Yes	$0.063776
Hamilton	$338,000,000	$33,800	Yes	$0.073964
Hill	$1,204,000,000	#120,400	Yes	$0.020764
Lampasas[3]	NA	NA	NA	NA
Limestone	$1,158,000,000	$115,800	Yes	$0.021589
McLennan	$7,089,000,000	$708,900	No	$0.003527
Mills[4]	NA	NA	NA	NA
Somervell	$1,780,000,000	$178,000	Yes	$0.014045

Source: Texas Association of Counties, 2003.
*Rounded up to nearest million.
1 Clearwater UWCD 3 Saratoga UWCD
2 Middle Trinity GCD 4 Fox Crossing WD

Conversely, a few groundwater conservation districts have been created without the authority to impose ad valorem taxes or water use fees. These districts have generally been funded by county government and are limited, by the amount of funding received, in the scope of programs they can implement.

District Creation Options

Water management and management planning can be carried out at various scales of oversight and authority. On a statewide scale, no federal or state entity has authority to regulate groundwater withdrawal or use. However, state-level water planning responsibilities and oversight responsibilities by GCDs for management plans are well defined, as previously discussed. Assessment and planning by the regional water planning groups can identify groundwater problem areas and appropriate management options for use by regional and local entities. These planning entities are not authorized to manage or regulate groundwater resources or implement water conservation programs. County and municipal authorities can require plat applicants to evaluate and demonstrate that site-specific groundwater resources are available and sufficient for new subdivisions. Cities, utilities, and water suppliers can implement programs to discourage groundwater waste and seek alternative supplies. However, none of these local entities is directly authorized to manage groundwater pumpage or use.

Table 19. Potential Revenue from Well Production Fees, Central Texas (Trinity Aquifer) PGMA Study.

	Trinity Aquifer				Other Aquifer				Total Fee Revenue ($)
	Non-Agriculture Use		Agriculture Use		Non-Agriculture Use		Agriculture Use		
	Subject to GCD Fees[1]	Potential Fee Revenue[2]	Subject to GCD Fees[1]	Potential Fee Revenue[3]	Subject to GCD Fees[1]	Potential Fee Revenue[2]	Subject to GCD Fees[1]	Potential Fee Revenue[3]	
Bosque	906	9,060	0	0	0	0	1,772[4]	1,772	10,832
Brown	0	0	1,282	1,282	24[7]	240	0	0	1,522
Callahan	403	4,030	1,233	1,233	0	0	0	0	5,263
Coryell	0	0	0	0	0	0	0	0	0
Eastland	108	1,080	4,411	4,411	0	0	0	0	5,491
Falls	0	0	0	0	0	0	11,792[4]	11,792	11,792
Falls	0	0	0	0	0	0	2,838[6]	2,838	2,838
Hamilton	321	3,210	900	900	0	0	0	0	4,110
Hill	932	9,320	0	0	46[5]	460	217[5]	217	9,997
Limestone	0	0	0	0	11,623[6]	116,230	0	0	116,230
McLennan	1,240	12,400	0	0	0	0	15,355[4]	15,355	27,755
McLennan	0	0	0	0	0	0	100[5]	100	100
Somervell	385	3,850	100	100	0	0	0	0	3,950
Totals	4,295	42,950	7,926	7,926	11,693	116,930	32,074	32,074	199,880

Notes:
1. Volumes in acre-feet per year.
2. Potential revenue generated at maximum fee rate of $10 per acre-foot per year.
3. Potential revenue generated at maximum fee rate of $1 per acre-foot per year.
4. Brazos River Alluvium aquifer.
5. Woodbine aquifer.
6. Carrizo-Wilcox aquifer.
7. Local alluvial deposits.

Several groundwater management options are available for the study area. In one scenario, local leadership, landowners, and citizens can opt not to take any action. If an area does not have any demonstrated or anticipated groundwater problems or issues, this may be an appropriate choice. If this were not the case, however, this choice would not offer any resource protection to landowners and would allow existing or anticipated groundwater problems to persist or worsen.

A groundwater conservation district created within the study area would have the necessary authority to address groundwater issues and accomplish groundwater management objectives identified in the preceding text. Such a district would have the best available regulatory authority to manage and protect groundwater resources in the area. A GCD could benefit the study area by implementing groundwater management strategies as authorized under Texas Water Code, Chapter 36. These management strategies might include groundwater monitoring and assessment; planning; and permitting programs to protect existing public and private water wells. A GCD could also benefit the area by implementing programs to prevent long-term water level drawdown and well interference, to actively identify and plug abandoned wells that serve as a conduit to contaminate groundwater supplies, to construct and maintain aquifer recharge enhancement features, and to maintain spring discharges for the protection of natural resources.

There are several methods to consider for the creation of a groundwater conservation district. Most GCDs are created by special Acts of the Texas Legislature. In other general law procedures, statute allows landowners to petition the TCEQ for the creation of a GCD. The statute also allows landowners to petition an existing district to have property added to that district (a single landowner, several landowners, an entire outcrop area, or a county/counties). Lastly, if an area is designated as a PGMA, landowners must accomplish one of the above district creation actions within a two-year period. If they do not, TCEQ is required to create a GCD or recommend the area be added to an existing GCD. (Methods of, and procedures for GCD creation are discussed in significant detail in TCE, 2002a, 2002b. and 2006)

District size must also be considered. Historically, single-county groundwater conservation districts have been the predominant choice of Texas citizens. However, multi-county GCDs covering larger portions of aquifers have increased in popularity over the past half-dozen years. Such districts can exercise consistent regulation and effective conservation and management planning on a larger or even aquifer-wide scale. Generally, multiple single-county GCDs or a few multi-county GCDs are created within the same groundwater management area and each district operates under its own rules and regulations to manage the groundwater resource. However, because these GCDs share common groundwater resources, it is imperative that their efforts to manage the resource be coordinated.

Under Texas Water Code, §36.108, GCDs within a common groundwater management area (GMA) are required to share their certified groundwater management plans with the other districts that are present within the GMA. The GCDs are required (under §36.108) to conduct joint public meetings to review management plans and plan-accomplishments for the GMA. The districts are further advised under §36.108 to consider the goals and effectiveness of each management plan and each management plan's impact on planning throughout the management area. Through these cooperative efforts, local GCDs can effectively provide coordinated regional management of a shared groundwater resource. The study area and other counties to the north of the study area are included in Groundwater Management Area 8 for the northern segment of the Trinity aquifer as designated by the TWDB in November 2002 (Figure 15).

Single-County Districts

Besides considering the different creation methods for groundwater conservation districts, several different GCD creation options must also be considered and the implications for each option. The occurrence and condition of groundwater, land use types, demographics, and the public-will are usually the defining factors for the GCD creation options. Table 18 shows the total appraised value for county taxation in each of the eleven counties in the study area and the potential revenue that could be generated in each county based on an ad valorem tax rate of $0.01 (one cent) per $100 assessed valuation. Only one county within the study area is capable of generating sufficient revenue to operate a viable GCD alone through an ad valorem tax of less than $0.01 per $100 valuation. For example, a tax rate near $0.003527 per $100 assessed valuation for McLennan County could generate slightly more the $250,000 annually. Tax rates needed to generate the same amount of revenue in the other ten counties would have to be significantly higher. The range of tax rates would be from about $0.01405 (1.4 cents) to $0.07962 (8 cents) per $100 valuation to generate around $250,000 (Table 18). Two study area counties – Brown and Somervell – would be able to fund a GCD at a tax rate under two cents per $100, and four other counties – Bosque, Coryell, Hill, and Limestone – would be able to do the same at a tax rate between two and three cents per $100. Four study-area counties – Callahan, Eastland, Falls, and Hamilton – would require higher rates (from 4.5 to 8 cents per $100) to fund a viable GCD.

Having single county GCDs for several counties in the study area would require a like number of individual groundwater management programs. This option provides for the most local control because each director represents a smaller area. However, this option would also contain much program duplication. For example, each GCD would be required to:

- establish, staff, and maintain an office;
- create procedures to address open meetings, open records, and records retention;
- annually address financial budgeting and auditing requirements;
- generate and adopt a management plan;
- craft and adopt administrative, well permitting, and other regulatory rules; and,
- meet and uphold other statutory requirements relating to policies and district operation.

The creation of single-county districts in the study area is feasible. However, better economic and administrative options exist. The only apparent trade-off would be that the most-localized form of groundwater management would be forfeited if something other than single-county GCDs were created. Creation of GCDs by special law, or Texas Water Code, Chapter 36, allow sufficient flexibility to assure that the number and representation by district directors alleviate this misconception. Under either method, district directors must be accountable and responsive to the voting public.

Multi-County Districts

The most economical option would be multi-county GCDs for areas with similar groundwater conditions and problems. Because of the broader tax base that this option provides, sufficient revenue could be generated to finance district operation and maintenance at a relatively low tax rate. These revenue estimates are in line with existing GCDs of the similar size and would be practical to finance groundwater management activity through a GCD for the five-county area.

Alternatively, a multi-county GCD could finance operations and maintenance through the assessment of well production fees. However, it is estimated (Table 19) that Bosque, Coryell, Hill, McLennan, and Somervell counties could only generate about $ 52,634 annually at the maximum fee rates authorized by Texas Water Code, Chapter 36. Chapter 36 authorizes GCDs to generate revenue through the levy of taxes and the assessment of well production fees. Frequently, the authority for special-law created GCDs requires the generation of revenue through either taxes or fees, but not both. It is doubtful any of the study area counties would be able to finance meaningful single-county district operations through well production fees alone. Furthermore, since the five-county GCD creation option would include the greatest areal extent of the Trinity aquifer, a single GCD management program for the aquifer would also represent the most favorable groundwater management option.

Regional Districts

A regional groundwater conservation district formed by the seven contiguous counties (Bosque, Coryell, Falls, Hamilton, Hill, McLennan, and Somervell) would include the greatest areal extent of the Trinity, Brazos River Alluvium, and Woodbine aquifers. From a resource protection perspective, this option would be the most beneficial. Although Limestone County uses some water from the Trinity aquifer, the majority of the water is from the Carrizo-Wilcox aquifer and therefore is not considered in this scenario. Under this scenario, a single groundwater management program would assure consistency across the region, provide a central groundwater management entity for decision-making purposes, and simplify groundwater management planning responsibilities related to Groundwater Management Area #8. Because of economy-of-scale issues, a regional GCD would also

be the economic choice. Such a district could be adequately financed through an ad valorem tax levied at a very low rate.
Conversely, generating citizen support to create a seven-county GCD may be difficult and there are only four groundwater management entities of this magnitude within the state, the Edwards Aquifer Authority, the High Plains UWCD No. 1, the North Plains GCD, and the Panhandle GCD. Besides building the necessary support to confirm creation of such a large district, board representation may also be an issue to area residents. Overcoming these issues would require much consensus building between state and local leadership and the large groundwater users in the region.

Actions of the 80th Legislature, Regular Session, 2007

Two groundwater conservation districts were created in the study area by special law during the 80th Legislature, Regular Session, 2007. Both are authorized with the powers and duties provided by Texas Water Code, Chapter 36 for GCDs. Senate Bill (SB) 1985 by Senator Kip Averitt created, subject to a confirmation election, the McLennan County Groundwater Conservation District, and SB 3, Article 11, also by Senator Averitt created, subject to a confirmation election, the Tablerock Groundwater Conservation District in Coryell County. Both Acts provide for the powers, duties, administration, operation, and financing of the two new GCDs.

SB 1985 and SB 3, Article 11 each require the commissioners' courts of the respective counties to appoint one temporary director from each of the four county commissioners' precincts, and for each county judge to appoint one temporary director to represent the county at large. The temporary directors for the two new GCDs are responsible for scheduling and holding elections to confirm creation of the district and may hold subsequent elections if the initial elections to confirm district creation is defeated by a majority of the voters. If director appointments are not made within set periods, or if vacancies occur on the board, the other directors are responsible for filling the vacancies on the district's board. Temporary directors for both new GCDs serve set terms and subsequent directors will serve staggered four-year terms. The subsequent directors of the McLennan County GCD will continue to be appointed by the commissioner's court and the county judge and subsequent directors of the Tablerock GCD will be elected. If the new GCDs have not been confirmed by the voters by September 1, 2012, the enabling legislation will expire on that date and the district will be dissolved.

SB 1985 and SB 3, Article 11 both include prohibitions from certain Texas Water Code, Chapter 36 powers and provide additional authorities to the respective GCDs. The McLennan County and Tablerock GCDs may not exercise the power of eminent domain and may require any new well or class of wells exempt from permitting to register the wells and comply with district spacing requirements. By rule, the new GCDs may require the owner or operator of a well or class of wells exempt from permitting to report groundwater usage. This authority specifically does not apply to private domestic water wells on tracts of land larger than 10 acres that produce less than 25,000 gallons per day. Further, existing water wells are exempt from GCD well spacing requirements. Both of the new GCDs are authorized to adopt rules and issue permits prior to the adoption of a management plan, and special provisions are included for potential elections to dissolve the districts. Both Acts require that, by September 1, 2011, both of the new GCDs' boundaries must include at least one adjacent county, or the districts will be subject to dissolution by the TCEQ.

Both of the new GCDs are authorized to establish, adopt, and enforce the collection of fees for services or for water withdrawn from nonexempt wells. The McLennan County GCD may not impose a fee for agricultural use that is more than 20 percent of the rate for municipal use. If approved by the voters, the Tablerock GCD is authorized to impose an ad valorem tax not to exceed two cents on each $100 of assessed valuation of taxable property. Both of the new GCDs may also solicit and accept grants from any private or public source and may contract with other governmental entities to perform district functions.

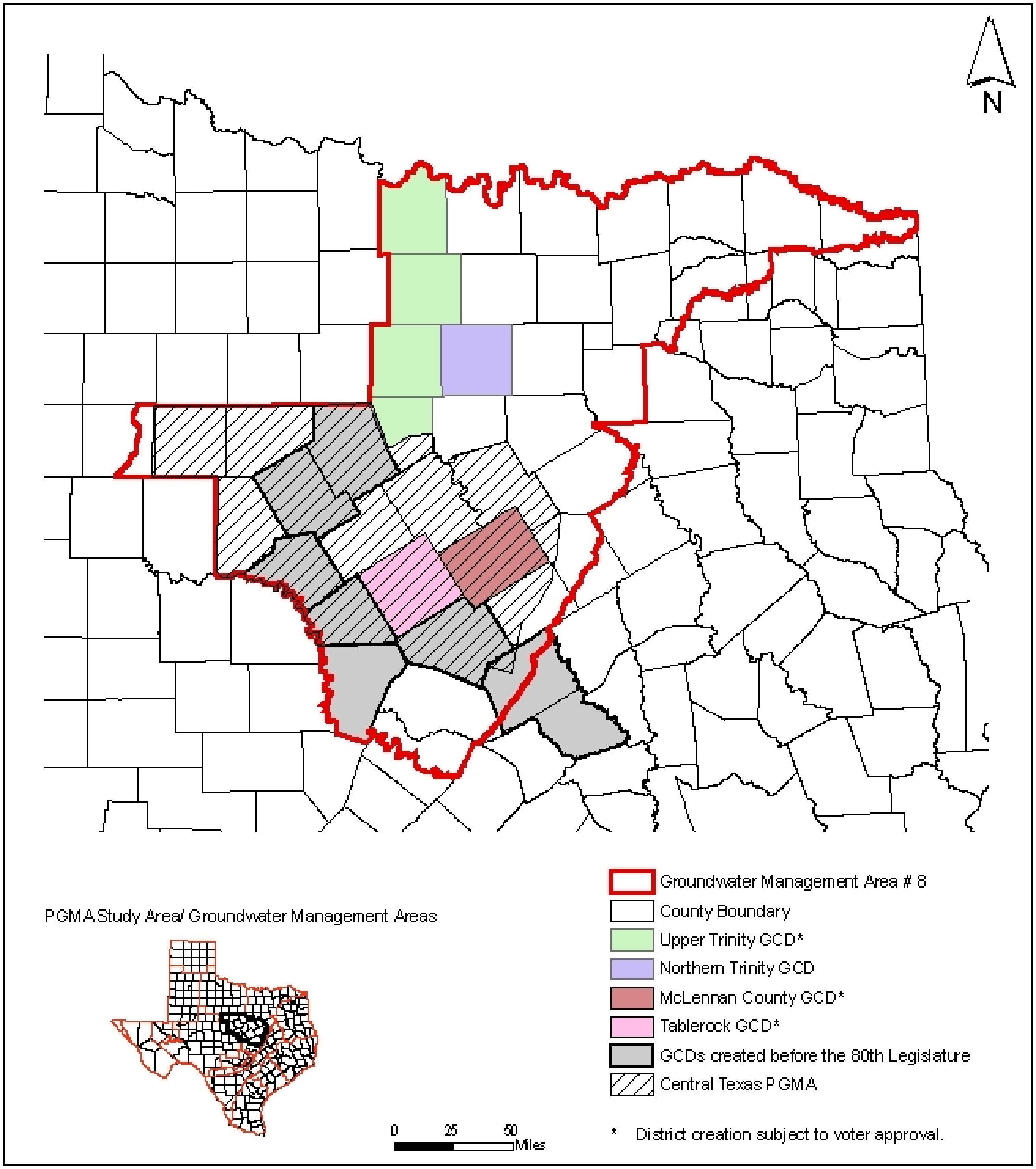

Figure 17. Groundwater Conservation Districts Created by the 80th Legislature.

Addition of Territory to Existing Districts

Counties having similar groundwater concerns could opt to join an existing groundwater conservation district through the petition and addition procedures outlined in Texas Water Code, Chapter 36, Subchapter J. Under such circumstances, and assuming that a petition to add territory is accepted by the receiving district, landowners in the study area would agree to assume the financial obligations of the district they would join and be provided equitable representation on the receiving district's board of directors. The advantage of joining an existing district include accessibility to the district's established regulations, programs, and infrastructure, and an increased tax base which may be less burdensome on the taxpayers in the study area. All or parts of a county, or several counties, down to individually owned tracts of land, could be added to adjacent districts.

Landowners in the study area could attempt to join any of the six existing GCDs located in Groundwater Management Area #8 (Figure 15), or any of the four new GCDs created in GMA #8 by the 80th Legislature (Figure 17). As noted above, the two new GCDs within the study area, McLennan County GCD and Tablerock GCD in Coryell County, must be confirmed by the voters and must include at least one additional county within their boundaries by September 1, 2011. This specific requirement indicates that establishment of multi-county GCDs, through the confirmation of the two new GCDs and the addition of territory to the new GCDs, is the method preferred by the special laws of the 80th Legislature.

It is understood that the voters in McLennan and Coryell counties must first consider and vote on the two new GCDs before these residents can consider other GCD creation options. In addition, the outcome of the two elections for the confirmation of the McLennan County and Tablerock GCDs will influence the GCD creation decision-making considerations for the adjacent counties. If the two new GCDs are confirmed by the voters, it would be logical for Trinity aquifer outcrop-counties such as Bosque, Hamilton, and Somervell to consider aligning with and attempting to join the Tablerock GCD, and for the Trinity aquifer confined-area counties of Falls and Hill to consider aligning with and attempting to join the McLennan County GCD.

Existing GCDs within the aquifer outcrop (Middle Trinity) and the confined aquifer in the down dip areas (Clearwater) have different groundwater management strategies. For this reason, it seems logical that counties with similar groundwater conditions join GCDs with like conditions. If the two new GCDs are voted down by the residents of McLennan and Coryell counties, the most feasible existing GCD that landowners in Coryell, Falls, and McLennan counties could join is the Clearwater Underground Water Conservation District (UWCD). HB 3172 created the Clearwater UWCD in Bell County in 1989 (Chapter 524, Acts of the 71st Legislature, Regular Session, 1989). The district was confirmed by election on August 21, 1999 by a vote of 2,272 for and 1,206 against. The voters also approved an operation and maintenance tax to be levied at a rate not to exceed $0.01 per $100 of assessed valuation. The district is currently levying a tax of $0.0044 per $100 (personal communication, Cheryl Maxwell, District Manager, Clearwater UWCD) and contracts with the Central Texas Council of Governments for administrative services. The district’s initial management program is geared toward controlling groundwater production to protect Salado Springs.

Brown, Callahan, Eastland, Hamilton, and Somervell counties are contiguous to the Middle Trinity GCD (Figure 15, Location section). If the Middle Trinity GCD were agreeable to an inclusion-petition from landowners in these counties, the resulting larger GCD would benefit from a larger tax base, would include a larger areal extent of the aquifer, and would be able to develop a more uniform management program for the aquifer. It would seem logical that the landowners in Eastland County living and relying heavily on the Trinity aquifer may find it to their advantage to join the Middle

Trinity GCD. The Middle Trinity GCD was created in Comanche and Erath counties in 2001 pursuant to the authorization provided by the 77th Texas Legislature (House Bill 3665). The voters of Comanche and Erath counties confirmed the creation of the District on May 4, 2002, and became operational in May 2004. The district is currently levying a tax of $0.015 per $100 (personal communication, Joe B. Cooper, III, District Manager, Middle Trinity GCD). The District completed a one-year registration of existing wells in May 2005, and created a database of 16,000 wells. The District has been concerned with the effects of hydrocarbon production and exploration in the surrounding area (see the section on the Barnett Shale).

Somervell County could also opt to join the Upper Trinity GCD created (subject to a confirmation election) by special law during the 80th Legislature, Regular Session, 2007. The initial boundaries for the Upper Trinity GCD are coextensive with the boundaries of Hood, Montague, Parker, and Wise counties. Limestone County might be better served to merge with the Brazos Valley GCD or the Mid-East Texas GCD since most of the groundwater there comes from the Carrizo-Wilcox aquifer. In addition, this creation option may become more feasible in the future if other GCDs are established over more of the Trinity aquifer. Likewise, the residents of Falls County living above and relying heavily on the Trinity aquifer and the Brazos River Alluvium aquifer could consider joining the Clearwater UWCD. In Falls County, there have been water-level declines in the Trinity aquifer of over 290 feet in the last 40 years Those landowners residing in the southeast portion of Falls County, which rely heavily on the Carrizo-Wilcox aquifer, could consider joining the Brazos Valley GCD to protect their groundwater resources.

Landowners could also consider joining the Saratoga UWCD in Lampasas County or the Fox Crossing Water District in Mills County. The Saratoga UWCD was created by Chapter 519, Acts of the 71st Legislature, Regular Session, 1989 (H.B. No. 3122) and confirmed by Lampasas County voters on November 7, 1989. The Saratoga UWCD does not levy ad valorem taxes. They are primarily funded by appropriations from the Commissioners Court of Lampasas County. The 69th Legislature, Regular Session, (H.B. No. 2487) created the Fox Crossing Water District on May 16, 1985. The Fox Crossing Water District does not levy ad valorem taxes. The District's original Management Plan was adopted several years ago but the new Board, elected in May 2005, is now working on revising it.

If any of the existing or new GCDs were agreeable to an inclusion-petition from landowners in the study area (assuming the new GCDs are confirmed by the voters), the resulting larger GCD would benefit from a larger tax base, would include a larger areal extent of the aquifers, and would be able to develop a more uniform management program for the aquifers. However, in some cases the special law for the adjoined GCD may need to be amended to allow sufficient flexibility for board member representation.

Under any of the scenarios outlined above for the creation of groundwater conservation districts - regional, multi-county, single-county, or addition of territory - it will be imperative for a district to understand various water supply options and strategies. These options and strategies are identified in the Region F, Brazos G, and Lower Colorado Regional Water Plans; the groundwater data that is built into the State Water Plan (TWDB, 2007); and the TWDB groundwater availability models. Even more pertinent will be the Trinity aquifer desired future condition considerations presently being discussed and formulated by the Groundwater Management Area #8 member GCDs. These data and water supply strategies will serve as guides for water planning in the study area, and in the region for the next 50 years. Further, a district should also intimately understand and recognize the drought contingency plans of the wholesale and retail water suppliers in the area and the water demands of areas that are proposed.

SUMMARY

Texas Water Code, Section 35.007, requires that a TCEQ Priority Groundwater Management Area (PGMA) report:

1) examines the reasons and supporting information for or against designating the study area as a PGMA;
2) recommends the delineation of boundaries if PGMA designation is proposed;
3) provides recommendations regarding creation of a groundwater conservation district in the study area;
4) recommends actions necessary to conserve natural resources within the study area; and
5) evaluates information or studies submitted by the study area stakeholders.

The Texas Water Code requires the report to identify present critical groundwater problems, or those expected to occur within a 25-year planning horizon. Critical groundwater problems that warrant PGMA designation include shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, and contamination of groundwater supplies. This report evaluates the authorities and management practices of existing water management entities and purveyors within the study area and makes recommendations on appropriate strategies necessary to conserve and protect groundwater resources in the area.

Water Use and Supply

Groundwater supplies in 2000 were an estimated 78,869 acre-feet (acft) and these supplies are projected to decrease slightly by 2030, to 76,357 acft (Table 7). The Trinity aquifer is the primary groundwater source in the study area. Groundwater is also supplied from the Carrizo-Wilcox aquifer, the Brazos River Alluvium aquifer, and the Woodbine aquifer. Water supply from the Trinity aquifer in the study area is projected to remain the same thorough 2030.

Water user groups within the study area predominantly use surface water from the Colorado and Brazos River Basins. In 2000, 536,375 acft of water was the estimated supply within the study area. Surface water accounted for 85 percent (457,506 acft), and groundwater accounted for 15 percent (78,869 acft) of the water supplies within the study area (Table 7). Increased use of surface water has occurred in the study area over the last ten-year period to meet increasing demands while groundwater production levels remained steady. Stream flow in the Brazos River and its tributaries, along with reservoirs in the Brazos River Basin, comprise the majority of the supply of surface water in the study area. These combined surface water supplies are not projected to change significantly between 2000 and 2030 in the study area.

Groundwater Levels and Quality Concerns

More groundwater is being withdrawn than recharged to aquifers in the Central Texas study area. This pumpage results in declining water levels, removal of water from aquifer storage, and possible deterioration of chemical quality in the Trinity Group aquifer. Water-level declines and reduction of artesian pressure are regional groundwater problems.

The Trinity aquifer has experienced some water-level decline over almost 60 percent of the study area. Forty percent of the area has declines of 100 feet and declines of 200 feet have occurred in Bell, Bosque, Falls, Hill, and McLennan counties. Declines of 300 feet have occurred in Hill and three areas in McLennan counties; and declines of over 400 feet southwest of Waco, McLennan County. The 2004 Trinity-Woodbine aquifer groundwater availability model (GAM) predicts up to 100 feet of additional drawdown to occur in Bosque, Falls, Limestone, and McLennan counties from 2000 to 2030.

Where the Trinity aquifer is overlain by the Glen Rose Limestone the water chemistry exhibits a significant increase in sodium sulfate and chloride ions. This change in water chemistry is indicative of leakage through the Glen Rose into the Trinity aquifer. Heavy pumping of the Trinity aquifer, from parts of Bell, Bosque, Coryell, Falls, Hill, and McLennan counties is creating excessive drawdown beyond the recharge capacity of aquifer's ability to replenish water removed from storage. The leaky nature of the Glen Rose Limestone allows significant amounts of sulfate-rich water to be drawn into the depressed areas allowing degradation of the water quality of the Trinity aquifer. The resulting water-level declines pose a threat to small water suppliers and to domestic water users in rural areas by increasing pumping costs and producing water of lesser quality.

Contamination of the Trinity Group aquifer from man made sources is possible. The potential for contamination is greater in the outcrop area than in the artesian portion of the aquifer. Heavy cultivation of land on the outcrop and the increase of concentrated animal feeding operations increase the potential for contamination. The presence of oil and gas operations is also a potential source of contamination. The recent interest in gas exploration of the Barnett Shale in the study area counties of Bosque, Comanche, Erath, Hamilton, Hill, and Somervell has increased the potential for contamination.

Projected Demand, Availability, and Strategies to Meet Needs

Water demand is the quantity of water projected to meet the overall necessities of a particular water user group in a specific future year. The regional and state water plans project that between the years 2000 and 2030; total population within the study area will increase by approximately 32.48 percent. The total water demand for 2000 was 337,412 acft and the total projected demand for 2030 is anticipated to be 416,937 acft, an increase of 79,525 acft, or 23.57 percent over the 30-year period. Municipal water user group represents the largest demand for water in the study area. Municipal demand is projected to increase by approximately 44,769 acft over the 30-year planning period. Municipal demand accounted for 43.06 percent of the total water used in 2000. This demand increases to 45.58 percent of the total water demand for 2030, from 145,281 acft to 190,050 acft.

Water availability is the maximum amount of water available during the drought of record, regardless of whether the supply is physically or legally available for use. The TWDB notes that current and projected groundwater availability in the Trinity aquifer could consist of the annual recharge and mining of the total recoverable storage until the year 2030. After 2030, water availability from the Trinity aquifer would be based on the estimated effective recharge. The availability is also based on the groundwater occurrence through out the areal extent of the downdip portion of the aquifer in the study area. The data from the 2002 State Water Plan indicate that 134,810 acft/yr of groundwater is available in the study area (Table 8). The Trinity aquifer accounts for 52.9 percent and although the Brazos River Alluvium aquifer is considered a Minor Aquifer, it supplies 25 percent of groundwater available to the study area. The Carrizo-Wilcox aquifer accounts for 15 percent of the available groundwater. The remainder of the groundwater available to the study area comes from the Edwards-BFZ (Northern Segment) aquifer (1.85 percent), Woodbine aquifer (1.16 percent), Marble Falls aquifer (3.1 percent), and Ellenburger-San Saba aquifer (0.41 percent).

There are eleven reservoirs within the study area. Lake Brownwood is the only one located in the Colorado River Basin, the other ten are in the Brazos River Basin. These reservoirs have a combined authorized storage of 1,440,892 acft with an authorized diversion of 425,683 acft/yr.

Water needs are determined when the demand for water exceeds the existing supply. The Region F, Brazos G, and Lower Colorado Region K Regional Water Planning Groups recommended similar water management strategies to meet the identified needs through the year 2030. These water supply strategies generally include conservation, contract renewal, infrastructure expansion, voluntary redistribution, and Trinity and Carrizo-Wilcox aquifer development. With the recommended water management strategies, all of the water user groups (WUGs) meet their identified needs.

The Barnett Shale is one of the largest and most active natural gas discoveries in the United States. The majority of Barnett Shale production has been from the Newark East Field in portions of Denton, Tarrant, and Wise counties. Present production also occurs in Erath, Hill, Hood, Johnson, Palo Pinto, and Parker counties. Potential production from Bosque, Comanche, Cooke, Ellis, Hamilton, Jack, Montague, and Somervell counties is anticipated. In the study area counties of Bosque, Comanche, Erath, Hamilton, Hill, and Somervell, 175 Barnett Shale drilling applications have been filed with the Railroad Commission of Texas (RCT) since 2000. The adopted regional water plans note that groundwater for mining in the study-area counties is derived from the Trinity, Woodbine, and Brazos River Alluvium aquifers. The regional water plans estimate that the 2000 use as well as the projected 2030 water demand for mining use is about 562 acft.

Millions of gallons of water are used in the drilling of wells and the stimulation of fractures in the Barnett Shale. A typical vertical completion consumes approximately 1.2 million gallons (3.68 acft), and a typical horizontal well completion 3.0 to 3.5 million gallons (9.21 to 10.74 acft) of fresh water. Using this estimate, the current number of drilling applications in the six-county area would potentially represent about 1,447 acft of fresh water use for this specific mining purpose from 2004 through March, 2006. This water demand is not anticipated to decrease over the 30-year planning horizon as the play expands out of its core area. At present, the number of active drilling rigs appears to be the only limiting factor to the number of Barnett Shale gas wells that can be drilled each year.

Water Supply Concerns

Two regions of the study area were investigated separately based primarily on location relative to the Trinity aquifer outcrop or confined portion of the aquifer. The western region is composed of Brown, Callahan, Comanche, Eastland, Erath, Hamilton, Lampasas, and Mills counties. The eastern region is composed of Bell, Bosque, Coryell, Falls, Hill, Limestone, McLennan, and Somervell counties. Of all the counties in the planning areas, only Comanche and Hamilton, in the western region, are not projected to have any water supply shortages in 2030.

Recommended strategies to meet projected water supply shortages of 13,366 acft in the Western Region (Brown, Callahan, Eastland, Erath, Lampasas, and Mills counties) are conservation, purchase from other entities, voluntary redistribution, additional Trinity aquifer development, brush control, and weather modification. It is anticipated that groundwater usage will remain constant in these counties through 2030. A detailed description of shortages and recommended strategies by water user groups is presented in Appendix VII.

Recommended strategies to meet projected water supply shortages of 43,167 acft in the Eastern Region (Bell, Bosque, Coryell, Falls, Hill, Limestone, McLennan, and Somervell counties) are conservation, voluntary redistribution, aquifer development (both the Trinity and Carrizo-Wilcox aquifers), purchase from other entities, and reuse It is anticipated that groundwater usage will increase in these counties through 2030. A detailed description of shortages and recommended strategies by water user groups is presented in Appendix VII.

Wholesale Water Providers

A Wholesale Water Provider (WWP) is anyone that has contracts to sell more than 1,000 acft of water wholesale in any one year during the five years immediately preceding the adoption of the last Regional Water Plan. Under this definition, the list of WWPs for the Central Texas (Trinity Aquifer) PGMA study area is as follows:

Aquilla Water Supply
Bell County WCID No. 1
Bluebonnet WSC
Brazos River Authority
Brown County WID No. 1
Central Texas WSC
City of Waco
Eastland County Water Supply District
Lower Colorado River Authority
Upper Leon Municipal Water District

The RWPGs are required to prepare estimates of the water available to the Wholesale Water Providers within each region. For each WWP with a projected shortage, a water supply plan has been developed and is presented in Appendix VIII. There are three WWPs with projected shortages for 2030. The Aquilla Water Supply District with a projected shortage of 1,561 acft plans to increase its contract with BRA. Bell County WCID No. 1 will purchase additional water supplies through an existing contract with BRA to meet the projected shortages.

The Brazos River Authority is projected to have shortages in three systems (Lake Aquilla System, 1,884 acft; Little River System, 5,329 acft; and Main Stem System, 207,433 acft. Water supply from the Main Stem/Lower Basin portion of the overall BRA System can be used to augment supply at Lake Aquilla. The BRA has applied to the TCEQ for an additional appropriation of water that can be developed by using its system of reservoirs to firm up uncontrolled runoff and return flows entering the basin below its reservoir system. Several of the water management strategies recommended to meet Water User Group needs would use this large potential supply of water. In addition to the firm supply, the BRA has requested appropriation of a large interruptible supply. Conjunctive use of groundwater or other supplies along the main stem and lower basin similar to the Lake Granger Augmentation strategy could be developed with the interruptible appropriation requested by the BRA. Interruptible supplies at Lake Somerville that are in excess of the firm yield of the reservoir could be firmed up through conjunctive use of nearby Carrizo-Wilcox groundwater.

Natural Resources Concerns

The population of the study area in 2000 was 770,899 and is projected to be 1,021,300 by 2030. Population growth gradually puts a stress on the study area's ecosystems. Stress on the different ecosystems come from the number of people, their location, and the nature and scale of their activities. The TPWD concluded that the selected natural resources mentioned in the report are facing an uncertain future, a future that depends on the quality and quantity of the water resources, both surface and groundwater, within the study area.

Mitigating the negative impacts of past and current practices, such as grazing, agriculture, industrialization, and urbanization will improve the chances of natural resources recovery, be it surface water, groundwater, or fauna and flora. Fundamental changes in land and water management and resources valuation will be needed for mitigation plans to be effective.

Water Planning and Regulation

Water planning and activities that affect groundwater resources are conducted by all levels of users. State agencies carry out programs to protect water quality through the regulation of waste management or implementation of best management practices, and provide water resource planning, project funding, and technical assistance functions. Water plans on the regional level include developing consensus on the availability of groundwater for use and developing strategies for water user groups to meet the long-term projected demands of the growing population. Wholesale, retail, and community water suppliers develop and implement conservation and drought contingency plans to address supply system efficiency and maintenance, and to identify actions they will take during times of potential water supply deficit. Even at the most rudimentary level, individual landowners, and operators implement strategies or best management practices to conserve natural resources and water supplies on private acreage.

Local governments have permissive groundwater management authority relating to the subdivision of tracts of land. If a new subdivision is going to rely on the groundwater resources under the land, municipal and county authorities can require plat applicants to demonstrate that sufficient groundwater is available to support the project when it is fully developed. Municipalities also have authority over the protection of public health and land use regulation. A city may also pass ordinances requiring registration of water wells and establishing setback distances for water wells. Wholesale and retail public water suppliers, including municipalities, river authorities, water supply corporations, water supply districts, investor-owned utilities, and water conservation and irrigation districts are important as water management entities because of their responsibility to provide safe, reliable water to their customers. Municipalities and other water suppliers can indirectly limit groundwater withdrawals by implementing and enforcing water conservation programs and securing alternative supplies.

None of the existing entities – state agencies, regional planning groups or councils, counties, municipalities, or water suppliers – is directly authorized to collectively manage or regulate groundwater withdrawals or use. Only groundwater conservation districts are given the authority to conserve, preserve, protect, recharge, and prevent waste of groundwater resources. Groundwater conservation districts are authorized to manage groundwater resources by adopting rules and permit requirements for the spacing of water wells, regulating the production of wells, and for transferring groundwater out of the district. New GCDs may not adopt rules limiting the production of wells until their management plan has been approved by the TWDB. GCDs may also undertake projects to recharge aquifers; survey, monitor, evaluate, and research groundwater quantity and quality; and protect groundwater quality by adopting well construction standards more stringent than state standards and requiring the closure of abandoned water wells. No other such entities are authorized with these broad powers to manage groundwater resources. Four GCDs have been established within and three adjacent to the study area.

There are four methods for the creation of a groundwater conservation district: three through local initiative and one though state directive if necessary. Most GCDs are created by special Acts of the Texas Legislature. In two other processes, state law allows landowners to petition the TCEQ for the creation of a GCD, or allows landowners to petition another district to have property or territory added into that district. Lastly, if an area is designated as a PGMA, landowners are provided a two-year period to accomplish one of the above district creation actions. If they do not, TCEQ is required to create a GCD or recommend the area be added to an existing GCD.

Two GCDs, the McLennan County Groundwater Conservation District and the Tablerock Groundwater Conservation District (Figures 15 and 17), were created by special law during the 80th Legislature, Regular Session, 2007. Senate Bill (SB) 1985 created, subject to a confirmation election, the McLennan County Groundwater Conservation District and provided for the powers, duties, administration, operations, and financing of the District. SB 1985 provides for the appointment and terms of office of the directors. The bill also prohibits the District from exercising the power of eminent domain, and provides authority for the District to require owners or operators of otherwise exempt rig supply wells to comply with District well spacing requirements and to submit water production reports. Existing wells will be exempt from District well spacing requirements. The District's well production fees for non-agricultural use are capped at 20 percent of the rate for municipal use. The temporary directors of the McLennan County GCD must hold an election to confirm creation of the District before any of its authorities are vested.

SB 3, Article 11 created the Tablerock Groundwater Conservation District in Coryell County and provided for the powers, duties, administration, operations, and financing of the District. This bill also provides for the election and terms of office of the directors. The bill also prohibits the District from exercising the power of eminent domain, and provides authority for the District to require owners or operators of otherwise exempt rig supply wells to comply with District well spacing requirements and to submit water production reports. Existing wells will be exempt from District well spacing requirements. The District may impose an ad valorem tax not to exceed two cents on each $100 of assessed valuation of taxable property The temporary directors of the Tablerock GCD must hold an election to confirm creation of the District before any of its authorities are vested. Each newly created District must add at least one adjacent county to their District before September 1, 2011.

CONCLUSIONS AND RECOMMENDATIONS

TCEQ staff have considered data and information provided by the TWDB and the 2002 State Water Plan; TPWD; stakeholders in the study area; the 2001 and 2006 Region F, Brazos G, and Lower Colorado Regional Water Plans; and, from independent research to support the following conclusions and recommendations regarding the Central Texas (Trinity Aquifer) PGMA Study Area.

Study Area Designation Consideration

Surface water quality has been impacted by long-term urbanization of the region and other anthropogenic activities such as confined animal feeding operations. Public water supply concerns in the area include chloride, sulfate, total dissolved solids, phosphorus, E. coli, sedimentation, and increased treatment costs due to mineralization. Sufficient federal, state, regional, and local programs to monitor, assess, and address these impacts have been established and are ongoing. Groundwater quality in the Trinity, Brazos River Alluvium, and Woodbine aquifers is acceptable for most municipal and industrial uses in the study area. Water quality in the Trinity and Woodbine aquifers is generally better in the outcrop areas and tends to decrease in quality from west to east in the downdip zones. Additional groundwater quality monitoring and analyses would allow programs to be developed and implemented to protect the groundwater resources.

More groundwater is being withdrawn than recharged to aquifers in most of the Central Texas study area. Historically, pumpage has exceeded recharge resulting in declining water levels, removal of water from aquifer storage, and possible deterioration of water quality in the Hosston and Hensell members of the Travis Peak Formation and the Paluxy Formation of the Trinity aquifer. Water-level declines and associated reduction of artesian pressure caused by the continued removal of water from aquifer storage are regional problems. Between 1967 and 2004, continued water-level declines were observed in parts of Bell, Bosque, Coryell, Falls, Hamilton, Hill, McLennan, and Somervell counties. The overdevelopment of aquifers threatens water supplies for rural domestic and small water providers who depend on groundwater resources. The water demands due to the continued urbanization of the area, and more recently, the growing natural gas exploration activity show no discernable trends to level out or to lessen over the next 25-year period.

The 2006 Brazos G Water Plan notes although the Trinity aquifer in the study area can provide 71,310 acft/yr, local areas have been severely over-drafted and cannot yield substantial supplies in the current planning period. The plan also notes that groundwater pumpage from the Trinity aquifer in the central area (which includes Bell, Bosque, Brown, Callahan, Comanche, Coryell, Eastland, Erath, Falls, Hamilton, Hill, Lampasas, Limestone, McLennan, Mills, and Somervell counties) is at or above the estimated long-term sustainable supply. The 2006 Brazos G Water plan also notes that overdevelopment of aquifers and resulting water-level declines poses a threat to small water suppliers and domestic users in rural areas.

Regional water plan strategies to increase reliance on the Trinity (Coryell, Eastland, Erath, Lampasas and Mills counties) and Carrizo-Wilcox (Falls and Limestone counties) aquifers have been adopted for many water user groups in the study area. Adding new wells or increasing existing well production are regional water plan strategies for nine water user groups in Coryell, Eastland, Erath, Falls, Lampasas, Limestone, and Mills counties.

The adopted regional water plans note that groundwater for mining in the study-area counties is derived from the Trinity, Woodbine, and Brazos River Alluvium aquifers. The mining user group data in the regional water plans estimate the presently available water supply in these six counties for mining use is about 562 acft/yr. The only projected shortages for the mining user group in the 2006

Region F, Brazos G, and Lower Colorado Region K Water Plans are in Lampasas and Mills counties and surface water strategies have been adopted to address these shortages. The effect of new water demands for the exploration and drilling of gas wells in Bosque, Comanche, Erath, Hamilton, Hill, and Somervell counties is not clear at present. If the Barnett Shale exploration continues to increase to the south, then the demand projections for the general mining water user group may underestimate the needs for this mining type. The water demands from the growing natural gas exploration activity are not expected to level out or to lessen over the next 25-year period. The actual amount of groundwater usage is dependant on the price of gas, i.e., if the price of gas increases then so will exploration thus more water will be consumed.

Many groundwater users along the outer edges of the Interstate 35 corridor, including many municipalities, will be converting to surface water sources, as infrastructures permit, over the next 10 to 20 years. However, increased groundwater pumpage to furnish water for newly developing areas farther away from the corridor and the growing suburban cities is anticipated to continue. Historically, overall groundwater pumpage has not lessened when providers convert to surface water sources because those who develop next, just outside of the area that has recently converted to surface water, will look primarily to use the less expensive groundwater resources.

Designation Recommendations

The population of the area is projected to increase by 32.48 percent by the year 2030. Total water demand projections indicate an increase from 337,412 to 416,937 acft/yr (23.57 percent) over the same period. Major water level declines have continued to occur in the area over the past 40 years. These declines are concentrated along the Interstate 35 corridor corresponding to the most populated areas. The groundwater users most affected by these water level declines are remote rural water suppliers; individual businesses, industries, small municipalities, and homeowners. Preserving the ability to rely on the limited groundwater resource is and will remain a primary objective. Protecting existing groundwater supplies is a critical issue for these groundwater users because the delivery of alternative surface water supplies is not projected to be economically feasible until the density of the development is adequate to fund ample infrastructure. For these reasons, it is recommended that the following counties be designated as the Central Texas (Trinity Aquifer) Priority Groundwater Management Area: Bosque, Coryell, Hill, McLennan, and Somervell.

In Brown, Callahan, Comanche, Falls, Hamilton, and Limestone counties, the regional water planning groups, do not anticipate new groundwater users or significant new demands on the Trinity aquifer through the year 2030. Present and projected use of the Trinity aquifer in these counties is well under the estimated safe supply. Critical groundwater problems are not presently occurring or projected to occur in Bell, Brown, Callahan, Comanche, Erath, Falls, Hamilton, Lampasas, Limestone, or Mills counties within the next 25-year period and should not be designated as part of the recommended Central Texas (Trinity Aquifer) Priority Groundwater Management Area. The PGMA designation recommendations are illustrated in Figure 18.

The Brazos G regional water plan reports that Eastland County had a total water shortage of 9,140 acft in 2000 for the irrigation water user group. The report also projects an annual shortage of about 9,200 acft/yr through 2030 when the shortage is projected to be 9,224 acft. Strategies to meet these needs are conservation, weather modification, and brush control. There do not appear to be any long-term water level declines in the Trinity aquifer in Eastland County, which indicates that there has been no significant mining of the aquifer (Figure 12). Therefore, Eastland County is not being designated as part of the recommended Central Texas (Trinity Aquifer) Priority Groundwater Management Area.

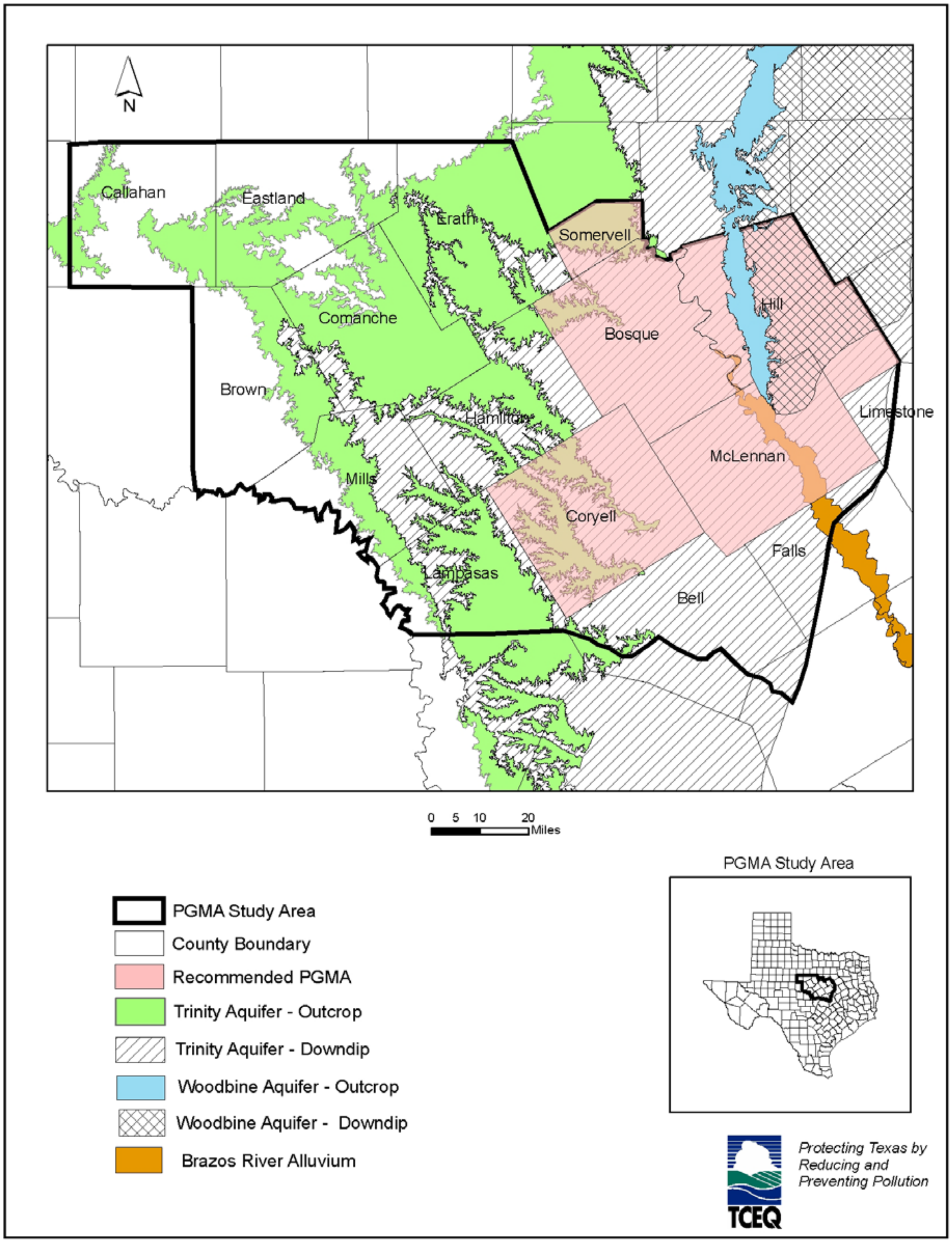

Figure 18. Recommended Central Texas (Trinity Aquifer) Priority Groundwater Management Area.

Groundwater Conservation District Considerations

One or more groundwater conservation districts created within Bosque, Coryell, Hill, McLennan, and Somervell counties would have the necessary authority to address the groundwater problems identified in the area. Such a district(s) would have the best available regulatory authority to manage and protect groundwater resources in the area and would benefit small water suppliers and domestic users in rural areas in these counties by implementing groundwater management programs as authorized under state law. GCD programs with the following goals would benefit groundwater users in these counties;

- manage groundwater withdrawals;
- quantify groundwater availability and quality;
- identify groundwater problems that should be addressed through aquifer- and area-specific research, monitoring, data collection, assessment, and education programs;
- quantify aquifer impacts from pumpage;
- establish a comprehensive water well inventory, registration, and permitting program; and
- evaluate and understand aquifer characteristics sufficiently to establish spacing regulations to minimize drawdown of water levels and to prevent interference among neighboring wells.

The remote rural water suppliers; individual businesses, industries, homeowners; and small municipalities of these counties would benefit from these and other types of management programs for the Trinity, Brazos River Alluvium, and Woodbine aquifers.

The 1990 Texas Water Commission report for the study area recognized that regional management practices are needed to stabilize groundwater levels and to help preserve the aquifer for future use. Interviews indicated that the residents of the area would not support the creation of GCDs financed by ad valorem taxes. There is a large dichotomy of population distribution and water supply source, mainly divided between large population centers using surface water and small population centers, rural, and farming areas using groundwater. Formation of a GCD would probably be viewed as only benefiting a relative few on groundwater while being financed by the majority on surface water. The 1990 report also recommended the Commission should monitor the conversion from groundwater to surface water usage, and if conversion plans are not being implemented or effective, consideration should be given to critical area designation.

Continued and new conversions are adopted regional water plan strategies for implementation over the next 30 years. GCDs have been established in five area counties, Bell County (Clearwater UWCD), Comanche and Erath counties (Middle Trinity GCD), Lampasas County (Saratoga UWCD), and Mills County (Fox Crossing WD). A regional groundwater conservation district for the recommended PGMA counties would include the greatest areal extent of the Trinity and Woodbine aquifers experiencing supply problems. From a resource protection perspective, this option would be the most efficient by allowing for a single groundwater management program that would assure consistency across the area, providing a central groundwater management entity for decision-making purposes, and simplifying groundwater management planning responsibilities related to Groundwater Management Area #8. This type of regional GCD could effectively be governed by a board of directors with one board member elected to represent each county.

Financing groundwater management activities solely through well production fees is concluded not to be a viable alternative. However, a regional GCD could be adequately funded by a combination of an ad valorem tax and well production fees. Using both revenue sources would decrease the tax rate required over a solely tax-based funding method. Multi-county GCDs with boundaries based on aquifer occurrence or on political boundaries or other political-preference considerations would also be considered feasible

The creation of multi-county GCDs with boundaries based on aquifer occurrence or on political boundaries or other political-preference considerations would also be considered feasible if sufficient revenue can be generated in the area to finance district operation and maintenance. This is the case for the new, 80th Legislature-created, McLennan County and Tablerock Groundwater Conservation Districts. Both of the GCDs are required to add at least one adjacent county to their boundaries by September 1, 2011, and it us expected that the targeted counties would be in the recommended PGMA. The creation of the new GCDs must be confirmed by the voters before they can establish groundwater management programs.

The creation of two or three GCDs would require a like number of largely duplicated administrative and groundwater management programs be implemented and coordinated. The creation of single-county GCDs – funded by the well production fees authorized by state law – is not considered practicable because none of the counties, on an individual basis, have enough groundwater production to generate sufficient revenue to operate an efficient and functional GCD. However, all of the recommended PGMA counties on an individual basis could feasibly finance GCD operation and maintenance through the levy of ad valorem taxes, and most could generate sufficient revenue to operate a GCD at a rate below $0.015 (one and a half cents) per $100 assessed valuation. Attempts to authorize a new taxing entity to manage groundwater resources will be difficult in counties where most of the voters rely on surface water sources.

Groundwater Conservation District Recommendations

<u>It is recommended that a regional groundwater conservation district for the preservation of the Trinity, Brazos River Alluvium, and Woodbine aquifers in Bosque, Coryell, Hill, McLennan, and Somervell counties represents the most feasible, economic, and practicable option for protection and management of the groundwater resources</u> (Figure 19). Under this recommendation, each county could have one member on the district's board of directors. An example of a range of revenue that could be generated from such a district would be from $500,000 to $1,000,000 annually from a $0.000385 to $0.0077/$100 ($3.85 for $100,000 to $7.70 for $100,000) valuation ad valorem tax. The ad valorem taxes could be used in combination with fees generated from permitting non-exempt water wells to finance the operation and maintenance of the district and to implement the groundwater assessment, monitoring, registration, permitting, planning, and educational programs that are needed to protect the Trinity, Brazos River Alluvium, and Woodbine aquifers. Such a district could also establish county committees for more localized and formal input to the board of directors. The county committees could be charged to make recommendations and advise the board of directors on water-related issues, programs, or activities that affect the individual counties. The purpose, board of directors configuration, and estimate of minimum financing needs for the recommended regional GCD are provided in Appendix IX.

<u>Alternatively, it is recommended that two multi-county GCDs could be created based on (1) local initiative to establish economically viable and functional districts, (2) aquifer occurrence and present and projected use, and (3) other political or location considerations</u> (Figure 20). Based on GCD creation bills passed during the 80th Legislature, Regular Session, 2007, it is suggested that one GCD could include the Trinity aquifer artesian zone counties of Hill and McLennan. A second GCD could consist of the combined Trinity aquifer outcrop and artesian zones of Bosque, Coryell, and Somervell counties.

It is also suggested that the landowners in Eastland County living and relying heavily on the Trinity aquifer (37.7 % of the county area) may find it to their advantage to attempt to join the already existing Middle Trinity GCD. The Brazos G regional water plan reported that Eastland County had a total water shortage of 9,140 acft in 2000 for the irrigation WUG. The report also projects an annual shortage of about 9,200 acft/yr through 2030 when the shortage is projected to be 9,224 acft.

Strategies to meet these needs are conservation, weather modification, and brush control. There do not appear to be any long-term water level declines in the Trinity aquifer in Eastland County, which indicates that there has been no significant mining of the aquifer.

For Brown, Callahan, Falls, and Hamilton counties, it is suggested that the creation of GCDs may be warranted in the future if groundwater usage practices and trends drastically exceed what is projected in the 2006 regional water plans. These counties can monitor and consider the need for groundwater management over a longer term because they do not presently have, or are projected to have critical groundwater problems in the next 25-year period.

Concerning the local actions taken in Coryell and McLennan counties, it is suggested that the temporary directors of the newly created Tablerock and McLennan County Groundwater Conservation Districts coordinate educational programming for the creation of the district with the Texas Cooperative Extension and the Texas Alliance of Groundwater Districts.

The use and application of the permissive authority granted to municipal and county platting authorities to require groundwater availability certification under the Local Government Code can be an effective tool to help ensure that residents of new subdivisions that will rely on individual household wells will have adequate groundwater resources. The exercise of this power by platting authorities can be used to help determine the lot size requirements needed to minimize or prevent well interference between and with the new neighbors. The aquifer testing required under the application of this authority would provide meaningful and valid data for groundwater management decision making. All of the above tools can be effective in protecting groundwater, especially if they are used in conjunction with GCD water well permitting responsibilities. It is recommended that local governments consider using this groundwater management tool to address water supply concerns in rapidly developing areas.

Natural Resource Considerations

Few species are directly dependent upon the groundwater resources of the study area. However, the study area springs contribute to surface water hydrology and have helped shape the existing ecosystems. Any groundwater management program that would abate and reverse aquifer over pumping and the resultant decline in water levels would benefit the land and habitat for the remaining species in the area. Groundwater management programs to monitor, evaluate, and understand the aquifers may be used peripherally to develop and establish educational programs to protect riparian habitats or to attempt to enhance or rejuvenate spring flows.

The TPWD concluded that protecting the quality and quantity of the ground and surface water of the Central Texas study area are important goals and the implementation of protection and management strategies will ultimately safeguard other natural and economic resources in the area that are either directly or indirectly influenced by groundwater. Designation of part of the study area as a PGMA and the creation of GCDs should lead to a more efficient use of the existing water resources in the area.

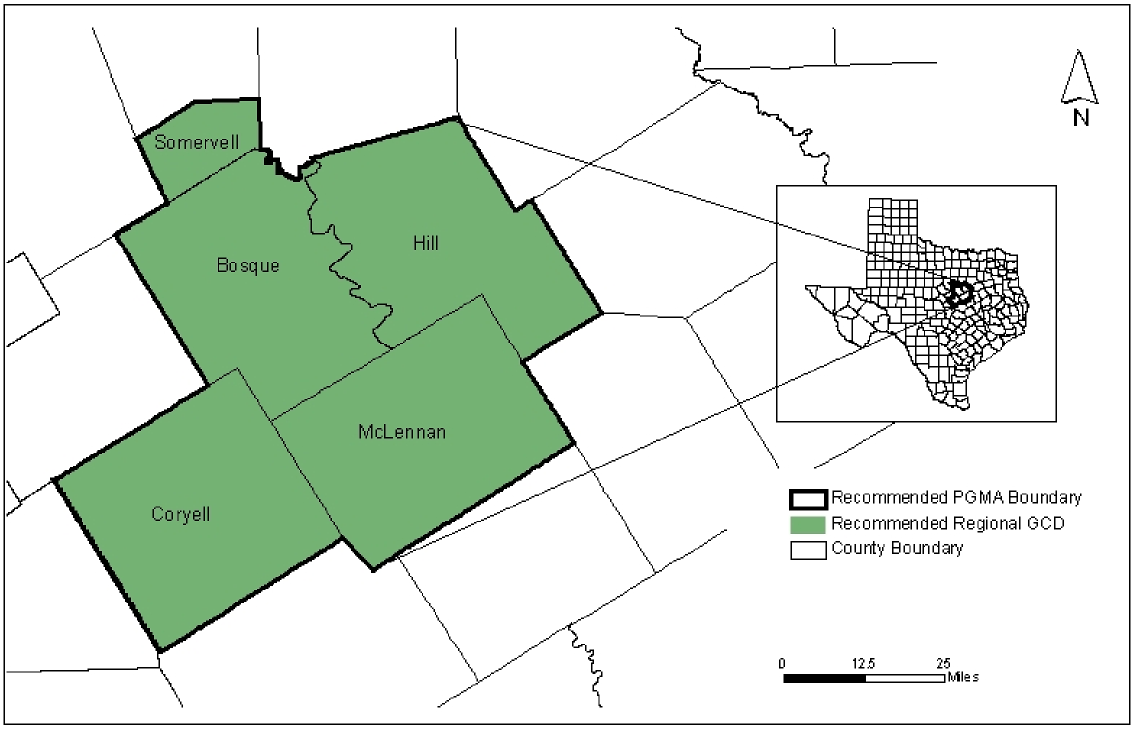

Figure 19. Regional Groundwater Conservation District Recommendation

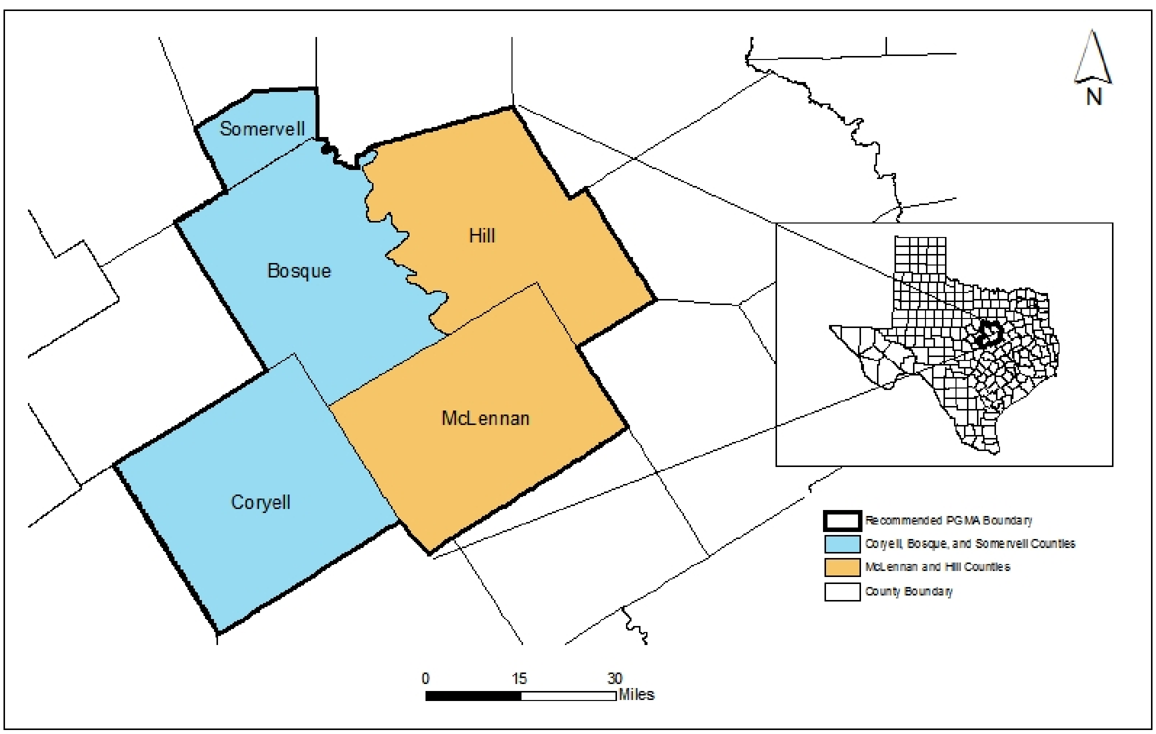

Figure 20. Alternative Recommendation for Two Multi-County Groundwater Conservation Districts.

Public Comment and Response

Three stakeholders provided written comments related to the February 2007 draft report findings, conclusions, and recommendations for this study. They are Dickie Clary, Hamilton County Commissioner, the Brazos River Authority, and the Lone Star Chapter of the Sierra Club.

Commissioner Clary's comments on the draft report were generally neutral to recommendations regarding PGMA designation and GCD creation.

The Brazos River Authority (BRA) provided information regarding their role in increasing the surface water supplies to customers in the Central Texas PGMA study area through the reallocation of storage in existing U. S. Army Corps of Engineers reservoir projects used by BRA. Development of natural gas resources in portions of the Barnett Shale located in the Central Texas PGMA study area is expected to increase short-term demand on the BRA's surface water resources. The BRA will continue to meet these demands to the extent that it can with available surface water supplies.

The Sierra Club submitted positive comments for the recommendation of the five-county designation in the Central Texas PGMA study area. However, there were some concerns regarding certain counties that were not included in the recommended designations. Those counties included Hamilton, Eastland, and Falls.

The recommendation for the designation of the 5-county area was not changed because a dedicated aquifer monitoring and management program is needed to protect Trinity and Woodbine aquifer users.

An alternative recommendation for the creation of two multi-county, GCDs was added based on local actions taken independently to create, subject to a confirmation election, the Tablerock GCD, Coryell County and the McLennan County GCD. Each newly created District must add at least one adjacent county to their District before September 1, 2011.

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APPENDIX I. 1990 CRITICAL AREA REPORT SUMMARY FOR TEXAS WATER COMMISSION

GROUNDWATER PROTECTION AND MANAGEMENT STRATEGIES FOR THE CENTRAL TEXAS (WACO) AREA
(A Critical Area Groundwater Study)
Chapter 52, Subchapter C, Texas Water Code

TECHNICAL SUMMARY

The Central Texas (Waco) Area, which includes Callahan, Eastland, Erath, Somervell, Hill, Bosque, Hamilton, Comanche, Brown, Mills, Lampasas, Coryell, McLennan, Limestone, Falls, Bell, and Milam counties was identified as a potential critical area and nominated for a detailed study by the Texas Water Commission and the Texas Water Development Board in a joint press release dated January 13, 1987. A study of the Central Texas Area was requested by the Executive Director in a letter to the Executive Administrator dated September 1, 1989. A draft report, summarizing the Board's study and titled Evaluation of Water Resources in Part of Central Texas was received from the Executive Administrator in December, 1989. A Critical Area Report has been prepared by Commission staff recommending that the study area not be designated a Critical Area, and providing information about the area in support of the recommendations.

A public meeting was held in Arlington, Texas on September 9, 1986, to solicit comment regarding critical area designation for the study area. Interviews of members of local government, industry, and concerned citizens were conducted in March of 1989. An eleven-member advisory committee, composed of representatives from throughout the study area, was formed in July, 1989, to assist TWC staff in assessing local groundwater conditions and to provide input and comments on both ground and surface water issues on a local level. The advisory committee provided input to the report and on the recommendations in the TWC report.

In the Central Texas study area, more ground water is being withdrawn than recharged to the aquifers. Pumpage has historically exceeded recharge, resulting in declining water levels and possibly deteriorating chemical quality in the Hosston and Hensel members of the Trinity Group aquifer in the eastern portion of the study area. In 1984, it was recognized by the Texas Department of Water Resources that overdrafts are occurring in the Trinity Group aquifer in portions of Bell, Bosque, Falls, Hill, and McLennan counties. The effective recharge to the Trinity Group aquifer is a little over 26,000 acre-feet per year. However, in 1985, a little less than 77,000 acre-feet of groundwater was pumped from the Trinity Group aquifer in the study area, resulting in a net loss of approximately 51,000 acre-feet of water from the aquifer in 1985. Water-level declines and associated reduction of artesian pressure caused by continued, deficit-removal of water from storage are a regional ground water problem.

Current and projected water demand for the area is based on three factors, increased population growth, water use, and current availability of both groundwater and surface water. The Texas Water Development Board projects the population to grow forty-eight percent between 1980 and 2010. The annual water requirement for the study area is expected to increase by approximately forty percent from 1985 to 2010. In 1985, a total of 80,930 acre-feet of groundwater was pumped from all aquifers in the study area with 95 percent or 76,884 acre-feet pumped from the Trinity Group. A total of 205,852 acre-feet of water was used for public supply, irrigation, industrial, power, and livestock purposes in the area with groundwater supplying 39 percent of the total and surface water supplying the remaining 61 percent or 124,922 acre-feet.

Shortage of present and future supplies of groundwater may pose a serious problem for the study area. However, the area is not facing a “critical” water supply problem due to the availability of surface water. Surface water supplies are adequate to meet current and projected needs beyond 2010. Many large-volume groundwater users, concentrated in the Waco area, have converted, to surface water sources in recent years. However, the reduction of pumpage by the large volume users has been offset by continued sharp increases by numerous small municipal users, utility districts, and water-supply corporations. While an underground water conservation district has broad powers to regulate activities that endanger aquifers from either overpumpage or pollution, protection of existing groundwater supplies through large-quantity producer conversion to surface water may be the best regional management method for the area. However, to convert to surface water supplies; reservoirs, treatment plants, and conveyance systems will have to be built. It is also recognized that an underground water district may not be the most appropriate mechanism for facilitating conversation to surface water.

There are a number of significant water quality problems in the study area. The western portion is affected locally by sodium chloride contamination from past oil and gas activities and locally by elevated nitrates. Deterioration of good quality groundwater from mixing with naturally occurring, more saline waters has occurred in the study area from poor well construction and possibly from heavy pumpage. In some parts of the eastern portion of the study area, groundwater used for public contains concentrations of some dissolved inorganic constituents in excess of Texas Department of Health standards. Man-induced groundwater quality problems are localized in their affects and do not affect the study area regionally. Naturally occurring mineralized groundwater does pose problems for public water supplies in the eastern portion of the study area.

In general, it is recognized that regional management practices are needed to stabilize groundwater levels and to help preserve the aquifers for future use. Interviews indicated that the area, as a whole, would probably not support the formation of a district created under Chapter 52 Subchapter C, Texas Water Code, mainly due to the ad valorem taxing structure. There is a large dichotomy in the population distribution and water-supply source, mainly divided between the large population centers on, or soon to be on, surface water supplies and small population centers, rural, and farming areas on groundwater supplies. As a result, an underground water conservation district would probably be viewed as only benefiting a relative few on groundwater while being financed by the majority on surface water.

Although many cities are currently experiencing problems with groundwater level declines in the aquifers that supply their water, they are implementing plans that will alleviate their supply problems in the future. Planning in many areas relies on surface water for future supplies. The groundwater problems in these areas will not be critical if future surface water supply plans are implemented. The major blockage to surface water conversion is the initially large expense to build reservoirs, treatment plants, and conveyance systems.

It is recommended that the Texas Water Commission not designate the Central Texas area as a Critical Area at this time. Progress towards the conversion from ground to surface water usage should be monitored by the Texas Water Commission over the next five years, and if conversion plans are not being implemented, consideration should again be given to “Critical Area” designation.

Prepared by:	Steve Musick, Geologist Groundwater Conservation Section Texas Water Commission	March 30, 1990
Approved by:	Bill Klemt, Chief Groundwater Conservation Section Texas Water Commission	March 30, 1990

APPENDIX II. STRATIGRAPHIC UNITS AND THEIR WATER-BEARING CHARACTERISTICS.

SYSTEM	SERIES	GROUP	STRATIGRAPHIC UNITS		HYDROLOGIC UNITS	THICKNESS (feet)	ROCK CHARACTERISTICS	WATER BEARING CHARACTERISTICS
Quaternary and Tertiary			Brazos River Alluvial deposits.		Alluvium & Terraces	--	Mostly gravel, sand, silt, and clay	Yields small to large quantities of water in local areas.
Cretaceous	Gulf	Navarro				0-550	Shale, marl, and sand.	Locally yields small quantities of usable water.
		Taylor				0-1,000	Marl and limy shale.	
		Austin				0-600	Chalky Limestone	
		Eagle Ford				0-300	Shale.	Not known to yield water.
		Woodbine				0-200	Ferruginous sand, sandstone, shale, sandy shale, clay, with some lignite and gypsum.	Yields small to moderate quantities of water
	Comanche	Washita	Buda Formation			0-50	Porcelaneous limestone.	Not known to yield water.
		Fredericks-burg	Del Rio Formation			0-100	Shale and clay.	Not known to yield water.
			Georgetown Formation			0-150	Limestone.	May yield water in connection with the Edwards.
			Kiamichi			0-50	Shale.	Not known to yield water.
			Edwards Formation			0-175	Reefal Limestone, shale, chert, and dolomite.	Yields small to large quantities s of water.
		Trinity	Comanche Peak Formation			0-150	Limestone and limy shale.	Yields little or no water.
			Walnut Formation			0-200	Limestone, shale, and clay..	Yields small quantities of water to shallow wells.
			Paluxy Formation		Upper Trinity	0-100	Sand, shale, and clay.	Yields small quantities of fresh to slightly saline water to wells.
			Glen Rose Formation		Upper Trinity / Middle Trinity	0-330	Limestone, marl, shale, and clay with sand lenses.	Yields small quantities of water to shallow wells in localized areas.
			Travis Peak Formation	Hensell Member	Middle Trinity	0-185	Fine- to coarse-grained sand, gravel, shale, sandstone, and clay.	Yields small to moderate quantities of fresh to slightly saline water.
				Pearsall Member		0-60	Clay, sandy clay, shale, and local sand lenses.	Yields no water or only small amounts along the outcrop.
				Cow Creek Member		0-130	Limestone	Yields small quantities of water near the outcrop.
				Hammett Member		0-140	Shale	Not known to yield water.
				Hosston Member	Lower Trinity	0-125	Medium- to coarse-grained sand, gravel, sandstone, shale, clay, and conglomerate (siliceous).	Yields moderate to large quantities of fresh to slightly saline water.
				Sycamore Member		-	Sand conglomerate with calcareous cement, shale, and limestone.	Yields little or no water.
				Sligo Member		0-130	Limestone.	Not known to yield water.

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APPENDIX III. SPECIES OF SPECIAL CONCERN.

Table III.1. Species of Special Concern, Central Texas (Trinity Aquifer) PGMA Study.

Scientific Name	Common Name	Fed Status	State Status	Bell	Bosque	Brown	Callahan	Comanche	Coryell	Eastland	Erath	Falls	Hamilton	Hill	Lampasas	Limestone	McLennan	Mills	Somervell
AMPHIBIANS																			
Eurycea chisholmensis	Salado springs salamander	C1		x															
BIRDS																			
Ammodramus bairdii*	Baird's sparrow					x		x		x	x								x
Ammodramus henslowii*	Henslow's sparrow			x	x				x		x	x	x	x		x	x		x
Athene cunicularia hypugaea*	Western burrowing owl			x	x	x	x	x	x	x	x	x	x	x		x	x		x
Charadrius melodus*	Piping plover	LT														x			x
Charadrius monatus*	Mountain plover			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Dendrioca chrysoparia*	Golden cheeked warbler	LE	E	x	x	x		x	x	x	x		x		x		x		x
Falco peregrinus anatum*	American peregrine falcon	DL	E			x	x	x		x	x	x	x		x			x	x
Falco peregrinus tundrius	Arctic peregrine falcon	DL	T	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Grus americana*	Whooping crane	LE	E	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Haliaeetus leucocephalus*	Bald eagle	LT-PDL	T		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lanius ludovicianus migrans*	Migrant loggerhead shrike			x	x				x			x		x		x	x		
Mycteria americana	Wood stork		T										x		x			x	
Plegadis chihi*	White-faced ibis		T									x		x		x	x		
Sterna antillarum athalassos*	Interior least tern	LE	E	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Vireo atricapillus*	Black-capped vireo	LE	E	x	x	x	x	x	x		x		x		x			x	x
FISHES																			
Angulla rostrata	American eel			x							x	x		x			x		

Scientific Name	Common Name	Fed Status	State Status	Bell	Bosque	Brown	Callahan	Comanche	Coryell	Eastland	Erath	Falls	Hamilton	Hill	Lampasas	Limestone	McLennan	Mills	Somervell
Micropterus treculi	Guadelupe bass			x	x	x						x			x		x	x	
Notropus buccula*	Smalleye shiner	C1		x	x		x	x	x	x	x	x	x	x	x	x	x		x
Notropis oxyrhincus*	Sharpnose Shiner	C1		x	x	x		x	x	x	x	x	x	x			x		x
MAMMALS																			
Canis lupus* (exterpated)	Grey wolf	LE	E			x		x		x	x		x		x			x	x
Canis rufus* (extirpated)	Red wolf	LE	E			x		x		x	x		x		x			x	x
Cynomys ludovicianus*	Black-tailed prairie dog															x			x
Myotis Austroriparius	Southeastern myotis bat							x											
Myotis velifer*	Cave myotis bat			x	x	x	x	x	x		x	x	x	x	x	x	x	x	
Spilogale putorius interrupta*	Plains spotted skunk			x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
INSECTS																			
Taeniopteryx stark*	Leon river winter stonefly				x			x	x	x	x		x						x
MOLLUSKS																			
Arcidens confagosus	Rock-pocketbook			x	x				x			x		x		x	x		x
Quadula houstonensis	Smooth pimpleback			x	x				x			x		x		x	x		
Quicuncina mitchelli	False spike mussel			x	x				x			x				x	x		
Tritogonia verrucosa	Pistolgrip			x	x		x		x		x	x		x		x	x		x
Truncilla macrodon	Texas fawnsfoot			x	x		x		x		x	x		x		x	x		x
REPTILES																			
Crotalus horridus*	Timber/canebrake rattlesnake		T		x						x	x		x		x	x		x
Nerodia harteri*	Brazos water snake		T		x					x	x								x
Nerodia paucimaculata	Concho water snake	LT				x									x			x	
Phrynosoma cornutum*	Texas horned lizard		T	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Thamnophis sirtalis annectens*	Texas garter snake			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
VASCULAR PLANTS																			
Argythamnia aphoroides	Hill country wild-mercury					x												x	

Scientific Name	Common Name	Fed Status	State Status	Bell	Bosque	Brown	Callahan	Comanche	Coryell	Eastland	Erath	Falls	Hamilton	Hill	Lampasas	Limestone	McLennan	Mills	Somervell
Croton alabamensis var texensis	Texabama croton			x					x										
Eriocaulon koernickianum*	Small-headed pipewort															x			
Yucca necopina*	Glen rose yucca																		x

* Species found near Off-Channel Reservoirs in Limestone and Somervell counties.

Status Key:

LE, LT	- Federally Listed Endangered/Threatened
E, T	- Federally Listed Endangered/Threatened by Similarity of Appearance
C1	- Federal Candidate for Listing, Category 1; information supports proposing to list as Endangered/Threatened
DL, PDL	- Federally Delisted/Proposed for Delisting
E, T	- State Listed Endangered/Threatened
“blank”	- Rare, but with no regulatory listing status

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APPENDIX IV. PROJECTED WATER DEMAND DATA. CENTRAL TEXAS (TRINITY AQUIFER) PGMA STUDY.

Table IV.1. Municipal Water Demand Projections for 2000 - 2060 (acre-feet).

REGION	COUNTY NAME	2000*	2010	2020	2030	2040	2050	2060
G	BELL	48,665	58,295	67,750	73,914	78,782	83,127	87,372
G	BOSQUE	2,539	2,829	3,138	3,342	3,382	3,389	3,437
F	BROWN	6,886	7,106	7,173	7,111	6,978	6,932	6,932
G	CALLAHAN	1,500	1,447	1,419	1,353	1,298	1,247	1,226
G	COMANCHE	1,770	1,830	1,832	1,798	1,745	1,683	1,630
G	CORYELL	13,284	15,761	17,969	20,079	21,531	22,836	24,017
G	EASTLAND	3,003	2,939	2,885	2,773	2,639	2,513	2,400
G	ERATH	4,619	4,907	5,252	5,554	5,845	6,870	7,547
G	FALLS	3,895	3,993	4,132	4,271	4,388	4,496	4,663
G	HAMILTON	1,360	1,279	1,239	1,199	1,176	1,146	1,145
G	HILL	4,790	4,862	5,000	5,164	5,331	5,573	5,892
G	LAMPASAS	3,667	4,467	4,956	5,290	5,519	5,675	5,774
G	LIMESTONE	3,193	3,293	3,447	3,510	3,544	3,616	3,752
G	McLENNAN	44,105	47,046	50,004	52,499	55,064	56,727	59,404
K	MILLS	992	971	999	991	982	966	951
G	SOMERVELL	1,013	1,071	1,145	1,202	1,229	1,238	1,245
	TOTAL	145,281	162,096	178,340	190,050	199,433	208,034	217,387

Table IV.2. Irrigation Water Demand Projections for 2000 - 2060 (acre-feet).

REGION	COUNTY NAME	2000*	2010	2020	2030	2040	2050	2060
G	BELL	1,679	1,656	1,634	1,611	1,591	1,569	1,546
G	BOSQUE	2,543	2,504	2,466	2,427	2,388	2,352	2,316
F	BROWN	10,112	12,313	12,272	12,230	12,189	12,146	12,105
G	CALLAHAN	819	806	793	780	767	755	742
G	COMANCHE	35,969	35,598	35,230	34,867	34,507	34,151	33,798
G	CORYELL	0	0	0	0	0	0	0
G	EASTLAND	16,274	16,302	16,327	16,352	16,370	16,377	16,385
G	ERATH	10,816	10,658	10,502	10,349	10,197	10,048	9,901
G	FALLS	1,928	1,866	1,806	1,748	1,691	1,637	1,584
G	HAMILTON	483	475	467	464	456	434	413
G	HILL	43	43	42	42	42	42	41
G	LAMPASAS	170	168	166	164	162	160	159
G	LIMESTONE	0	0	0	0	0	0	0
G	McLENNAN	2,819	2,816	2,814	2,812	2,809	2,806	2,803
K	MILLS	3,001	2,936	2,872	2,810	2,749	2,689	2,631
G	SOMERVELL	475	474	471	468	467	464	461
	TOTAL	87,131	88,615	87,862	87,124	86,385	85,630	84,885

Adapted from 2006 TWDB Water Demand Projections

Table IV.3. Manufacturing Water Demand Projections for 2000 - 2060 (in acre-feet).

REGION	COUNTY NAME 1	2000*	2010	2020	2030	2040	2050	2060
G	BELL	800	980	1,085	1,180	1,273	1,355	1,463
G	BOSQUE	794	1,005	1,151	1,285	1,417	1,531	1,664
F	BROWN	479	577	636	686	734	775	837
G	CALLAHAN	0	0	0	0	0	0	0
G	COMANCHE	26	31	34	37	39	41	44
G	CORYELL	7	9	10	11	12	13	14
G	EASTLAND	36	43	47	50	53	55	59
G	ERATH	57	73	82	90	98	105	
G	FALLS	2	2	2	2	2	2	2
G	HAMILTON	3	4	5	6	7	8	9
G	HILL	67	85	97	108	119	129	140
G	LAMPASAS	108	129	142	153	164	174	187
G	LIMESTONE	39	48	53	58	63	67	72
G	McLENNAN	2,804	3,526	4,068	4,577	5,096	5,561	6,022
K	MILLS	1	1	1	1	1	1	1
G	SOMERVELL	5	6	7	8	9	10	11
	TOTAL	5,228	6,519	7,420	8,252	9,087	9,827	10,525

Adapted from 2006 TWDB Water Demand Projections.

Table IV.4. Steam Electric Water Demand Projections for 2000 - 2060 (in acre-feet).

REGION	COUNTY NAME 1	2000*	2010	2020	2030	2040	2050	2060
G	BELL	0	0	3,674	4,296	5,053	5,977	7,102
G	BOSQUE	521	4,323	6,188	7,235	8,510	10,065	11,961
F	BROWN	0	0	0	0	0	0	0
G	CALLAHAN	0	0	0	0	0	0	0
G	COMANCHE	0	0	0	0	0	0	0
G	CORYELL	0	0	0	0	0	0	0
G	EASTLAND	0	0	0	0	0	0	0
G	ERATH	0	0	0	0	0	0	0
G	FALLS	0	0	0	0	0	0	0
G	HAMILTON	0	0	0	0	0	0	0
G	HILL	0	0	0	0	0	0	0
G	LAMPASAS	0	0	0	0	0	0	0
G	LIMESTONE	22,065	22,332	22,598	26,420	31,079	36,758	43,681
G	McLENNAN	24,412	37,098	32,983	35,720	39,056	43,123	48,081
K	MILLS	0	0	0	0	0	0	0
G	SOMERVELL	18,000	23,200	23,200	23,200	23,200	23,200	23,200
	TOTAL	64,998	86,953	88,643	96,871	106,898	119,123	134,025

Adapted from 2006 TWDB Water Demand Projections.

Table IV.5. Livestock Water Demand Projections for 2000 - 2060 (in acre-feet).

REGION	COUNTY NAME 1	2000*	2010	2020	2030	2040	2050	2060
G	BELL	953	953	953	953	953	953	953
G	BOSQUE	1,048	1,048	1,048	1,048	1,048	1,048	1,048
F	BROWN	1,471	1,636	1,636	1,636	1,636	1,636	1,636
G	CALLAHAN	976	,976	976	976	976	976	976
G	COMANCHE	4,253	4,253	4,253	4,253	4,253	4,253	4,253
G	CORYELL	1,339	1,339	1,339	1,339	1,339	1,339	1,339
G	EASTLAND	1,121	1,121	1,121	1,121	1,121	1,121	1,121
G	ERATH	9,321	9,321	9,321	9,321	9,321	9,321	9,321
G	FALLS	1,626	1,626	1,626	1,626	1,626	1,626	1,626
G	HAMILTON	1,961	1,961	1,961	1,961	1,961	1,961	1,961
G	HILL	1,401	1,401	1,401	1,401	1,401	1,401	1,401
G	LAMPASAS	,688	688	688	688	688	688	,688
G	LIMESTONE	1,487	1,487	1,487	1,487	1,487	1,487	1,487
G	McLENNAN	1,151	1,151	1,151	1,151	1,151	1,151	1,151
K	MILLS	918	918	918	918	918	918	918
G	SOMERVELL	166	166	166	166	166	166	166
	TOTAL	29,880	30,045	30,045	30,045	30,045	30,045	30,045

Adapted from 2006 TWDB Water Demand Projections.

Table IV.6. Mining Water Demand Projections for 2000 - 2060 (in acre-feet).

REGION	COUNTY NAME 1	2000*	2010	2020	2030	2040	2050	2060
G	BELL	174	155	150	147	144	141	139
G	BOSQUE	276	210	197	189	182	176	172
F	BROWN	2,427	2,487	2,504	2,510	2,516	2,522	2,530
G	CALLAHAN	81	92	96	98	100	101	103
G	COMANCHE	80	54	51	50	49	48	47
G	CORYELL	100	108	111	113	115	117	118
G	EASTLAND	79	95	102	105	108	111	115
G	ERATH	0	0	0	0	0	0	0
G	FALLS	133	101	95	91	88	85	83
G	HAMILTON	0	0	0	0	0	0	0
G	HILL	118	100	96	94	92	90	89
G	LAMPASAS	193	152	144	139	135	131	128
G	LIMESTONE	360	380	387	392	396	400	403
G	McLENNAN	481	416	399	389	380	371	366
K	MILLS	0	0	0	0	0	0	0
G	SOMERVELL	392	304	287	278	270	263	257
	TOTAL	4,894	4,654	4,619	4,595	4,575	4,556	4,550

Adapted from 2006 TWDB Water Demand Projections.

* Historical Data

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APPENDIX V. WATER DEMAND AND SUPPLY PROJECTIONS.

Table V.1. Total Water Demand and Supply Projections for 2000 - 2060 (in acre-feet).

Year			Historical	Projections (acft/yr)					
			2000	2010	2020	2030	2040	2050	2060
BELL COUNTY									
Municipal	Municipal Demand		48,665	58,295	67,750	73,914	78,782	83,127	87,372
	Municipal Existing Supply	Groundwater	2,242	2,239	2,238	2,236	2,235	2,234	2,233
		Surface water	101,979	101,568	101,416	101,262	101,088	100,907	100,722
	Total Existing Municipal Supply		104,221	103,807	103,654	103,498	103,323	103,141	102,955
	Municipal Balance		55,556	45,512	35,904	29,584	24,541	20,014	15,583
Industrial	Manufacturing Demand		800	980	1,085	1,180	1,273	1,355	1,463
	Manufacturing Existing Supply	Groundwater	17	17	17	17	17	17	17
		Surface water	0	0	0	0	0	0	0
	Total Manufacturing Supply		17	17	17	17	17	17	17
	Manufacturing Balance		(783)	(963)	(1,068)	(1,163)	(1,256)	(1,338)	(1,446)
	Steam-Electric Demand		0	0	3,674	4,296	5,053	5,977	7,102
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	8,762	8,762	8,762	8,762	8,762	8,762	8,762
	Total Steam-Electric Supply		8,762	8,762	8,762	8,762	8,762	8,762	8,762
	Steam-Electric Balance		8,762	8,762	5,088	4,466	3,709	2,785	1,660
	Mining Demand		174	155	150	147	144	141	139
	Mining Existing Supply	Groundwater	174	155	150	147	144	141	139
		Surface water	2	2	2	2	2	2	2
	Total Mining Supply		176	157	152	149	146	143	141
	Mining Balance		2	2	2	2	2	2	2
Agriculture	Irrigation Demand		1,679	1,656	1,634	1,611	1,591	1,569	1,546
	Irrigation Existing Supply	Groundwater	215	212	209	206	204	201	198
		Surface water	5,730	5,743	5,755	5,768	5,780	5,793	5,805
	Total Irrigation Supply		5,945	5,955	5,964	5,974	5,984	5,994	6,003
	Irrigation Balance		4,266	4,299	4,330	4,363	4,393	4,425	4,457
	Livestock Demand		953	953	953	953	953	953	953
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	953	953	953	953	953	953	953
	Total Livestock Supply		953	953	953	953	953	953	953
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		49,639	59,430	72,659	79,537	85,252	90,600	96,076
	Existing Municipal & Industrial Supply	Groundwater	2,433	2,411	2,405	2,400	2,396	2,392	2,389
		Surface water	110,743	110,332	110,181	110,027	109,853	109,671	109,486
	Total Municipal & Industrial Supply		113,176	112,743	112,586	112,427	112,249	112,063	111,875
	Municipal & Industrial Balance		63,537	53,313	39,927	32,890	26,997	21,463	15,799
	Agriculture Demand		2,632	2,609	2,587	2,564	2,544	2,522	2,499
	Existing Agricultural Supply	Groundwater	215	212	209	206	204	201	198
		Surface water	6,683	6,696	6,708	6,721	6,733	6,746	6,758
	Total Agriculture Supply		6,898	6,908	6,917	6,927	6,937	6,947	6,956
	Agriculture Balance		4,266	4,299	4,330	4,363	4,393	4,425	4,457
	Total Demand		52,271	62,039	75,246	82,101	87,796	93,122	98,575
	Total Supply	Groundwater	2,648	2,623	2,614	2,606	2,600	2,593	2,587
		Surface water	117,426	117,028	116,889	116,747	116,586	116,417	116,244
	Total Supply		120,074	119,651	119,503	119,353	119,186	119,010	118,831
	Total Balance		67,803	57,812	44,257	37,252	31,390	25,888	20,256

Table V.1 (continued).

Year			Historical 2000	Projections(acft/yr) 2010	2020	2030	2040	2050	2060
BOSQUE COUNTY									
Municipal	Municipal Demand		2,539	2,829	3,138	3,342	3,382	3,389	3,437
	Municipal Existing Supply	Groundwater	1,460	1,460	1,460	1,460	1,460	1,460	1,460
		Surface water	1,191	1,186	1,181	1,176	1,171	1,166	1,161
	Total Existing Municipal Supply		2,651	2,646	2,641	2,636	2,631	2,626	2,621
	Municipal Balance		112	(183)	(497)	(706)	(751)	(763)	(816)
Industrial	Manufacturing Demand		794	1,005	1,151	1,285	1,417	1,531	1,664
	Manufacturing Existing Supply	Groundwater	363	363	363	363	363	363	363
		Surface water	1	1	1	1	1	1	1
	Total Manufacturing Supply		364	364	364	364	364	364	364
	Manufacturing Balance		(430)	(641)	(787)	(921)	(1,053)	(1,167)	(1,300)
	Steam-Electric Demand		521	4,323	6,188	7,235	8,510	10,065	11,961
	Steam-Electric Existing Supply	Groundwater	238	238	238	238	238	238	238
		Surface water	3,500	3,500	3,500	3,500	3,500	3,500	3,500
	Total Steam-Electric Supply		3,738	3,738	3,738	3,738	3,738	3,738	3,738
	Steam-Electric Balance		3,217	(585)	(2,450)	(3,497)	(4,772)	(6,327)	(8,223)
	Mining Demand		276	210	197	189	182	176	172
	Mining Existing Supply	Groundwater	276	210	197	189	182	176	172
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		276	210	197	189	182	176	172
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		2,543	2,504	2,466	2,427	2,388	2,352	2,316
	Irrigation Existing Supply	Groundwater	468	461	454	447	439	433	426
		Surface water	6,966	6,966	6,966	6,966	6,966	6,966	6,966
	Total Irrigation Supply		7,434	7,427	7,420	7,413	7,405	7,399	7,392
	Irrigation Balance		4,891	4,923	4,954	4,986	5,017	5,047	5,076
	Livestock Demand		1,048	1,048	1,048	1,048	1,048	1,048	1,048
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,048	1,048	1,048	1,048	1,048	1,048	1,048
	Total Livestock Supply		1,048	1,048	1,048	1,048	1,048	1,048	1,048
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		4,130	8,367	10,674	12,051	13,491	15,161	17,234
	Existing Municipal & Industrial Supply	Groundwater	2,337	2,271	2,258	2,250	2,243	2,237	2,233
		Surface water	4,693	4,688	4,683	4,678	4,673	4,668	4,663
	Total Municipal & Industrial Supply		7,030	6,959	6,941	6,928	6,916	6,905	6,896
	Municipal & Industrial Balance		2,900	(1,408)	(3,733)	(5,123)	(6,575)	(8,256)	(10,338)
	Agriculture Demand		3,591	3,552	3,514	3,475	3,436	3,400	3,364
	Existing Agricultural Supply	Groundwater	468	461	454	447	439	433	426
		Surface water	8,014	8,014	8,014	8,014	8,014	8,014	8,014
	Total Agriculture Supply		8,482	8,475	8,468	8,461	8,453	8,447	8,440
	Agriculture Balance		4,891	4,923	4,954	4,986	5,017	5,047	5,076
	Total Demand		7,721	11,919	14,188	15,526	16,927	18,561	20,598
	Total Supply	Groundwater	2,805	2,732	2,712	2,697	2,682	2,670	2,659
		Surface water	12,707	12,702	12,697	12,692	12,687	12,682	12,677
	Total Supply		15,512	15,434	15,409	15,389	15,369	15,352	15,336
	Total Balance		7,791	3,515	1,221	(137)	(1,558)	(3,209)	(5,262)

Table V.1 (continued).

Year			Historical	Projections(acft/yr)					
			2000	2010	2020	2030	2040	2050	2060
BROWN COUNTY									
Municipal	Municipal Demand		6,885	7,106	7,173	7,111	6,978	6,932	6,932
	Municipal Existing Supply	Groundwater	168	21	21	21	21	21	21
		Surface water	6,717	7,666	7,697	7,650	7,561	7,532	7,533
	Total Existing Municipal Supply		6,885	7,687	7,718	7,671	7,582	7,553	7,554
	Municipal Balance		0	581	545	560	604	621	622
Industrial	Manufacturing Demand		479	577	636	686	734	775	837
	Manufacturing Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	479	577	636	686	734	775	837
	Total Manufacturing Supply		479	577	636	686	734	775	837
	Manufacturing Balance		0	0	0	0	0	0	0
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		2,427	2,487	2,504	2,510	2,516	2,522	2,530
	Mining Existing Supply	Groundwater	153	213	230	236	242	248	256
		Surface water	2,274	2,274	2,274	2,274	2,274	2,274	2,274
	Total Mining Supply		2,427	2,487	2,504	2,510	2,516	2,522	2,530
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		10,112	12,313	12,272	12,230	12,189	12,146	12,105
	Irrigation Existing Supply	Groundwater	2,320	1,559	1,542	1,536	1,536	1,530	1,516
		Surface water	7,792	7,748	7,748	7,748	7,748	7,748	7,748
	Total Irrigation Supply		10,112	9,307	9,290	9,284	9,284	9,278	9,264
	Irrigation Balance		0	(3,006)	(2,982)	(2,946)	(2,905)	(2,868)	(2,841)
	Livestock Demand		1,471	1,636	1,636	1,636	1,636	1,636	1,636
	Livestock Existing Supply	Groundwater	147	313	313	313	313	313	313
		Surface water	1,324	1,323	1,323	1,323	1,323	1,323	1,323
	Total Livestock Supply		1,471	1,636	1,636	1,636	1,636	1,636	1,636
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		9,791	7,683	7,809	7,671	7,713	7,707	7,769
	Existing Municipal & Industrial Supply	Groundwater	321	21	21	21	21	21	21
		Surface water	9,470	8,243	8,333	8,336	8,295	8,307	8,370
	Total Municipal & Industrial Supply		9,791	8,264	8,354	8,357	8,316	8,328	8,391
	Municipal & Industrial Balance		0	581	545	560	604	621	622
	Agriculture Demand		11,583	13,949	13,908	13,866	13,825	13,782	13,741
	Existing Agricultural Supply	Groundwater	2,467	1,872	1,855	1,849	1,849	1,843	1,829
		Surface water	9,116	9,071	9,071	9,071	9,071	9,071	9,071
	Total Agriculture Supply		11,583	10,943	10,926	10,920	10,920	10,914	10,900
	Agriculture Balance		0	(3,006)	(2,982)	(2,946)	(2,905)	(2,868)	(2,841)
	Total Demand		21,374	24,119	24,221	24,173	24,053	24,011	24,040
	Total Supply	Groundwater	2,788	1,893	1,876	1,870	1,870	1,864	1,850
		Surface water	18,586	17,314	17,404	17,407	17,366	17,378	17,441
	Total Supply		21,374	19,207	19,280	19,277	19,236	19,242	19,291
	Total Balance		0	(2,425)	(2,437)	(2,386)	(2,301)	(2,247)	(2,219)

Table V.1 (continued).

Year			Historical 2000	Projections 2010	2020	2030	2040	2050	2060
CALLAHAN COUNTY									
Municipal	Municipal Demand		1,500	1,447	1,419	1,353	1,298	1,247	1,226
	Municipal Existing Supply	Groundwater	1,092	1,092	1,092	1,092	1,092	1,092	1,092
		Surface water	1,176	1,176	1,176	1,176	1,176	1,176	1,176
	Total Existing Municipal Supply		2,268	2,268	2,268	2,268	2,268	2,268	2,268
	Municipal Balance		768	821	849	915	970	1,021	1,042
Industrial	Manufacturing Demand		0	0	0	0	0	0	0
	Manufacturing Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Manufacturing Supply		0	0	0	0	0	0	0
	Manufacturing Balance		0	0	0	0	0	0	0
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		81	92	96	98	100	101	103
	Mining Existing Supply	Groundwater	81	92	96	98	100	101	103
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		81	92	96	98	100	101	103
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		819	806	793	780	767	755	742
	Irrigation Existing Supply	Groundwater	800	787	774	762	749	737	725
		Surface water	44	44	43	43	43	42	42
	Total Irrigation Supply		844	831	817	805	792	779	767
	Irrigation Balance		25	25	24	25	25	24	25
	Livestock Demand		976	976	976	976	976	976	976
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	976	976	976	976	976	976	976
	Total Livestock Supply		976	976	976	976	976	976	976
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		1,581	1,539	1,515	1,451	1,398	1,348	1,329
	Existing Municipal & Industrial Supply	Groundwater	1,173	1,184	1,188	1,190	1,192	1,193	1,195
		Surface water	1,176	1,176	1,176	1,176	1,176	1,176	1,176
	Total Municipal & Industrial Supply		2,349	2,360	2,364	2,366	2,368	2,369	2,371
	Municipal & Industrial Balance		768	821	849	915	970	1,021	1,042
	Agriculture Demand		1,795	1,782	1,769	1,756	1,743	1,731	1,718
	Existing Agricultural Supply	Groundwater	800	787	774	762	749	737	725
		Surface water	1,020	1,020	1,019	1,019	1,019	1,018	1,018
	Total Agriculture Supply		1,820	1,807	1,793	1,781	1,768	1,755	1,743
	Agriculture Balance		25	25	24	25	25	24	25
	Total Demand		3,376	3,321	3,284	3,207	3,141	3,079	3,047
	Total Supply	Groundwater	1,973	1,971	1,962	1,952	1,941	1,930	1,920
		Surface water	2,196	2,195	2,195	2,195	2,194	2,194	2,194
	Total Supply		4,169	4,166	4,157	4,147	4,135	4,124	4,114
	Total Balance		793	845	873	940	994	1,045	1,067

Table V.1 (continued).

Year			Historical	Projections					
			2000	2010	2020	2030	2040	2050	2060
COMANCHE COUNTY									
Municipal	Municipal Demand		1,770	1,830	1,832	1,798	1,745	1,683	1,630
	Municipal Existing Supply	Groundwater	1,095	1,095	1,095	1,095	1,095	1,095	1,095
		Surface water	1,038	1,114	1,112	1,096	1,070	1,043	1,016
	Total Existing Municipal Supply		2,133	2,209	2,207	2,191	2,165	2,138	2,111
	Municipal Balance		363	379	375	393	420	455	481
Industrial	Manufacturing Demand		26	31	34	37	39	41	44
	Manufacturing Existing Supply	Groundwater	44	44	44	44	44	44	44
		Surface water	0	0	0	0	0	0	0
	Total Manufacturing Supply		44	44	44	44	44	44	44
	Manufacturing Balance		18	13	10	7	5	3	0
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	
	Mining Demand		80	54	51	50	49	48	47
	Mining Existing Supply	Groundwater	80	54	51	50	49	48	47
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		80	54	51	50	49	48	47
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		35,969	35,598	35,230	34,867	34,507	34,151	33,798
	Irrigation Existing Supply	Groundwater	19,783	19,579	19,377	19,177	18,979	18,783	18,589
		Surface water	20,582	20,582	20,582	20,582	20,582	20,582	20,582
	Total Irrigation Supply		40,365	40,161	39,959	39,759	39,561	39,365	39,171
	Irrigation Balance		4,396	4,563	4,729	4,892	5,054	5,214	5,373
	Livestock Demand		4,253	4,253	4,253	4,253	4,253	4,253	4,253
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	4,253	4,253	4,253	4,253	4,253	4,253	4,253
	Total Livestock Supply		4,253	4,253	4,253	4,253	4,253	4,253	4,253
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		1,876	1,915	1,917	1,885	1,833	1,772	1,721
	Existing Municipal & Industrial Supply	Groundwater	1,219	1,193	1,190	1,189	1,188	1,187	1,186
		Surface water	1,038	1,114	1,112	1,096	1,070	1,043	1,016
	Total Municipal & Industrial Supply		2,257	2,307	2,302	2,285	2,258	2,230	2,202
	Municipal & Industrial Balance		381	392	385	400	425	458	481
	Agriculture Demand		40,222	39,851	39,483	39,120	38,760	38,404	38,051
	Existing Agricultural Supply	Groundwater	19,783	19,579	19,377	19,177	18,979	18,783	18,589
		Surface water	24,835	24,835	24,835	24,835	24,835	24,835	24,835
	Total Agriculture Supply		44,618	44,414	44,212	44,012	43,814	43,618	43,424
	Agriculture Balance		4,396	4,563	4,729	4,892	5,054	5,214	5,373
	Total Demand		42,098	41,766	41,400	41,005	40,593	40,176	39,772
	Total Supply	Groundwater	21,002	20,772	20,567	20,366	20,167	19,970	19,775
		Surface water	25,873	25,949	25,947	25,931	25,905	25,878	25,851
	Total Supply		46,875	46,721	46,514	46,297	46,072	45,848	45,626
	Total Balance		4,777	4,955	5,114	5,292	5,479	5,672	5,854

Table V.1 (continued).

Year			Historical	Projections					
			2000	2010	2020	2030	2040	2050	2060
CORYELL COUNTY									
Municipal	Municipal Demand		13,284	15,761	17,969	20,079	21,531	22,836	24,017
	Municipal Existing Supply	Groundwater	363	363	363	363	363	363	363
		Surface water	23,712	23,910	23,857	23,811	23,768	23,731	23,697
	Total Existing Municipal Supply		24,075	24,273	24,220	24,174	24,131	24,094	24,060
	Municipal Balance		10,791	8,512	6,251	4,095	2,600	1,258	43
Industrial	Manufacturing Demand		7	9	10	11	12	13	14
	Manufacturing Existing Supply	Groundwater	14	14	14	14	14	14	14
		Surface water	0	0	0	0	0	0	0
	Total Manufacturing Supply		14	14	14	14	14	14	14
	Manufacturing Balance		7	5	4	3	2	1	0
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		100	108	111	113	115	117	118
	Mining Existing Supply	Groundwater	100	108	111	113	115	117	118
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		100	108	111	113	115	117	118
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		0	0	0	0	0	0	0
	Irrigation Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,739	1,739	1,739	1,739	1,739	1,739	1,739
	Total Irrigation Supply		1,739	1,739	1,739	1,739	1,739	1,739	1,739
	Irrigation Balance		1,739	1,739	1,739	1,739	1,739	1,739	1,739
	Livestock Demand		1,339	1,339	1,339	1,339	1,339	1,339	1,339
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,339	1,339	1,339	1,339	1,339	1,339	1,339
	Total Livestock Supply		1,339	1,339	1,339	1,339	1,339	1,339	1,339
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		13,391	15,878	18,090	20,203	21,658	22,966	24,149
	Existing Municipal & Industrial Supply	Groundwater	477	485	488	490	492	494	495
		Surface water	23,712	23,910	23,857	23,811	23,768	23,731	23,697
	Total Municipal & Industrial Supply		24,189	24,395	24,345	24,301	24,260	24,225	24,192
	Municipal & Industrial Balance		10,798	8,517	6,255	4,098	2,602	1,259	43
	Agriculture Demand		1,339	1,339	1,339	1,339	1,339	1,339	1,339
	Existing Agricultural Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	3,078	3,078	3,078	3,078	3,078	3,078	3,078
	Total Agriculture Supply		3,078	3,078	3,078	3,078	3,078	3,078	3,078
	Agriculture Balance		1,739	1,739	1,739	1,739	1,739	1,739	1,739
	Total Demand		14,730	17,217	19,429	21,542	22,997	24,305	25,488
	Total Supply	Groundwater	477	485	488	490	492	494	495
		Surface water	26,790	26,988	26,935	26,889	26,846	26,809	26,775
	Total Supply		27,267	27,473	27,423	27,379	27,338	27,303	27,270
	Total Balance		12,537	10,256	7,994	5,837	4,341	2,998	1,782

Table V.1 (continued).

Year			Historical	Projections					
			2000	2010	2020	2030	2040	2050	2060
EASTLAND COUNTY									
Municipal	Municipal Demand		3,003	2,939	2,885	2,773	2,639	2,513	2,400
	Municipal Existing Supply	Groundwater	128	128	128	128	127	127	127
		Surface water	4,221	4,215	4,212	4,205	4,198	4,191	4,186
	Total Existing Municipal Supply		4,349	4,343	4,340	4,333	4,325	4,318	4,313
	Municipal Balance		1,346	1,404	1,455	1,560	1,686	1,805	1,913
Industrial	Manufacturing Demand		36	43	47	50	53	55	59
	Manufacturing Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	460	460	460	460	460	460	460
	Total Manufacturing Supply		460	460	460	460	460	460	460
	Manufacturing Balance		424	417	413	410	407	405	401
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		79	95	102	105	108	111	115
	Mining Existing Supply	Groundwater	27	32	34	35	36	37	39
		Surface water	745	745	745	745	745	745	745
	Total Mining Supply		772	777	779	780	781	782	784
	Mining Balance		693	682	677	675	673	671	669
Agriculture	Irrigation Demand		16,274	16,302	16,327	16,352	16,370	16,377	16,385
	Irrigation Existing Supply	Groundwater	4,698	4,693	4,691	4,690	4,689	4,688	4,687
		Surface water	2,436	2,437	2,438	2,439	2,439	2,440	2,441
	Total Irrigation Supply		7,134	7,130	7,129	7,129	7,128	7,128	7,128
	Irrigation Balance		(9,140)	(9,172)	(9,198)	(9,224)	(9,242)	(9,249)	(9,257)
	Livestock Demand		1,121	1,121	1,121	1,121	1,121	1,121	1,121
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,121	1,121	1,121	1,121	1,121	1,121	1,121
	Total Livestock Supply		1,121	1,121	1,121	1,121	1,121	1,121	1,121
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		3,118	3,077	3,034	2,928	2,800	2,679	2,574
	Existing Municipal & Industrial Supply	Groundwater	155	160	162	163	163	164	166
		Surface water	5,426	5,420	5,417	5,410	5,403	5,396	5,391
	Total Municipal & Industrial Supply		5,581	5,580	5,579	5,573	5,566	5,560	5,557
	Municipal & Industrial Balance		2,463	2,503	2,545	2,645	2,766	2,881	2,983
	Agriculture Demand		17,395	17,423	17,448	17,473	17,491	17,498	17,506
	Existing Agricultural Supply	Groundwater	4,698	4,693	4,691	4,690	4,689	4,688	4,687
		Surface water	3,557	3,558	3,559	3,560	3,560	3,561	3,562
	Total Agriculture Supply		8,255	8,251	8,250	8,250	8,249	8,249	8,249
	Agriculture Balance		(9,140)	(9,172)	(9,198)	(9,224)	(9,242)	(9,249)	(9,257)
	Total Demand		20,513	20,500	20,482	20,401	20,291	20,177	20,080
	Total Supply	Groundwater	4,853	4,853	4,853	4,853	4,852	4,852	4,853
		Surface water	8,983	8,978	8,976	8,969	8,963	8,957	8,953
	Total Supply		13,836	13,831	13,829	13,822	13,815	13,809	13,806
	Total Balance		(6,677)	(6,669)	(6,653)	(6,579)	(6,476)	(6,368)	(6,274)

Table V.1 (continued).

Year			Historical	Projections					
			2000	2010	2020	2030	2040	2050	2060
ERATH COUNTY									
Municipal	Municipal Demand		4,619	4,907	5,252	5,554	5,845	6,870	7,547
	Municipal Existing Supply	Groundwater	7,200	7,200	7,200	7,200	7,200	7,200	7,200
		Surface water	454	2,347	2,378	2,406	2,438	2,544	2,615
	Total Existing Municipal Supply		7,654	9,547	9,578	9,606	9,638	9,744	9,815
	Municipal Balance		3,035	4,640	4,326	4,052	3,793	2,874	2,268
Industrial	Manufacturing Demand		57	73	82	90	98	105	114
	Manufacturing Existing Supply	Groundwater	74	74	74	74	74	74	74
		Surface water	0	0	0	0	0	0	0
	Total Manufacturing Supply		74	74	74	74	74	74	74
	Manufacturing Balance		17	1	(8)	(16)	(24)	(31)	(40)
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		0	0	0	0	0	0	0
	Mining Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		0	0	0	0	0	0	0
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		10,816	10,658	10,502	10,349	10,197	10,048	9,901
	Irrigation Existing Supply	Groundwater	7,658	7,546	7,435	7,327	7,219	7,114	7,010
		Surface water	5,344	5,344	5,344	5,344	5,344	5,344	5,344
	Total Irrigation Supply		13,002	12,890	12,779	12,671	12,563	12,458	12,354
	Irrigation Balance		2,186	2,232	2,277	2,322	2,366	2,410	2,453
	Livestock Demand		9,321	9,321	9,321	9,321	9,321	9,321	9,321
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	9,321	9,321	9,321	9,321	9,321	9,321	9,321
	Total Livestock Supply		9,321	9,321	9,321	9,321	9,321	9,321	9,321
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		4,676	4,980	5,334	5,644	5,943	6,975	7,661
	Existing Municipal & Industrial Supply	Groundwater	7,274	7,274	7,274	7,274	7,274	7,274	7,274
		Surface water	454	2,347	2,378	2,406	2,438	2,544	2,615
	Total Municipal & Industrial Supply		7,728	9,621	9,652	9,680	9,712	9,818	9,889
	Municipal & Industrial Balance		3,052	4,641	4,318	4,036	3,769	2,843	2,228
	Agriculture Demand		20,137	19,979	19,823	19,670	19,518	19,369	19,222
	Existing Agricultural Supply	Groundwater	7,658	7,546	7,435	7,327	7,219	7,114	7,010
		Surface water	14,665	14,665	14,665	14,665	14,665	14,665	14,665
	Total Agriculture Supply		22,323	22,211	22,100	21,992	21,884	21,779	21,675
	Agriculture Balance		2,186	2,232	2,277	2,322	2,366	2,410	2,453
	Total Demand		24,813	24,959	25,157	25,314	25,461	26,344	26,883
	Total Supply	Groundwater	14,932	14,820	14,709	14,601	14,493	14,388	14,284
		Surface water	15,119	17,012	17,043	17,071	17,103	17,209	17,280
	Total Supply		30,051	31,832	31,752	31,672	31,596	31,597	31,564
	Total Balance		5,238	6,873	6,595	6,358	6,135	5,253	4,681

Table V.1 (continued).

Year			Historical	Projections					
			2000	2010	2020	2030	2040	2050	2060
FALLS COUNTY									
Municipal	Municipal Demand		3,895	3,993	4,132	4,271	4,388	4,496	4,663
	Municipal Existing Supply	Groundwater	564	564	564	564	564	564	564
		Surface water	6,748	6,734	6,721	6,707	6,694	6,679	6,666
	Total Existing Municipal Supply		7,312	7,298	7,285	7,271	7,258	7,243	7,230
	Municipal Balance		3,417	3,305	3,153	3,000	2,870	2,747	2,567
Industrial	Manufacturing Demand		2	2	2	2	2	2	2
	Manufacturing Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,506	1,493	1,480	1,467	1,454	1,442	1,429
	Total Manufacturing Supply		1,506	1,493	1,480	1,467	1,454	1,442	1,429
	Manufacturing Balance		1,504	1,491	1,478	1,465	1,452	1,440	1,427
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		133	101	95	91	88	85	83
	Mining Existing Supply	Groundwater	133	101	95	91	88	85	83
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		133	101	95	91	88	85	83
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		1,928	1,866	1,806	1,748	1,691	1,637	1,584
	Irrigation Existing Supply	Groundwater	1,166	1,129	1,093	1,058	1,023	990	958
		Surface water	5,064	5,070	5,076	5,083	5,089	5,095	5,101
	Total Irrigation Supply		6,230	6,199	6,169	6,141	6,112	6,085	6,059
	Irrigation Balance		4,302	4,333	4,363	4,393	4,421	4,448	4,475
	Livestock Demand		1,626	1,626	1,626	1,626	1,626	1,626	1,626
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,626	1,626	1,626	1,626	1,626	1,626	1,626
	Total Livestock Supply		1,626	1,626	1,626	1,626	1,626	1,626	1,626
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		4,030	4,096	4,229	4,364	4,478	4,583	4,748
	Existing Municipal & Industrial Supply	Groundwater	697	665	659	655	652	649	647
		Surface water	8,254	8,228	8,201	8,175	8,148	8,121	8,094
	Total Municipal & Industrial Supply		8,951	8,893	8,860	8,830	8,800	8,770	8,741
	Municipal & Industrial Balance		4,921	4,797	4,631	4,466	4,322	4,187	3,993
	Agriculture Demand		3,554	3,492	3,432	3,374	3,317	3,263	3,210
	Existing Agricultural Supply	Groundwater	1,166	1,129	1,093	1,058	1,023	990	958
		Surface water	6,690	6,696	6,702	6,709	6,715	6,721	6,727
	Total Agriculture Supply		7,856	7,825	7,795	7,767	7,738	7,711	7,685
	Agriculture Balance		4,302	4,333	4,363	4,393	4,421	4,448	4,475
	Total Demand		7,584	7,588	7,661	7,738	7,795	7,846	7,958
	Total Supply	Groundwater	1,863	1,794	1,752	1,713	1,675	1,639	1,605
		Surface water	14,944	14,924	14,903	14,883	14,863	14,842	14,821
	Total Supply		16,807	16,718	16,655	16,596	16,538	16,481	16,426
	Total Balance		9,223	9,130	8,994	8,858	8,743	8,635	8,468

Table V.1 (continued).

Year			Historical	Projections					
			2000	2010	2020	2030	2040	2050	2060
HAMILTON COUNTY									
Municipal	Municipal Demand		1,360	1,279	1,239	1,199	1,176	1,146	1,145
	Municipal Existing Supply	Groundwater	947	947	947	947	947	947	947
		Surface water	1,046	1,046	1,046	1,046	1,046	1,046	1,046
	Total Existing Municipal Supply		1,993	1,993	1,993	1,993	1,993	1,993	1,993
	Municipal Balance		633	714	754	794	817	847	848
Industrial	Manufacturing Demand		3	4	5	6	7	8	9
	Manufacturing Existing Supply	Groundwater	9	9	9	9	9	9	9
		Surface water	0	0	0	0	0	0	0
	Total Manufacturing Supply		9	9	9	9	9	9	9
	Manufacturing Balance		6	5	4	3	2	1	0
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		0	0	0	0	0	0	0
	Mining Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		0	0	0	0	0	0	0
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		483	475	467	464	456	434	413
	Irrigation Existing Supply	Groundwater	189	186	183	182	179	170	162
		Surface water	3,437	3,435	3,433	3,432	3,430	3,428	3,426
	Total Irrigation Supply		3,626	3,621	3,616	3,614	3,609	3,598	3,588
	Irrigation Balance		3,143	3,146	3,149	3,150	3,153	3,164	3,175
	Livestock Demand		1,961	1,961	1,961	1,961	1,961	1,961	1,961
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,961	1,961	1,961	1,961	1,961	1,961	1,961
	Total Livestock Supply		1,961	1,961	1,961	1,961	1,961	1,961	1,961
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		1,363	1,283	1,244	1,205	1,183	1,154	1,154
	Existing Municipal & Industrial Supply	Groundwater	956	956	956	956	956	956	956
		Surface water	1,046	1,046	1,046	1,046	1,046	1,046	1,046
	Total Municipal & Industrial Supply		2,002	2,002	2,002	2,002	2,002	2,002	2,002
	Municipal & Industrial Balance		639	719	758	797	819	848	848
	Agriculture Demand		2,444	2,436	2,428	2,425	2,417	2,395	2,374
	Existing Agricultural Supply	Groundwater	189	186	183	182	179	170	162
		Surface water	5,398	5,396	5,394	5,393	5,391	5,389	5,387
	Total Agriculture Supply		5,587	5,582	5,577	5,575	5,570	5,559	5,549
	Agriculture Balance		3,143	3,146	3,149	3,150	3,153	3,164	3,175
	Total Demand		3,807	3,719	3,672	3,630	3,600	3,549	3,528
	Total Supply	Groundwater	1,145	1,142	1,139	1,138	1,135	1,126	1,118
		Surface water	6,444	6,442	6,440	6,438	6,436	6,435	6,433
	Total Supply		7,589	7,584	7,579	7,576	7,571	7,561	7,551
	Total Balance		3,782	3,865	3,907	3,946	3,971	4,012	4,023

Table V.1 (continued).

Year			Historical 2000	Projections 2010	2020	2030	2040	2050	2060
HILL COUNTY									
Municipal	Municipal Demand		4,790	4,862	5,000	5,164	5,331	5,573	5,892
	Municipal Existing Supply	Groundwater	2,033	2,033	2,033	2,033	2,033	2,033	2,033
		Surface water	6,638	6,104	5,570	5,037	4,503	3,971	3,283
	Total Existing Municipal Supply		8,671	8,137	7,603	7,070	6,536	6,004	5,316
	Municipal Balance		3,881	3,275	2,603	1,906	1,205	431	(576)
Industrial	Manufacturing Demand		67	85	97	108	119	129	140
	Manufacturing Existing Supply	Groundwater	87	87	87	87	87	87	87
		Surface water	0	0	0	0	0	0	0
	Total Manufacturing Supply		87	87	87	87	87	87	87
	Manufacturing Balance		20	2	(10)	(21)	(32)	(42)	(53)
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		118	100	96	94	92	90	89
	Mining Existing Supply	Groundwater	118	100	96	94	92	90	89
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		118	100	96	94	92	90	89
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		43	43	42	42	42	42	41
	Irrigation Existing Supply	Groundwater	6	6	6	6	6	6	6
		Surface water	1,040	1,040	1,040	1,040	1,040	1,040	1,040
	Total Irrigation Supply		1,046	1,046	1,046	1,046	1,046	1,046	1,046
	Irrigation Balance		1,003	1,003	1,004	1,004	1,004	1,004	1,005
	Livestock Demand		1,401	1,401	1,401	1,401	1,401	1,401	1,401
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,401	1,401	1,401	1,401	1,401	1,401	1,401
	Total Livestock Supply		1,401	1,401	1,401	1,401	1,401	1,401	1,401
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		4,975	5,047	5,193	5,366	5,542	5,792	6,121
	Existing Municipal & Industrial Supply	Groundwater	2,238	2,220	2,216	2,214	2,212	2,210	2,209
		Surface water	6,638	6,104	5,570	5,037	4,503	3,971	3,283
	Total Municipal & Industrial Supply		8,876	8,324	7,786	7,251	6,715	6,181	5,492
	Municipal & Industrial Balance		3,901	3,277	2,593	1,885	1,173	389	(629)
	Agriculture Demand		1,444	1,444	1,443	1,443	1,443	1,443	1,442
	Existing Agricultural Supply	Groundwater	6	6	6	6	6	6	6
		Surface water	2,441	2,441	2,441	2,441	2,441	2,441	2,441
	Total Agriculture Supply		2,447	2,447	2,447	2,447	2,447	2,447	2,447
	Agriculture Balance		1,003	1,003	1,004	1,004	1,004	1,004	1,005
	Total Demand		6,419	6,491	6,636	6,809	6,985	7,235	7,563
	Total Supply	Groundwater	2,244	2,226	2,222	2,220	2,218	2,216	2,215
		Surface water	9,079	8,545	8,011	7,478	6,944	6,412	5,724
	Total Supply		11,323	10,771	10,233	9,698	9,162	8,628	7,939
	Total Balance		4,904	4,280	3,597	2,889	2,177	1,393	376

Table V.1 (continued).

Year			Historical 2000	Projections 2010	2020	2030	2040	2050	2060
LAMPASAS COUNTY									
Municipal	Municipal Demand		3,667	4,467	4,956	5,290	5,519	5,675	5,774
	Municipal Existing Supply	Groundwater	672	679	681	682	683	684	684
		Surface water	5,794	5,582	5,623	5,650	5,670	5,680	5,686
	Total Existing Municipal Supply		6,466	6,261	6,304	6,332	6,353	6,364	6,370
	Municipal Balance		2,799	1,794	1,348	1,042	834	689	596
Industrial	Manufacturing Demand		108	129	142	153	164	174	187
	Manufacturing Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	18	18	18	18	18	18	18
	Total Manufacturing Supply		18	18	18	18	18	18	18
	Manufacturing Balance		(90)	(111)	(124)	(135)	(146)	(156)	(169)
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		193	152	144	139	135	131	128
	Mining Existing Supply	Groundwater	158	126	119	115	111	109	105
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		158	126	119	115	111	109	105
	Mining Balance		(35)	(26)	(25)	(24)	(24)	(22)	(23)
Agriculture	Irrigation Demand		170	168	166	164	162	160	159
	Irrigation Existing Supply	Groundwater	136	134	132	131	129	128	127
		Surface water	1,255	1,255	1,255	1,255	1,255	1,255	1,255
	Total Irrigation Supply		1,391	1,389	1,387	1,386	1,384	1,383	1,382
	Irrigation Balance		1,221	1,221	1,221	1,222	1,222	1,223	1,223
	Livestock Demand		688	688	688	688	688	688	688
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	688	688	688	688	688	688	688
	Total Livestock Supply		688	688	688	688	688	688	688
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		3,968	4,748	5,242	5,582	5,818	5,980	6,089
	Existing Municipal & Industrial Supply	Groundwater	830	805	800	797	794	793	789
		Surface water	5,812	5,600	5,641	5,668	5,687	5,697	5,704
	Total Municipal & Industrial Supply		6,642	6,405	6,441	6,465	6,481	6,490	6,493
	Municipal & Industrial Balance		2,674	1,657	1,199	883	663	510	404
	Agriculture Demand		858	856	854	852	850	848	847
	Existing Agricultural Supply	Groundwater	136	134	132	131	129	128	127
		Surface water	1,943	1,943	1,943	1,943	1,943	1,943	1,943
	Total Agriculture Supply		2,079	2,077	2,075	2,074	2,072	2,071	2,070
	Agriculture Balance		1,221	1,221	1,221	1,222	1,222	1,223	1,223
	Total Demand		4,826	5,604	6,096	6,434	6,668	6,828	6,936
	Total Supply	Groundwater	966	939	932	928	923	921	916
		Surface water	7,755	7,543	7,584	7,611	7,630	7,640	7,647
	Total Supply		8,721	8,482	8,516	8,539	8,553	8,561	8,563
	Total Balance		3,895	2,878	2,420	2,105	1,885	1,733	1,627

Table V.1 (continued).

Year			Historical	Projections					
			2000	2010	2020	2030	2040	2050	2060
LIMESTONE COUNTY									
Municipal	Municipal Demand		3,193	3,293	3,447	3,510	3,544	3,616	3,752
	Municipal Existing Supply	Groundwater	3,556	3,556	3,556	3,556	3,535	3,366	3,197
		Surface water	2,496	2,327	2,158	1,989	1,842	1,842	1,842
	Total Existing Municipal Supply		6,052	5,883	5,714	5,545	5,376	5,207	5,039
	Municipal Balance		2,859	2,590	2,267	2,035	1,832	1,591	1,287
Industrial	Manufacturing Demand		39	48	53	58	63	67	72
	Manufacturing Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	26	22	18	15	11	7	3
	Total Manufacturing Supply		26	22	18	15	11	7	3
	Manufacturing Balance		(13)	(26)	(35)	(44)	(52)	(60)	(69)
	Steam-Electric Demand		22,065	22,332	22,598	26,420	31,079	36,758	43,681
	Steam-Electric Existing Supply	Groundwater	9,867	9,867	9,867	9,867	9,867	9,867	9,867
		Surface water	18,000	18,000	18,000	18,000	18,000	18,000	18,000
	Total Steam-Electric Supply		27,867	27,867	27,867	27,867	27,867	27,867	27,867
	Steam-Electric Balance		5,802	5,535	5,269	1,447	(3,212)	(8,891)	(15,814)
	Mining Demand		360	380	387	392	396	400	403
	Mining Existing Supply	Groundwater	360	380	387	392	396	400	403
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		360	380	387	392	396	400	403
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		0	0	0	0	0	0	0
	Irrigation Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	19	19	19	19	19	19	19
	Total Irrigation Supply		19	19	19	19	19	19	19
	Irrigation Balance		19	19	19	19	19	19	19
	Livestock Demand		1,487	1,487	1,487	1,487	1,487	1,487	1,487
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,487	1,487	1,487	1,487	1,487	1,487	1,487
	Total Livestock Supply		1,487	1,487	1,487	1,487	1,487	1,487	1,487
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		25,657	26,053	26,485	30,380	35,082	40,841	47,908
	Existing Municipal & Industrial Supply	Groundwater	13,783	13,803	13,810	13,815	13,798	13,633	13,467
		Surface water	20,522	20,349	20,176	20,004	19,852	19,848	19,845
	Total Municipal & Industrial Supply		34,305	34,152	33,986	33,819	33,650	33,481	33,312
	Municipal & Industrial Balance		8,648	8,099	7,501	3,439	(1,432)	(7,360)	(14,596)
	Agriculture Demand		1,487	1,487	1,487	1,487	1,487	1,487	1,487
	Existing Agricultural Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,506	1,506	1,506	1,506	1,506	1,506	1,506
	Total Agriculture Supply		1,506	1,506	1,506	1,506	1,506	1,506	1,506
	Agriculture Balance		19	19	19	19	19	19	19
	Total Demand		27,144	27,540	27,972	31,867	36,569	42,328	49,395
	Total Supply	Groundwater	13,783	13,803	13,810	13,815	13,798	13,633	13,467
		Surface water	22,028	21,855	21,682	21,510	21,358	21,354	21,351
	Total Supply		35,811	35,658	35,492	35,325	35,156	34,987	34,818
	Total Balance		8,667	8,118	7,520	3,458	(1,413)	(7,341)	(14,577)

Table V.1 (continued).

Year			Historical 2000	Projections 2010	2020	2030	2040	2050	2060
McLENNAN COUNTY									
Municipal	Municipal Demand		44,105	47,046	50,004	52,499	55,064	56,727	59,404
	Municipal Existing Supply	Groundwater	1,485	1,485	1,485	1,485	1,485	1,485	1,485
		Surface water	89,039	88,722	88,509	88,285	88,027	87,759	87,554
	Total Existing Municipal Supply		90,524	90,207	89,994	89,770	89,512	89,244	89,039
	Municipal Balance		46,419	43,161	39,990	37,271	34,448	32,517	29,635
Industrial	Manufacturing Demand		2,804	3,526	4,068	4,577	5,096	5,561	6,022
	Manufacturing Existing Supply	Groundwater	232	232	232	232	232	232	232
		Surface water	1,997	2,510	2,895	3,256	3,625	3,955	4,282
	Total Manufacturing Supply		2,229	2,742	3,127	3,488	3,857	4,187	4,514
	Manufacturing Balance		(575)	(784)	(941)	(1,089)	(1,239)	(1,374)	(1,508)
	Steam-Electric Demand		24,412	37,098	32,983	35,720	39,056	43,123	48,081
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	14,120	14,111	14,102	14,093	14,083	14,074	14,065
	Total Steam-Electric Supply		14,120	14,111	14,102	14,093	14,083	14,074	14,065
	Steam-Electric Balance		(10,292)	(22,987)	(18,881)	(21,628)	(24,973)	(29,049)	(34,016)
	Mining Demand		481	416	399	389	380	371	366
	Mining Existing Supply	Groundwater	481	416	399	389	380	371	366
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		481	416	399	389	380	371	366
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		2,819	2,816	2,814	2,812	2,809	2,806	2,803
	Irrigation Existing Supply	Groundwater	1,956	1,954	1,953	1,951	1,949	1,947	1,945
		Surface water	8,374	8,375	8,376	8,377	8,377	8,378	8,379
	Total Irrigation Supply		10,330	10,329	10,329	10,328	10,326	10,325	10,324
	Irrigation Balance		7,511	7,513	7,515	7,516	7,517	7,519	7,521
	Livestock Demand		1,151	1,151	1,151	1,151	1,151	1,151	1,151
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	1,151	1,151	1,151	1,151	1,151	1,151	1,151
	Total Livestock Supply		1,151	1,151	1,151	1,151	1,151	1,151	1,151
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		71,802	88,086	87,454	93,185	99,596	105,782	113,873
	Existing Municipal & Industrial Supply	Groundwater	2,198	2,133	2,116	2,106	2,097	2,088	2,083
		Surface water	105,156	105,342	105,506	105,634	105,736	105,788	105,901
	Total Municipal & Industrial Supply		107,354	107,475	107,622	107,740	107,833	107,876	107,984
	Municipal & Industrial Balance		35,552	19,389	20,168	14,555	8,237	2,094	(5,889)
	Agriculture Demand		3,970	3,967	3,965	3,963	3,960	3,957	3,954
	Existing Agricultural Supply	Groundwater	1,956	1,954	1,953	1,951	1,949	1,947	1,945
		Surface water	9,525	9,526	9,527	9,528	9,528	9,529	9,530
	Total Agriculture Supply		11,481	11,480	11,480	11,479	11,477	11,476	11,475
	Agriculture Balance		7,511	7,513	7,515	7,516	7,517	7,519	7,521
	Total Demand		75,772	92,053	91,419	97,148	103,556	109,739	117,827
	Total Supply	Groundwater	4,154	4,087	4,069	4,057	4,046	4,035	4,028
		Surface water	114,681	114,868	115,033	115,161	115,264	115,317	115,431
	Total Supply		118,835	118,955	119,102	119,218	119,310	119,352	119,459
	Total Balance		43,063	26,902	27,683	22,070	15,754	9,613	1,632

Table V.1 (continued).

Year			Historical	Projections					
			2000	2010	2020	2030	2040	2050	2060
MILLS COUNTY									
Municipal	Municipal Demand		992	971	994	991	982	966	957
	Municipal Existing Supply	Groundwater							
		Surface water							
	Total Existing Municipal Supply								
	Municipal Balance								
Industrial	Manufacturing Demand		1	1	1	1	1	1	
	Manufacturing Existing Supply	Groundwater							
		Surface water							
	Total Manufacturing Supply								
	Manufacturing Balance								
	Steam-Electric Demand		0	0	0	0	0	0	0
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Steam-Electric Supply		0	0	0	0	0	0	0
	Steam-Electric Balance		0	0	0	0	0	0	0
	Mining Demand		0	0	0	0	0	0	0
	Mining Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		0	0	0	0	0	0	0
	Mining Balance		0	0	0	0	0	0	0
Agriculture	Irrigation Demand		3,001	2,936	2,872	2,810	2,749	2,689	2,631
	Irrigation Existing Supply	Groundwater							
		Surface water							
	Total Irrigation Supply								
	Irrigation Balance								
	Livestock Demand		918	918	918	918	918	918	918
	Livestock Existing Supply	Groundwater							
		Surface water							
	Total Livestock Supply								
	Livestock Balance								
Total	Municipal & Industrial Demand		993	972	995	992	983	967	952
	Existing Municipal & Industrial Supply	Groundwater							
		Surface water							
	Total Municipal & Industrial Supply								
	Municipal & Industrial Balance								
	Agriculture Demand		3,919	3,854	3,790	3,728	3,667	3,607	3,549
	Existing Agricultural Supply	Groundwater							
		Surface water							
	Total Agriculture Supply								
	Agriculture Balance								
	Total Demand		4,912	4,826	4,785	4,720	4,650	4,574	4,501
	Total Supply	Groundwater	2,003	2,003	2,003	1,818	1,818	1,584	
		Surface water	4,524	4,524	4,524	2,837	2,837	2,837	
	Total Supply		6,527	6,527	6,527	4,655	4,655	4,421	
	Total Balance		1,615	1,701	1,741	(65)	(5)	(153)	

Table V.1 (continued).

Year			Historical	Projections					
			2000	2010	2020	2030	2040	2050	2060
SOMERVELL COUNTY									
Municipal	Municipal Demand		1,013	1,071	1,145	1,202	1,229	1,238	1,245
	Municipal Existing Supply	Groundwater	951	995	1,004	1,009	1,014	1,017	1,022
		Surface water	0	0	0	0	0	0	0
	Total Existing Municipal Supply		951	995	1,004	1,009	1,014	1,017	1,022
	Municipal Balance		(62)	(76)	(141)	(193)	(215)	(221)	(223)
Industrial	Manufacturing Demand		5	6	7	8	9	10	11
	Manufacturing Existing Supply	Groundwater	4	4	4	4	4	4	4
		Surface water	0	0	0	0	0	0	0
	Total Manufacturing Supply		4	4	4	4	4	4	4
	Manufacturing Balance		(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Steam-Electric Demand		18,000	23,200	23,200	23,200	23,200	23,200	23,200
	Steam-Electric Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	48,830	48,810	48,790	48,770	48,750	48,730	48,710
	Total Steam-Electric Supply		48,830	48,810	48,790	48,770	48,750	48,730	48,710
	Steam-Electric Balance		30,830	25,610	25,590	25,570	25,550	25,530	25,510
	Mining Demand		393	304	287	278	270	263	257
	Mining Existing Supply	Groundwater	244	198	189	184	179	175	172
		Surface water	0	0	0	0	0	0	0
	Total Mining Supply		244	198	189	184	179	175	172
	Mining Balance		(149)	(106)	(98)	(94)	(91)	(88)	(85)
Agriculture	Irrigation Demand		475	474	471	468	467	464	461
	Irrigation Existing Supply	Groundwater	34	36	36	36	36	36	36
		Surface water	1,375	1,376	1,376	1,377	1,377	1,378	1,378
	Total Irrigation Supply		1,409	1,412	1,412	1,413	1,413	1,414	1,414
	Irrigation Balance		934	938	941	945	946	950	953
	Livestock Demand		166	166	166	166	166	166	166
	Livestock Existing Supply	Groundwater	0	0	0	0	0	0	0
		Surface water	166	166	166	166	166	166	166
	Total Livestock Supply		166	166	166	166	166	166	166
	Livestock Balance		0	0	0	0	0	0	0
Total	Municipal & Industrial Demand		19,411	24,581	24,639	24,688	24,708	24,711	24,713
	Existing Municipal & Industrial Supply	Groundwater	1,199	1,197	1,197	1,197	1,197	1,196	1,198
		Surface water	48,830	48,810	48,790	48,770	48,750	48,730	48,710
	Total Municipal & Industrial Supply		50,029	50,007	49,987	49,967	49,947	49,926	49,908
	Municipal & Industrial Balance		30,618	25,426	25,348	25,279	25,239	25,215	25,195
	Agriculture Demand		641	640	637	634	633	630	627
	Existing Agricultural Supply	Groundwater	34	36	36	36	36	36	36
		Surface water	1,541	1,542	1,542	1,543	1,543	1,544	1,544
	Total Agriculture Supply		1,575	1,578	1,578	1,579	1,579	1,580	1,580
	Agriculture Balance		934	938	941	945	946	950	953
	Total Demand		20,052	25,221	25,276	25,322	25,341	25,341	25,340
	Total Supply	Groundwater	1,233	1,233	1,233	1,233	1,233	1,232	1,234
		Surface water	50,371	50,352	50,332	50,313	50,293	50,274	50,254
	Total Supply		51,604	51,585	51,565	51,546	51,526	51,506	51,488
	Total Balance		31,552	26,364	26,289	26,224	26,185	26,165	26,148

2006 Region F ,Brazos G, and Lower Colorado Region K Regional Water Plans.

APPENDIX VI. HYDROGRAPHS OF SELECTED WATER WELLS BY FORMATIONS WITHIN THE TRINITY GROUP AQUIFER IN THE STUDY AREA.

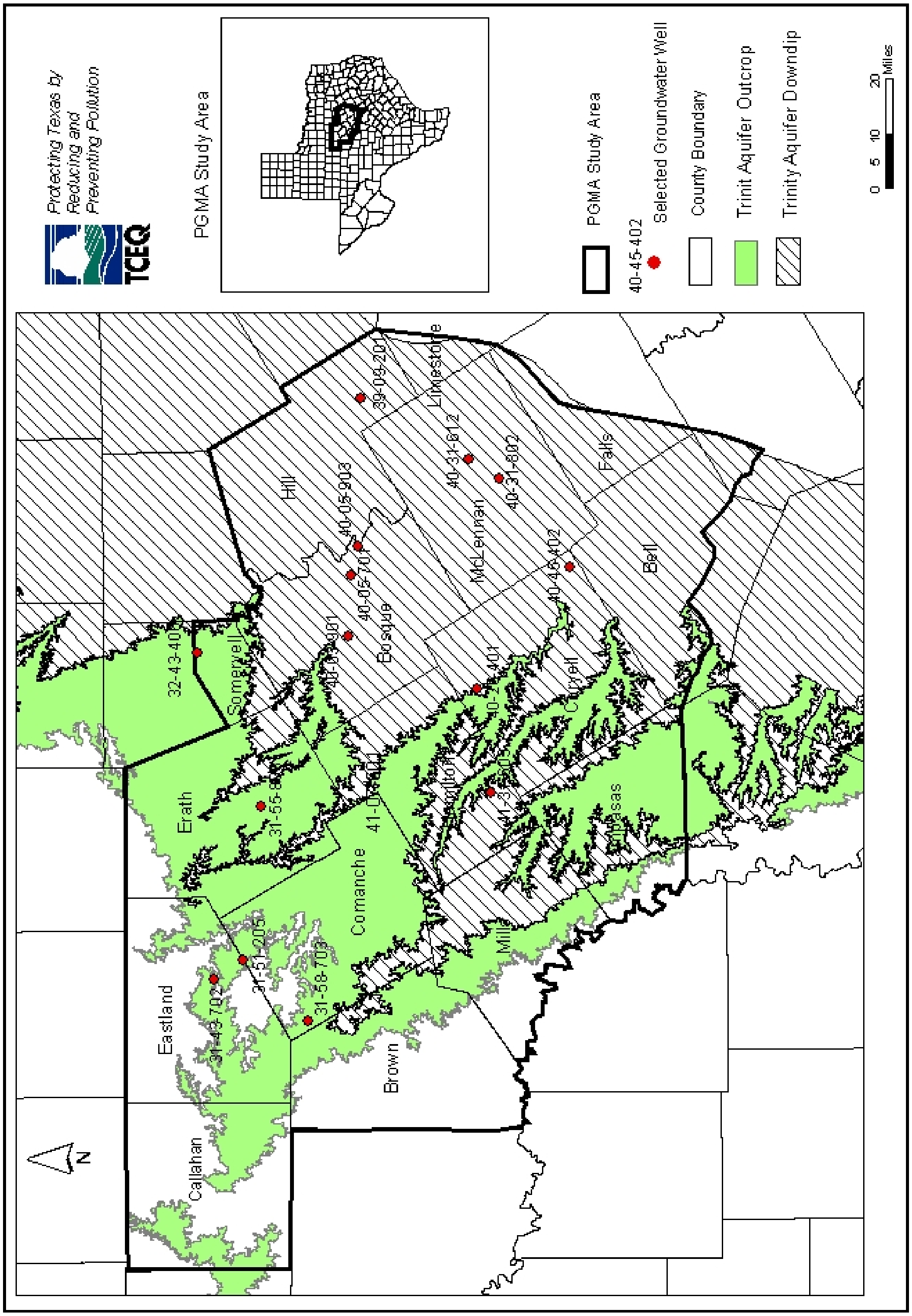
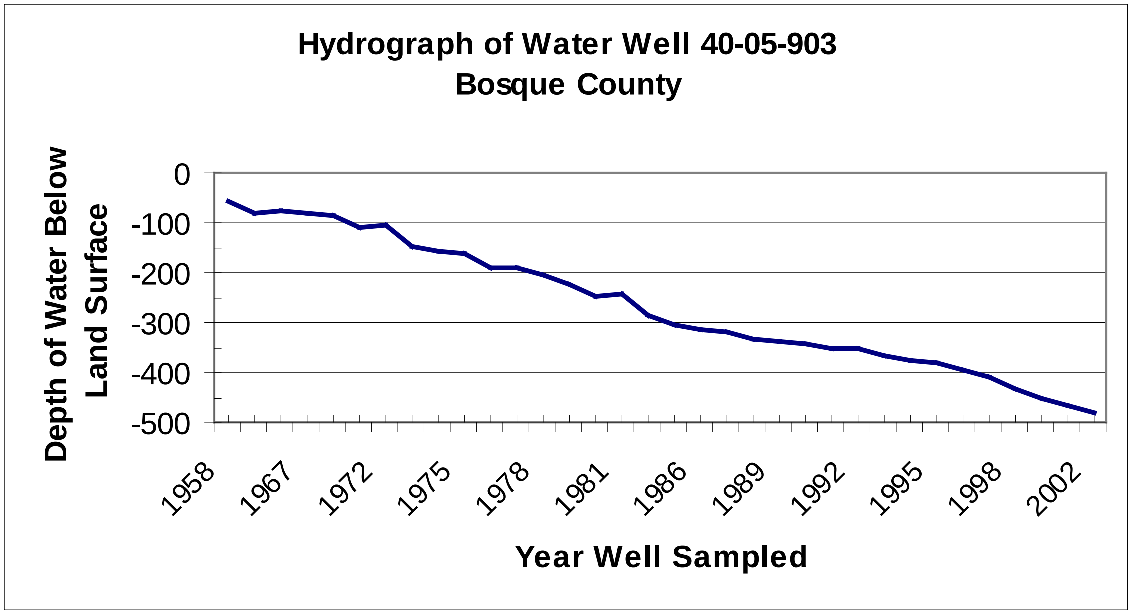
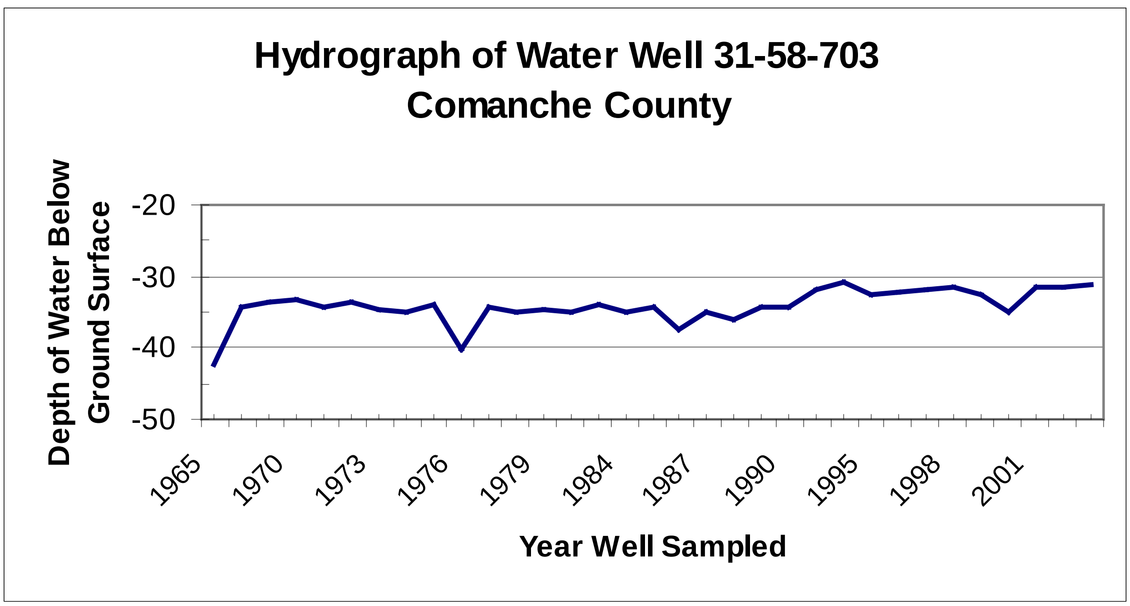


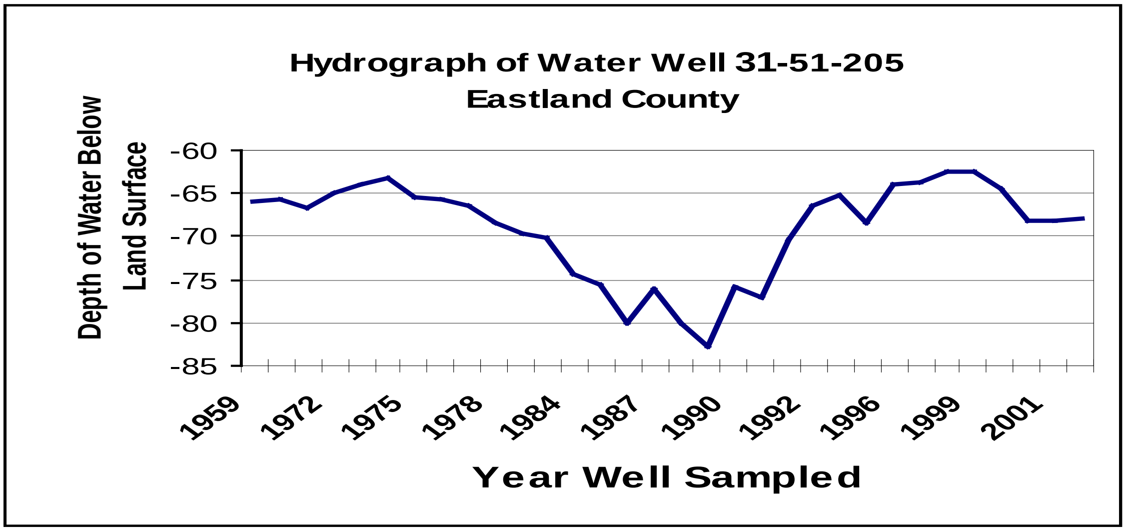
Figure VI.1. Location Map of selected Hydrographs within the Trinity Group Aquifer.

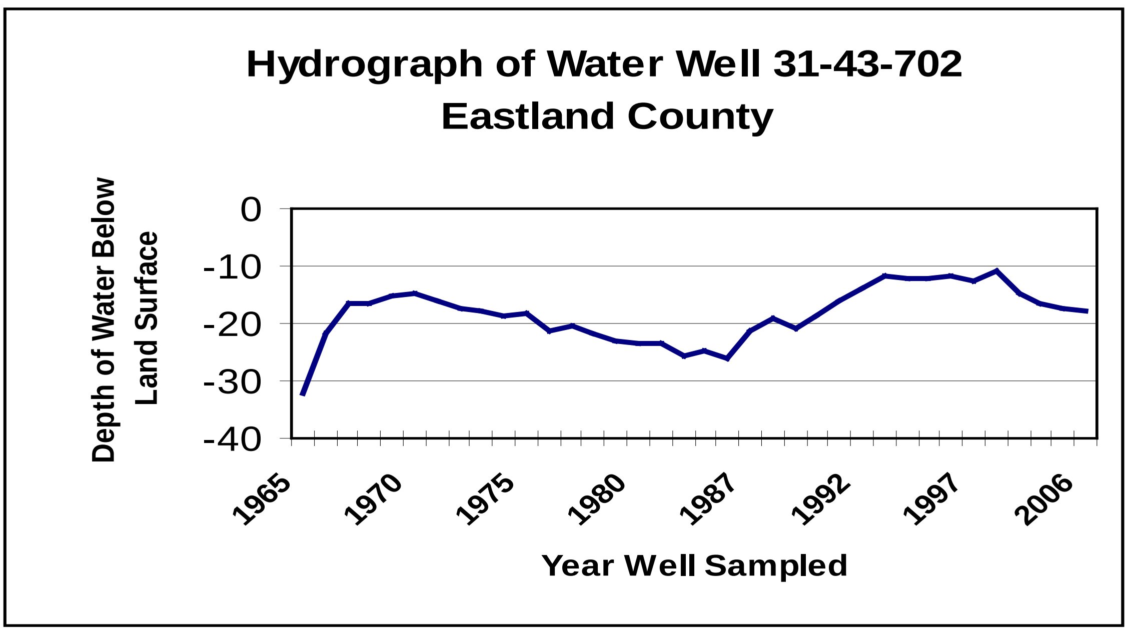
Travis Peak Formation.



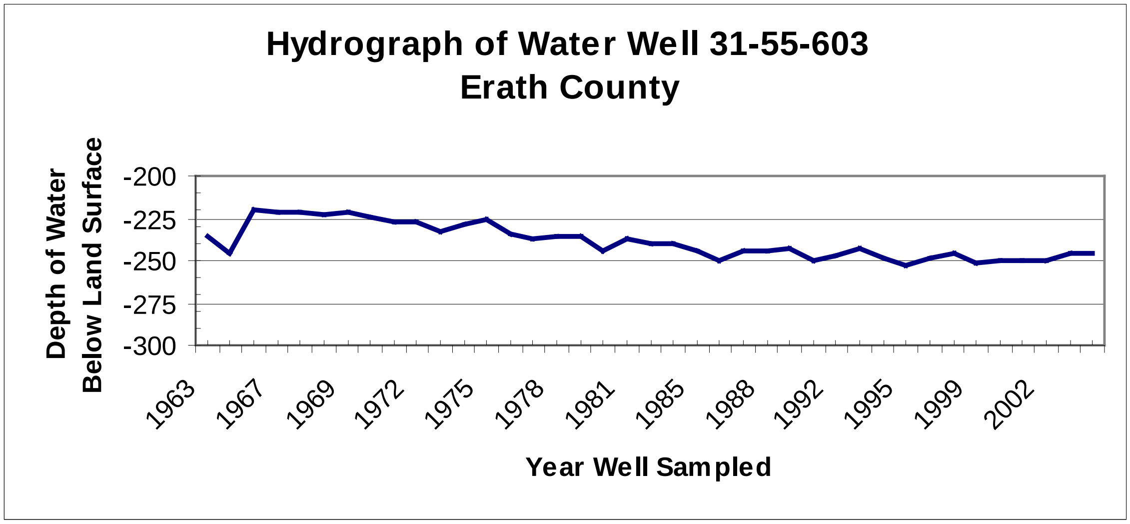


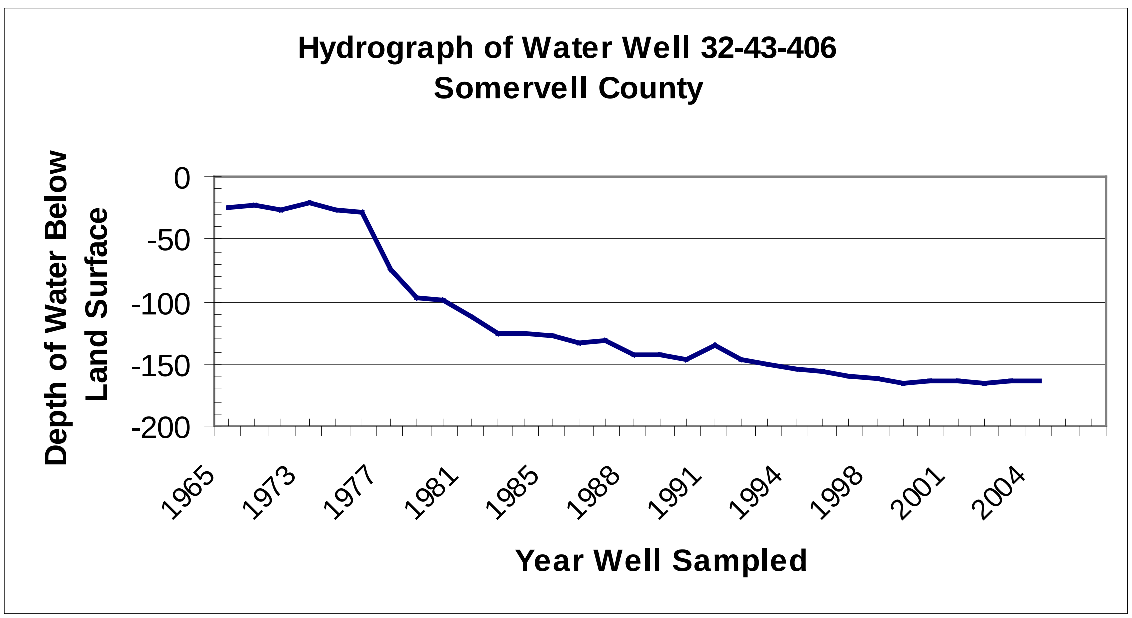
Travis Peak Formation (continued).



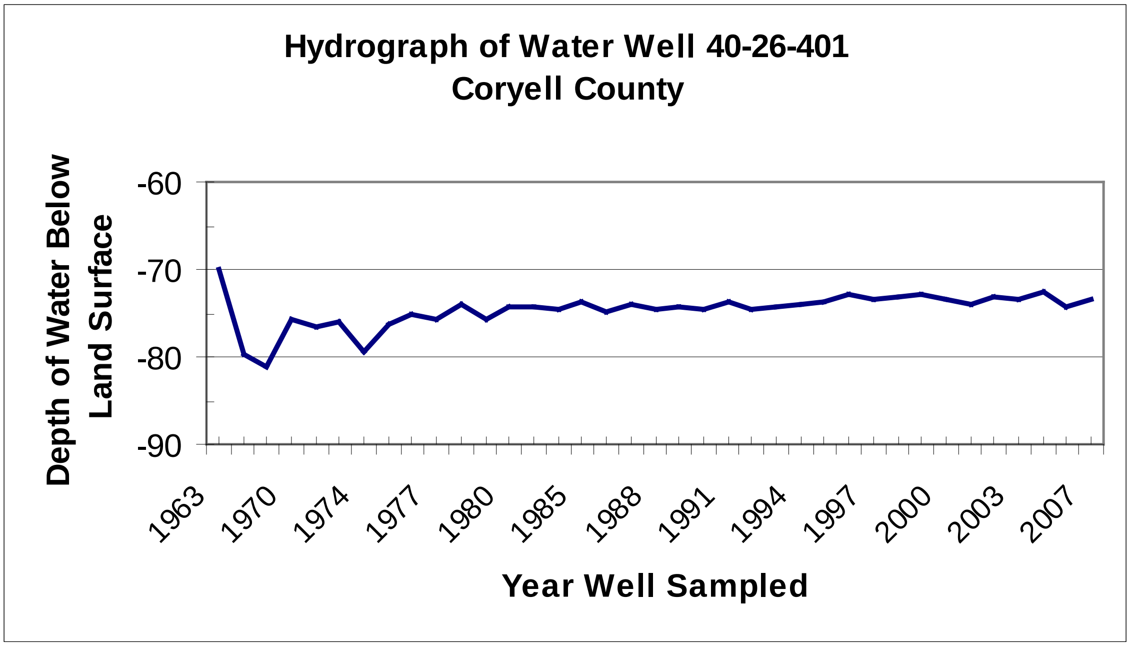


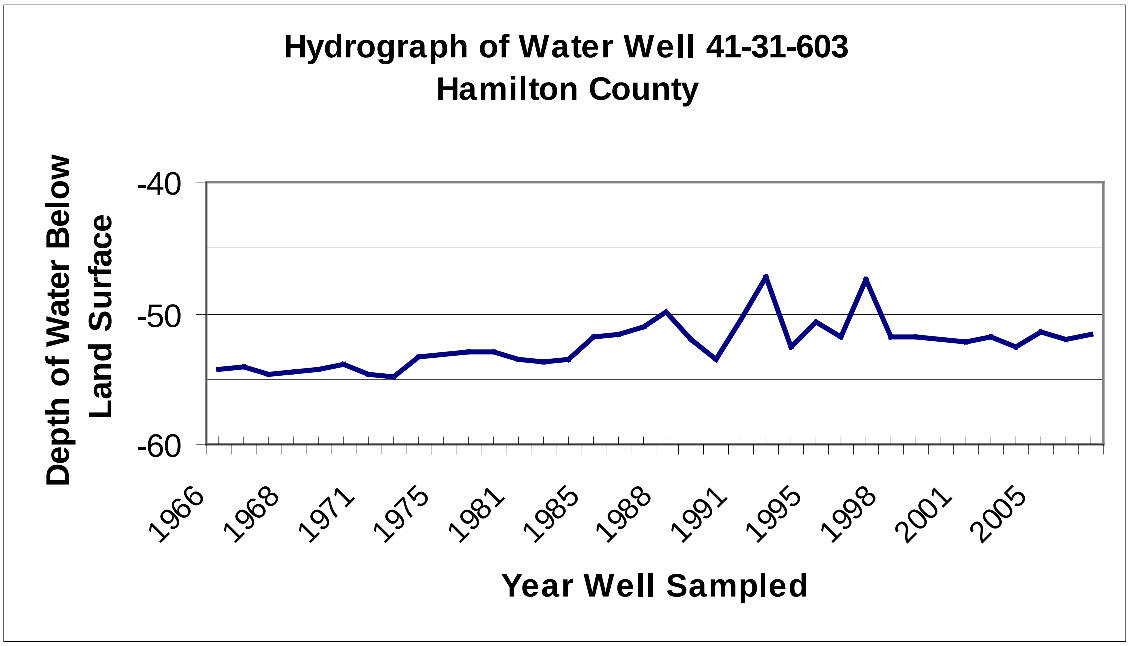
Travis Peak Formation (continued).



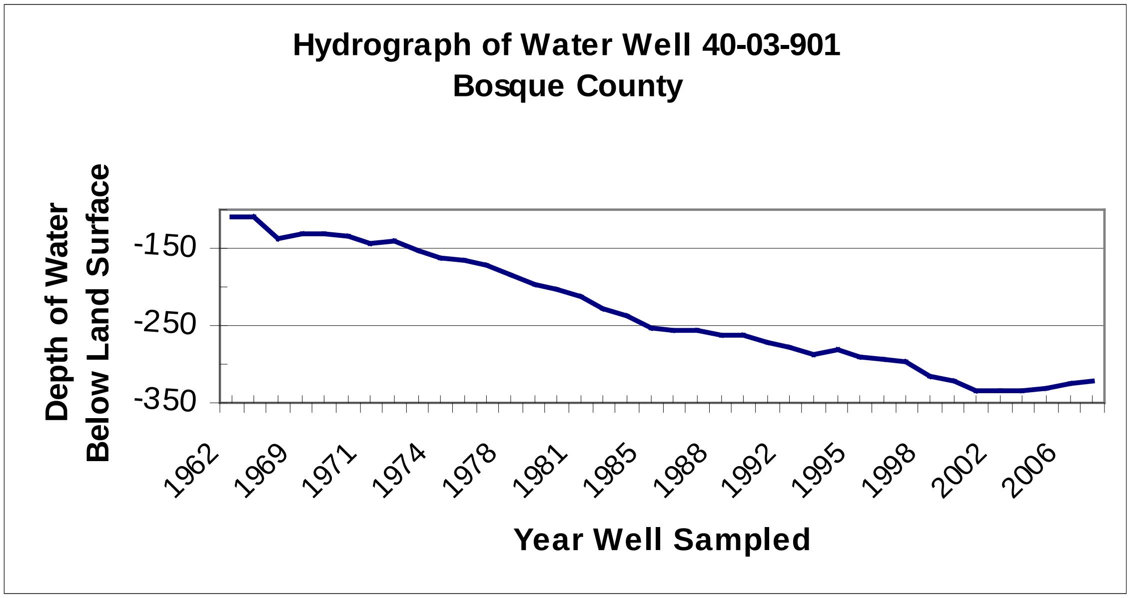


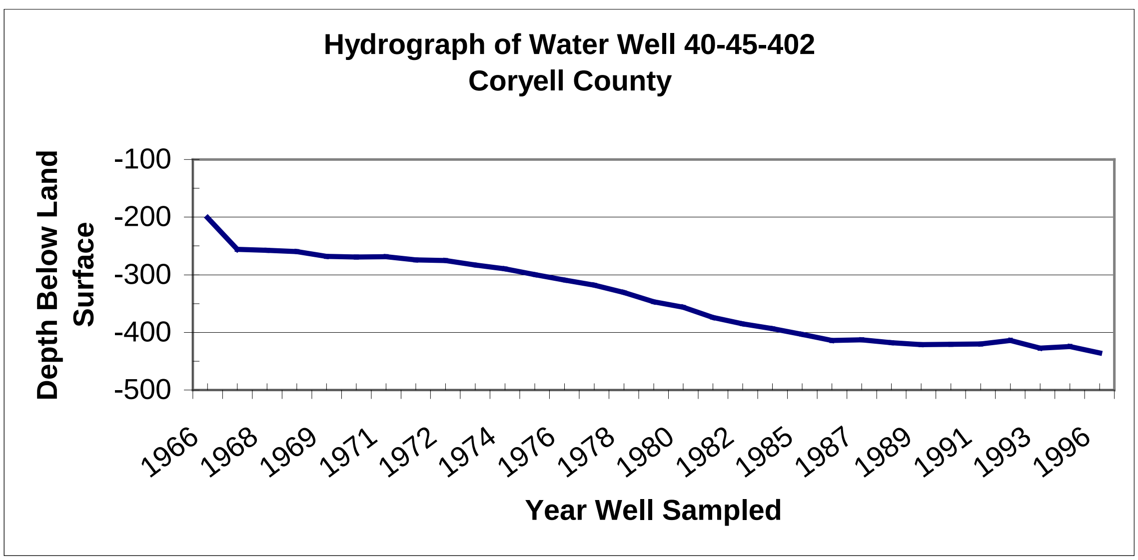
Paluxy Formation.



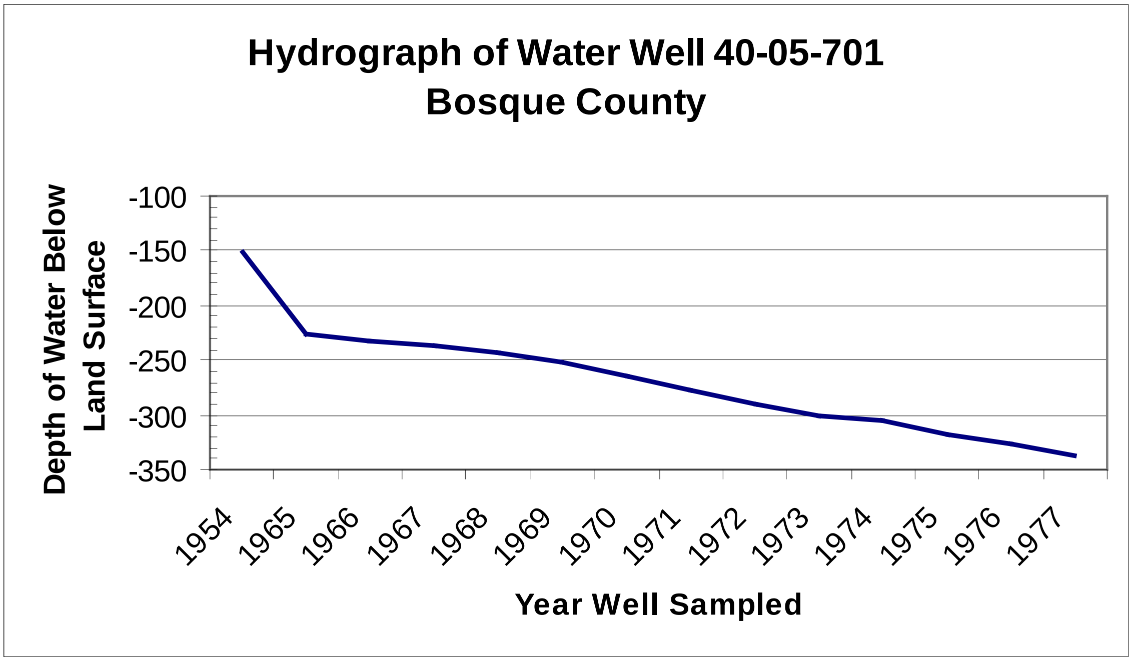


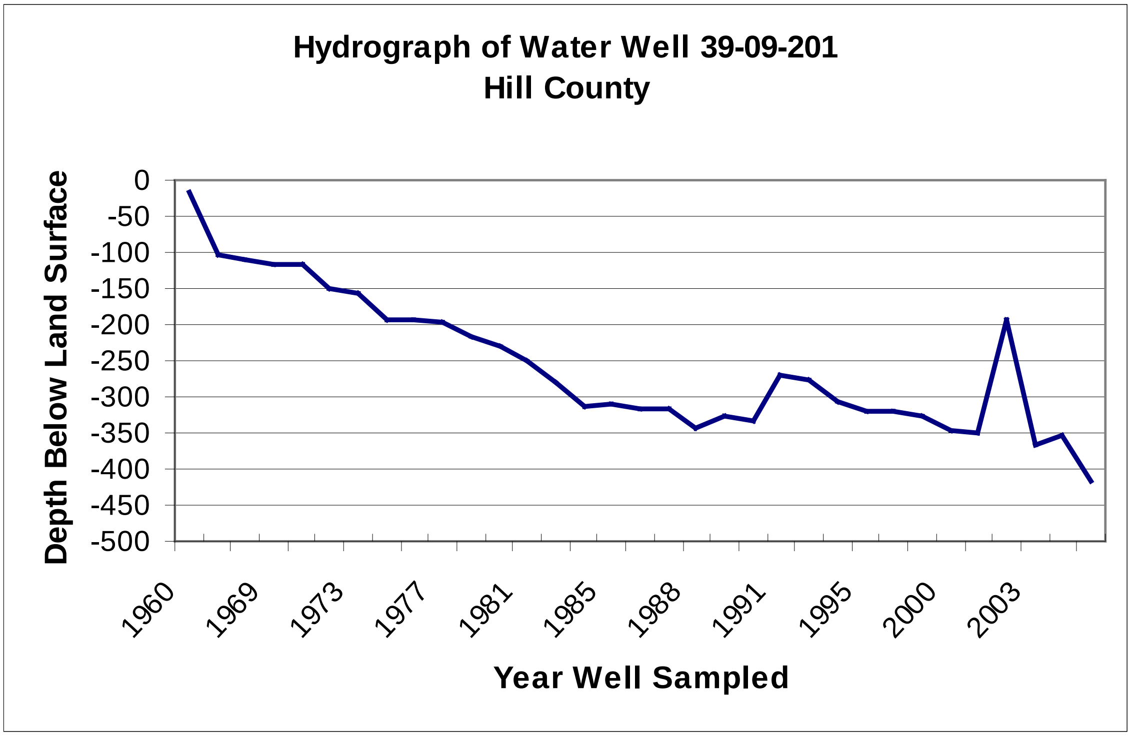
Hensell Member of the Travis Peak Formation.



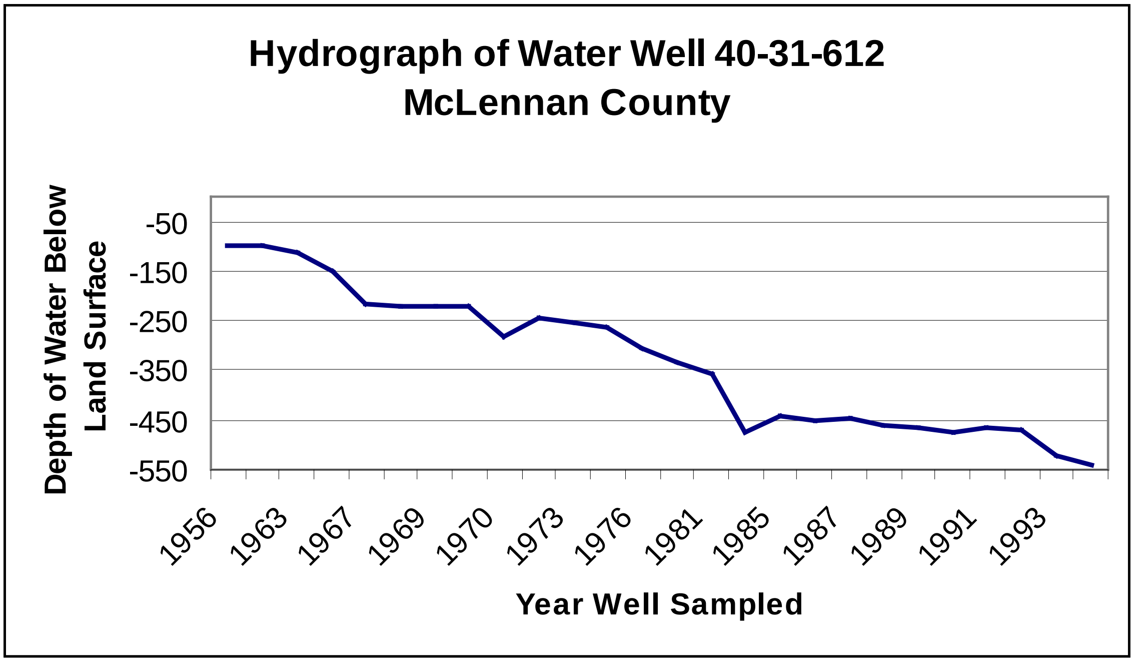


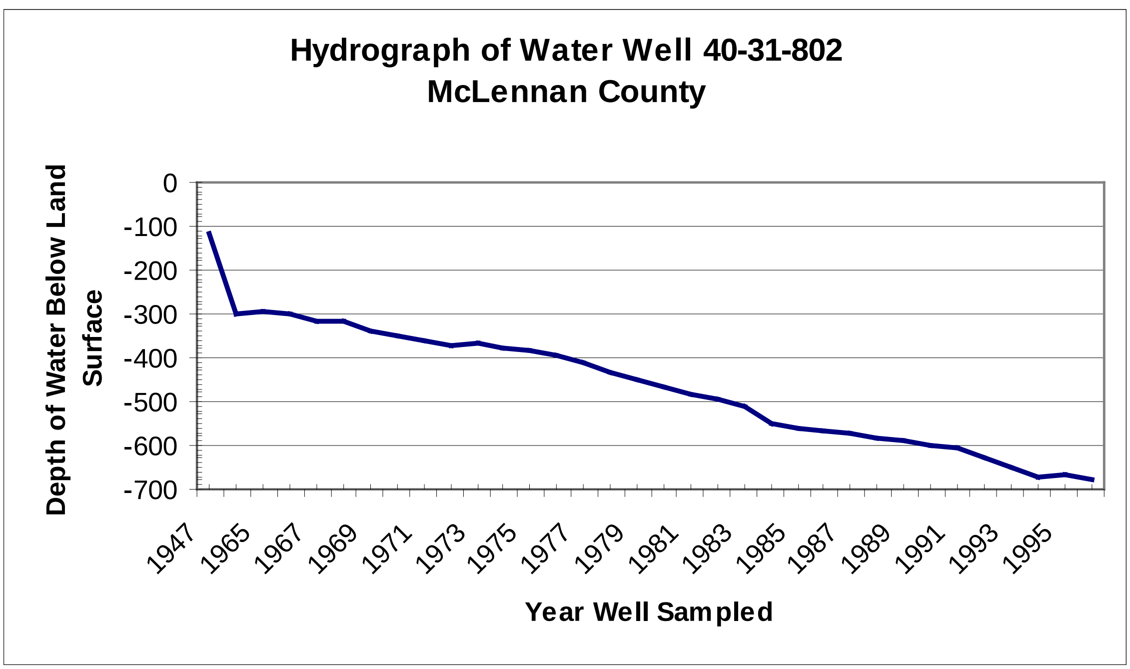
Hosston Member of the Travis Peak Formation.





Hosston Member of the Travis Peak Formation (continued).





APPENDIX VII. WATER SUPPLY NEEDS AND IDENTIFIED STRATEGIES TO ADDRESS THOSE NEEDS.

Water Supply Concerns This chapter summarizes data and information to evaluate whether the study area is experiencing or is expected to experience critical groundwater problems within the next 25-years. Discussions in this chapter address groundwater level declines that may be indicative of aquifer over drafting, water quality conditions that may limit usability, water supply concerns, and environmental obligations. These discussions rely primarily upon work of the Region F, Brazos G, and Lower Colorado Region K Water Planning Groups, and information from the TWDB, TCEQ, and TPWD.

Identified Water Supply Needs and Strategies to Address Needs The following information is summarized from the 2002 State Water Plan, and the 2006 regional water plans. The major water supply strategies that have been adopted by the planning groups to address water shortages in the study area primarily involve in-area surface water supplies. The purpose of the following discussion is to identify the regional water planning group strategies for water user groups within the study area to meet anticipated needs

Table VII.1. Identified Water Supply Needs and Strategies to Address Needs, Central Texas (Trinity Aquifer) PGMA Study.

County/Water User Group	Region	2030 Shortage	Strategies to Address Needs
Bell County	G	(1,808)	
Bell-Milam-Falls WSC		(261)	Increase contract with Central Texas WSC
Dog Ridge WSC		(205)	Ditto
Elm Creek WSC		(479)	Increase contract with Bluebonnet WSC
City of Little River Academy		(20)	Voluntary Redistribution from City of Temple.
City of Morgan's Point Resort		(202)	Ditto
Manufacturing		(1,163)	Conservation and Voluntary Redistribution from City of Temple.
Bosque County	G	(5,784)	
Childress Creek WSC		(193)	Purchase water from City of Clifton VIA Bosque Co Regional Project
Meridian		(68)	Ditto
Valley Mills (P)		(103)	Ditto and Conservation
Walnut Springs		(60)	Purchase water from City of Clifton VIA Bosque Co Regional Project
County-other		(842)	BRA System Operation Supply to Bosque County
Manufacturing		(921)	Conservation and BRA System Operation Supply to Bosque County
Steam Electric		(3,497)	Ditto
Brown County	F	(2,946)	
Irrigation		(2,946)	Conservation and Purchase water from Brown County WID
Callahan County	G		
Coleman County WSC		(64)	Purchase water from Lake Coleman
Coryell County	G	(2,103)	
County-other		(2,103)	Conservation, Additional Trinity aquifer development, and Increase Contract with Central Texas WSC
Eastland County	G	(9,439)	
City of Rising Star		(10)	New Trinity aquifer supply
County-other		(205)	Purchase additional water from Eastland County WSD
Irrigation		(9,224)	Conservation, Brush control, and Weather Modification

Table VII.1. (continued).

County/Water User Group	Region	2030 Shortage	Strategies to Address Needs
Erath County	G	(16)	
Manufacturing		(16)	Conservation and Additional Trinity aquifer development
Falls County	G	(541)	
West Brazos WSC		(430)	Purchase water from the City of Waco
County-other		(111)	Additional Carrizo-Wilcox aquifer development.
Hill County	G	(487)	
White Bluff Community WS		(341)	Conservation and BRA System Operation.
Woodrow-Osceola WSC		(119)	BRA System Operation.
Manufacturing		(21)	Conservation and BRA System Operation
Lampasas County	G	(862)	
County-other		(703)	Conservation and Additional Trinity aquifer development.
Manufacturing		(135)	Conservation and Purchase water from the City of Lampasas.
Mining		(24)	Ditto
Limestone County	G	(44)	
Manufacturing		(44)	Conservation and Development of the Carrizo-Wilcox aquifer.
McLennan County	G	(32,071)	
Chalk Bluff WSC		(550)	Purchase water from City of Waco or BRA System Operation and/or reuse water from WMARSS.
Crawford		(60)	Purchase water from City of Waco, or BRA System Operation
Cross Country WSC		(521)	Ditto.
Gholson		(175)	Purchase water from City of Waco, or BRA System Operation and/or reuse water from WMARSS.
Hallsburg		(148)	Ditto and Conservation.
Mart		(342)	Purchase water from City of Waco, or BRA System Operation and/or reuse water from WMARSS.
North Bosque WSC		(479)	Purchase water from City of Waco, or BRA System Operation.
Riesel		(112)	Ditto and Conservation, Reuse from WMARSS.
West		(411)	Purchase water from City of Waco, or BRA System Operation.
Western Hills WS		(489)	Conservation, Reuse from WMARSS, Purchase water from City of Waco, or BRA System Operation.
County-other		(6,067)	Conservation, Purchase water from City of Waco, or BRA System Operation.
Manufacturing		(1,089)	Ditto and Reuse from WMARSS.
Steam-electric		(21,628)	Ditto
Mills County	K	(618)	
Brookesmith SUD (WSC)		(8)	Conservation and Voluntary Redistribution
Goldthwaite		(368)	Conservation and Additional groundwater development
Irrigation		(241)	Ditto
Manufacturing		(1)	Voluntary Redistribution from WUGs with surplus
Somervell County	G	(329)	
County-other		(231)	Off-channel reservoir
Manufacturing		(4)	Conservation and Purchase water from the City of Glen Rose
Mining		(94)	Conservation and Voluntary Redistribution from Steam-Electric.

Western Region

Study Area Counties in the Western Region Planning Area Conservation, voluntary redistribution, brush control, and weather modification are some of the recommended strategies to meet projected water supply shortages in Brown, Callahan, Eastland, Erath, Lampasas, and Mills counties (HDR, et al., 2005). It is anticipated that groundwater usage will remain constant in these counties through 2030. Brown and Eastland counties water usage versus supplies indicate an overall shortage in 2030 (Table V.1).

Region F Water Planning Area

BROWN COUNTY

Water supply corporations (WSCs) provide most of the water for municipal use in the rural portions of Brown County. Most of this water comes from Lake Brownwood. However, the northern portion of the county relies exclusively on groundwater supplies from either the Trinity aquifer or formations classified by TWDB as 'other aquifers'. Historically, more water has been used from the Trinity aquifer in Brown County than has been recharged to the aquifer. Municipal users of the Trinity aquifer must compete with irrigation and livestock use. Irrigation WUG is projected to have a shortage of 2,946 acft in 2030. Region F recommends improvements in the efficiency of irrigation equipment as the most effective water conservation strategy for irrigation within the region. The reliability of supplies from the unclassified aquifers is unknown, so projected supplies are based on historical use from the source. Because of concerns about the reliability of municipal supplies from groundwater, it is anticipated that more of the existing and future municipal water use in northern Brown County will come from treated Lake Brownwood water. Brookesmith SUD (WSC) has completed studies to provide water to approximately 400 connections north of Lake Brownwood. Zephyr WSC also may expand its service area to include areas currently using groundwater supplies.

Region K Water Planning Area

MILLS COUNTY

The primary source of groundwater in Mills County is the Trinity aquifer. Surface water supplies are available through the City of Goldthwaite Reservoir and other local supply sources. Irrigation demands in Mills County represent 60 percent of the water demand in the county with most of the remainder of the demand being for livestock and municipal purposes. Voluntary redistribution is the recommended water supply plan for the Brookesmith SUD (WSC) and for manufacturing shortages. For Brookesmith SUD (WSC), the water allocated from County-Other will have costs associated with it since there is no information showing that Brookesmith SUD (WSC) is currently using a groundwater source. Brookesmith SUD (WSC) is a new WUG this planning cycle and would have been included in County-Other in the last plan. Additional development of groundwater is recommended for the City of Goldthwaite and for irrigation water deficits for the year 2030 (Lower Colorado Regional Water Planning Group, January 2006).

Region G Water Planning Area

CALLAHAN COUNTY

Coleman County WSC
Coleman County WSC obtains its water supply from the City of Coleman via Lake Coleman; however, there are projected shortages beginning in 2010 through 2060. There is an estimated shortage of 64 acft/yr in 2030. Working within the planning criteria established by the Brazos G RWPG, the following water supply plan is recommended to meet the projected shortage of Coleman County WSC.

• Increase supply from City of Coleman.
• Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

<u>EASTLAND COUNTY</u>

City of Rising Star
The City of Rising Star uses locally available groundwater for its water supply; however, there are projected shortages beginning in 2010 through 2060. There is an estimated shortage of 10 acft/yr for the year 2030. Working within the planning criteria established by the Brazos G RWPG, the following water supply plan is recommended to meet the projected shortage of the City of Rising Star:
• Connect to Westbound WSC
• Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

County-Other
The County-Other WUG shows a projected shortage from 2010 through 2060. There is an estimated shortage of 205 acft/yr for the year 2030. Currently contract purchases through 2060 exist with the City of Cisco (147 acft/yr), the City of Clyde (221 acft/yr), and Eastland County WSC (120 acft/yr). Working within the established planning criteria, the following water supply plan is recommended to meet the projected shortage of County-Other:
• Purchase additional water from Eastland County WSD
• Conservation was considered; however, County-Other's current per capita use rate is below 140 gpcd.

Irrigation
Surface water supplies for Eastland County Irrigation are obtained from Lake Leon, the Leon River, and its tributaries. A current and long-term shortage in Irrigation water supplies exists through the year 2060, with a shortage of 9,224 acft/yr for 2030. Working within the established planning criteria, the following water supply plan is recommended to partially mitigate projected shortages:
• Conservation
• Brush Control and Weather Modification.

<u>ERATH COUNTY</u>

Manufacturing
Manufacturing entities in Erath County currently obtain their water supply from the Trinity aquifer. There is an estimated shortage of 16 acft/yr for the year 2030. Working within the established planning criteria, the following water supply plan is recommended to meet the projected shortage of Erath County Manufacturing:
• Conservation
• Additional Trinity Aquifer Development

<u>LAMPASAS COUNTY</u>

County-Other
County-Other WUG obtains its water supply from groundwater in the Trinity aquifer. Based on the available groundwater supply, Lampasas County-Other is projected to have a shortage of 703 acft/yr in the year 2030. Working within the established planning criteria, the following water supply plan is recommended to meet the projected shortage of Lampasas County-Other:
• Conservation,
• Additional Trinity Aquifer Development.

Manufacturing
Lampasas County Manufacturing obtains its water supply from run-of-river rights. Based on the available surface water supply, Lampasas County Manufacturing is projected to have a shortage of 135 acft/yr in the year 2030. Working within the established planning criteria, the following water supply plan is recommended to meet the projected shortage of Lampasas County Manufacturing:
• Conservation,
• Purchase water from the City of Lampasas.

Mining
Lampasas County Mining obtains its water supply from groundwater from the Trinity and Marble Falls aquifers. Based on the available groundwater supply, Lampasas County Mining is projected to have a shortage of 24 acft/yr in the year 2030. Working within the established planning criteria, the following water supply plan is recommended to meet the this projected shortage:
• Conservation,
• Purchase water from the City of Lampasas.

Eastern Region

Water Supply Concerns This chapter summarizes data and information to evaluate whether the study area is experiencing or is expected to experience critical groundwater problems within the next 25-years. Discussions in this chapter address groundwater level declines that may be indicative of aquifer over pumping, water quality conditions that may limit usability, water supply concerns, and environmental obligations. These discussions rely primarily upon work of the Region F, Brazos G, and Region K Water Planning Groups, and information from the TWDB, TCEQ, and TPWD.

Study Area Counties in the Eastern Region Planning Area

Conservation, voluntary redistribution, aquifer development, purchase from other entities, and reuse are some of the recommended strategies to meet projected water supply shortages in Bell, Bosque, Coryell, Falls, Hill, Limestone, McLennan, and Somervell counties (HDR, et al., 2005). It is anticipated that groundwater usage will remain constant in these counties through 2030.

BELL COUNTY

In Bell County, six water user groups are projected to have shortages by 2030. The water user groups are Bell-Milam-Falls WSC (261 acft/yr), Dog Ridge WSC (205 acft/yr), Elm Creek WSC (479 acft/yr), the City of Little River-Academy (20 acft/yr), the City of Morgan's Point-Resort (202 acft/yr), and manufacturing (1,163 acft/yr) (Brazos G Regional Water Planning Group et al., 2006).

Bell-Milam-Falls WSC
Bell-Milam-Falls WSC receives its water from two sources, surface water from a contract with Central Texas WSC from Stillhouse Hollow Reservoir and groundwater from the Trinity aquifer. The estimated reliable supply is 817 acft/yr. Working within the established planning criteria, the following water supply plan is recommended to meet the projected shortage of Bell-Milam-Falls WSC:
• Increase contract with Central Texas WSC by 100 acft/yr by 2010 and by 600 acft/yr by 2060.
• Conservation was considered; however, the WSC's current per capita use rate is below 140 gpcd.

Dog Ridge WSC
Dog Ridge WSC receives its water from a surface water contract with Central Texas WSC from Stillhouse Hollow Reservoir. The estimated reliable supply is 671 acft/yr. Working within the

established planning criteria, the following water supply plan is recommended to meet the projected shortage of Dog Ridge WSC:

- Increase contract with Central Texas WSC by 100 acft/yr by 2010, and by 400 acft/yr by 2060.
- Conservation was considered; however, the WSC's current per capita use rate is below 140 gpcd.

Elm Creek WSC

Elm Creek WSC purchases treated water from Bluebonnet WSC (out of Lake Belton) and has wells located in the Trinity aquifer. The estimated reliable supply is 92 acft/yr Working within the established planning criteria, the following water supply plan is recommended to meet the projected shortage of Elm Creek WSC:

- Increase contract with Bluebonnet WSC by 400 acft/yr by 2010, increasing to 700 acft/yr by 2060.
- Conservation was considered; however, the WSC's current per capita use rate is below 140 gpcd.

City of Little River-Academy

City of Little River-Academy received its water from both groundwater (Trinity aquifer) and surface water (purchased from the City of Temple). Groundwater supply is supplemented by treated surface water, which the City of Temple supplies to Little River-Academy by transmission pipeline. The estimated reliable supply is 272 acft/yr. Working within the established planning criteria, the following water supply plan is recommended to meet the projected shortage of the City of Little River-Academy:

- Voluntary Redistribution from City of Temple. Little River-Academy would meet the projected shortage by buying an additional 50 acft/yr from the City of Temple. The existing facilities have adequate capacity to deliver the additional water.
- Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

City of Morgan's Point Resort

The City of Morgan's Point Resort has a contract with the City of Temple to purchase treated surface water. Morgan's Point Resort receives its water through a transmission pipeline. The estimated reliable supply is calculated at 291 acft/yr. Working within the established planning criteria, the following water supply plan is recommended to meet the projected shortage of the City of Morgan's Point Resort:

- Voluntary Redistribution from City of Temple. Morgan's Point Resort would meet its shortage through purchase of an additional 300 acft/yr from the City of Temple.
- Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

Manufacturing

Groundwater from the Trinity aquifer furnishes water for manufacturing in Bell County. There is an estimated 17 acft/yr reliable supply at present. To meet the projected shortage for 2030 the recommended water supply plan for Manufacturing in Bell County is the following;

- Voluntary Redistribution through purchase of an additional 1,500 acft/yr from the City of Temple.
- Conservation.

<u>BOSQUE COUNTY</u>

In Bosque County, seven water user groups are projected to have shortages by 2030. These are Childress Creek WSC (193 acft/yr), the City of Meridian (68 acft/yr), the City of Valley Mills (103 acft/yr), the City of Walnut Springs (60 acft/yr), county-other (842 acft/yr), manufacturing (921 acft/yr), and steam-electric (3,497 acft/yr) (Brazos G Regional Water Planning Group et al., 2006).

Childress Creek WSC

The Childress Creek WSC gets its water supply from groundwater wells located in the Trinity aquifer. There is currently an estimated reliable supply of 196 acft/yr. The following water supply plan is

recommended to meet the projected shortage for 2030 of Childress Creek WSC:
• Purchase water from the City of Clifton through the Bosque County Regional Project
• Conservation was considered; however, the WSC's current per capita use rate is below 140 gpcd.

City of Meridian
The City of Meridian obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, the City is projected to have a shortage of 68 acft/yr in the year 2030 and 69 acft/yr in the year 2060. The following water supply plan is recommended to meet the projected shortage of the City of Meridian for 2030:
• Purchase water from the City of Clifton through the Bosque County Regional Project
• Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

City of Valley Mills
The City of Valley Mills obtains its water supply from groundwater from the Trinity aquifer. Based on the groundwater supply available, the City of Valley Mills is projected to have a shortage of 103 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of the City of Valley Mills:
• Conservation
• Purchase water from the City of Clifton through the Bosque County Regional Project.

City of Walnut Springs
The City of Walnut Springs obtains its water supply from groundwater from the Trinity aquifer. Based on the groundwater availability in the Trinity aquifer, the City of Walnut Springs is projected to have a shortage of 60 acft/yr in the year 2030 .The recommended water supply plan to meet the projected shortage of the City of Walnut Springs follows:
• Purchase water from the City of Clifton through the Bosque County Regional Project.
• Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

County-Other
Municipal entities included in Bosque County-Other WUG obtain their water supply from groundwater from the Trinity aquifer. None of the County-Other entities utilize surface water as a water supply. Based on the available groundwater supply in the Trinity aquifer, County-Other is projected to have a shortage of 842 acft/yr in the year 2030. Working within the established planning criteria, the following water supply plan is recommended to meet the projected shortages of the County-Other WUG:
• Purchase water from the City of Clifton through the Bosque County Regional Project;
• BRA System Operations Supply to Bosque County,
• Conservation was considered; however, the entity's current per capita use rate is below 140 gpcd.

Manufacturing
Water supply for manufacturing in Bosque County is obtained by purchase from a city or water supply corporation, from private wells operated by the manufacturing entity, or by limited surface water supplies. Based on the available supplies, Manufacturing is projected to have a shortage of 921 acft/yr in the year 2030. Working within the planning criteria established by the Brazos G RWPG and TWDB, the following water supply plan is recommended to meet the projected shortages for manufacturing:
• Conservation,
• BRA System Operations Supply to Bosque County.

Steam-Electric
The water supply for Steam-Electric use in Bosque County consists of surface water contracts with the Brazos River Authority and a limited amount of groundwater from the Trinity aquifer. Steam-Electric

WUG is projected to have a shortage of 3,497 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage for Steam-Electric for 2030:
• Conservation.
• BRA System Operations Supply to Bosque County.

CORYELL COUNTY

County-Other
The water supply for County-Other use in Coryell County consists of various contracts with the Brazos River Authority obtaining surface water Lake Belton and a limited amount of groundwater from the Trinity aquifer. The estimated reliable supply for the year 2060 is 1,104 acft/yr County-Other WUG is projected to have a shortage of 2,103 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of Coryell County-Other for 2030;
• Conservation
• Additional Trinity Aquifer Development
• Increase Contract with Central Texas WSC

FALLS COUNTY

In Falls County, two water user groups are projected to have shortages by 2030, West Brazos WSC (430 acft/yr), and county-other (111 acft/yr) (Brazos G Regional Water Planning Group et al., 2006).

West Brazos WSC
The water supply for West Brazos WSC in Falls County consists of groundwater from the Trinity aquifer. West Brazos WSC is projected to have a shortage of 430 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage for 2030:
• Purchase water from the City of Waco.
• Conservation was considered; however, the WSC's current per capita use rate is below 140 gpcd.

County-Other
The water supply for County-Other use in Falls County consists of surface water contracts with Central Texas WSC and groundwater from the Trinity aquifer. Currently there is an estimated reliable supply of 102 acft/yr. Falls County-Other WUG is projected to have a shortage of 111 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage for Falls County-Other for 2030:
• Additional Carrizo-Wilcox Aquifer Development.
• Conservation was considered; however, this entity's current per capita use rate is below 140 gpcd.

HILL COUNTY

In Hill County, three water user groups are projected to have shortages by 2030, White Bluff Community WS (341 acft/yr), Woodrow-Osceola WSC (119 acft/yr), and manufacturing (21 acft/yr) (Brazos G Regional Water Planning Group et al., 2006).

White Bluff Community WS
The water supply for White Bluff Community WS in Hill County consists of groundwater from the Trinity aquifer. Currently there is an estimated reliable supply of 212 acft/yr. White Bluff Community WS is projected to have a shortage of 341 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage for White Bluff Community WS for 2030:
• Conservation, and
• BRA System Operation.

Woodrow-Osceola WSC
The water supply for Woodrow-Osceola WSC use in Hill County consists of groundwater from the Trinity aquifer. Currently there is an estimated reliable supply of 165 acft/yr. Woodrow-Osceola WSC is projected to have a shortage of 119 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage for Woodrow-Osceola WSC for 2030:
• BRA System Operation.
• Conservation was considered; however, the WSC's current per capita use rate 140 gpcd.

Manufacturing
The water supply for Manufacturing use in Hill County consists of groundwater from the Woodbine aquifer. Currently there is an estimated reliable supply of 87 acft/yr. Manufacturing WUG is projected to have a shortage of 21 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage for Manufacturing WUG for 2030:
• Conservation, and
• BRA System Operation.

LIMESTONE COUNTY

Manufacturing
Limestone County Manufacturing obtains its water supply from various run-of-river Rights. Based on the available surface water supply, Limestone County Manufacturing is projected to have a shortage of 44 acft/yr in the year 2030. Working within established planning criteria, the following water supply plan is recommended to meet the projected shortage of Limestone County Manufacturing:
• Conservation, and
• Development of the Carrizo-Wilcox Aquifer.

McLENNAN COUNTY

In McLennan County, twelve water user groups are projected to have shortages by 2030. Those groups include Chalk Bluff WSC (550 acft/yr), the City of Crawford (60 acft/yr), Cross County WSC 521 acft/yr), the City of Gholson (175 acft/yr), the City of Hallsburg (148 acft/yr), the City of Mart (342 acft/yr), North Bosque WSC (479 acft/yr), the City of Riesel (112 acft/yr), the City of West (411 acft/yr), Western Hills WS (489 acft/yr), county-other (6,067 acft/yr), and manufacturing (1,089 acft/yr) (Brazos G Regional Water Planning Group et al., 2006).

Chalk Bluff WSC
Chalk Bluff WSC obtains its water supply from groundwater from the Trinity aquifer. Chalk Bluff WSC is projected to have a shortage of 550 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of Chalk Bluff WSC:
• Purchase water from the City of Waco. In order to reduce demands on the Trinity aquifer, provide for future growth, and coordinate with the City of Waco's plans, water purchased from the City of Waco is in excess of projected future demands for this WUG.
• An alternative water management strategy is to develop supplies from the Carrizo-Wilcox aquifer in Burleson County in conjunction with the FHLM Water Supply Corporation, an entity comprised of 15 water supply corporations and cities in Falls, Hill, Limestone, and McLennan Counties, including Chalk Bluff WSC. Other alternatives include purchasing supply from BRA System Operation and/or reuse water from WMARSS.
• Conservation was considered; however, the WSC's current per capita use rate is below 140 gpcd.

City of Crawford
The City of Crawford obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, the City of Crawford is projected to have a shortage of 60 acft/yr in

the year 2030. The following water supply plan is recommended to meet the projected shortage:
• Purchase water from the City of Waco.
• An alternative to this strategy is to purchase water from BRA System Operation.
• Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

Cross Country WSC

Cross Country WSC obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, Cross Country WSC is projected to have a shortage of 521 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of Cross Country WSC:
• Purchase water from the City of Waco.
• An alternative to this strategy is to purchase water from BRA System Operation.
• Conservation was considered; however, the WSC's current per capita use rate is below 140 gpcd.

City of Gholson

The City of Gholson obtains its water supply from groundwater from the Trinity aquifer through Gholson WSC. Based on the available groundwater supply, the City of Gholson is projected to have a shortage of 175 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of the City of Gholson:
• Purchase water from the City of Waco. In order to reduce demands on the Trinity aquifer, provide for future growth, and coordinate with the City of Waco's plans, water purchased from the City of Waco is in excess of projected future demands for this WUG.
• An alternative water management strategy is to develop supplies from the Carrizo-Wilcox aquifer in Burleson County in conjunction with the FHLM Water Supply Corporation, an entity comprised of 15 water supply corporations and cities in Falls, Hill, Limestone, and McLennan Counties, including Gholson WSC. Other alternatives include purchasing supply from BRA System Operation and/or reuse water from WMARSS.
• Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

City of Hallsburg

The City of Hallsburg obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, the City of Hallsburg is projected to have a shortage of 148 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of the City of Hallsburg:
• Conservation,
• Purchase water from the City of Waco.
• Alternatives to these strategies are purchasing from BRA System Operation and/or reuse water from WMARSS.

City of Mart

The City of Mart obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, the City of Mart is projected to have a shortage of 342 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of the City of Mart:
• Purchase water from the City of Waco.
• An alternative water management strategy is to develop supplies from the Carrizo-Wilcox aquifer in Burleson County in conjunction with the FHLM Water Supply Corporation, an entity comprised of 15 water supply corporations and cities in Falls, Hill, Limestone, and McLennan Counties, including the City of Mart. Other alternatives include purchasing supply from BRA System Operation and/or reuse water from WMARSS.
• Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

North Bosque WSC

North Bosque WSC obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, North Bosque WSC is projected to have a shortage of 479 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of North Bosque WSC:

• Conservation,
• Purchase water from the City of Waco.
• An alternative to this strategy is to purchase water from BRA System Operation.

City of Riesel

The City of Riesel obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, the City of Riesel is projected to have a shortage of 112 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of the City of Riesel:

• Purchase water from the City of Waco.
• An alternative water management strategy is to develop supplies from the Carrizo-Wilcox aquifer in Burleson County in conjunction with the FHLM Water Supply Corporation, an entity comprised of 15 water supply corporations and cities in Falls, Hill, Limestone, and McLennan counties, including the City of Riesel. Other alternatives include purchasing supply from BRA System Operation and/or reuse water from WMARSS.
• Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

City of West

The City of West obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, the City of West is projected to have a shortage of 411 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage for the City of West:

• Purchase water from the City of Waco.
• An alternative to this strategy is to purchase supply from BRA System Operation.
• Conservation was considered; however, the City's current per capita use rate is below 140 gpcd.

Western Hills WS

Western Hills WS obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, Western Hills WS is projected to have a shortage of 489 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of Western Hills WS:

• Purchase water from the City of Waco.
• An alternative to this strategy is to purchase water from BRA System Operation.
• Conservation was considered; however, the entity's current per capita use rate is below 140 gpcd.

County-Other

McLennan County-Other obtains its water supply from groundwater from the Trinity aquifer and surface water from Lake Belton and Lake Waco. Based on the available groundwater and surface water supply, McLennan County-Other is projected to have a shortage of 6,067 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of McLennan County-Other:

• Conservation,
• Purchase water from the City of Waco.
• Alternatives to this strategy are purchasing from BRA System Operation and/or reuse water from WMARSS.

Manufacturing
McLennan County Manufacturing obtains its water supply from groundwater from the Trinity aquifer and surface water from run-of-river rights and Lake Waco. Based on the available groundwater and surface water supply, McLennan County Manufacturing is projected to have a shortage of 1,089 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of McLennan County Manufacturing:

- Conservation,
- Purchase water from the City of Waco.
- An alternative to this strategy is to purchase water from BRA System Operation.

Steam-Electric
McLennan County Steam-Electric obtains its water supply from Tradinghouse Reservoir. Based on the available surface water supply, McLennan County Steam-Electric is projected to have a shortage of 21,628 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of McLennan County Steam-Electric:

- Conservation,
- Reuse from WMARSS,
- Purchase water from the City of Waco.
- An alternative to this strategy is BRA System Operation.

SOMERVELL COUNTY

In Somervell County, three water user groups are projected to have shortages by 2030, county-other (231 acft/yr), manufacturing (4 acft/yr), and steam-electric (94 acft/yr) (Brazos G Regional Water Planning Group et al., 2006).

County-Other
Somervell County-Other obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, Somervell County-Other is projected to have a shortage of 231 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of Somervell County-Other:

- Wheeler Branch Off-Channel Reservoir – the project has obtained a water rights permit from the TCEQ and is projected to be completed by 2010,
- Conservation was considered; however, the County-Other's per capita use rate is below 140 gpcd.

Manufacturing
Somervell County Manufacturing obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, Somervell County Manufacturing is projected to have a shortage of four acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of Somervell County Manufacturing:

- Conservation,
- Purchase water from the City of Glen Rose.

Mining
Somervell County Mining obtains its water supply from groundwater from the Trinity aquifer. Based on the available groundwater supply, Somervell County Mining is projected to have a shortage of 94 acft/yr in the year 2030. The following water supply plan is recommended to meet the projected shortage of Somervell County Mining:

- Conservation,
- Voluntary Redistribution from Steam-Electric.

APPENDIX VIII. WHOLESALE WATER PROVIDERS.

The RWPGs are required to prepare estimates of the water available to the Wholesale Water Providers (WWPs) within each region. For each WWP with a projected shortage, a water supply plan has been developed and is presented in the following subsections.

Brown County Water Improvement District Number 1

The Brown County Water Improvement District Number 1 (BCWID) owns and operates Lake Brownwood and a water treatment plant located in the City of Brownwood. Lake Brownwood is one of the few surface water sources in Region F with a surplus after meeting all expected local needs. Because of its relatively senior priority date of 1925, the reservoir is able to provide its permitted diversion of 29,712 acre-feet with and without subordination. The planning process has identified Lake Brownwood as a potential source to meet needs in Runnels and Coke Counties. There is adequate water supply for this use without depleting water supplies for the WUGs in Brown County.

Brazos River Authority (Lake Aquilla System)

The Brazos River Authority (Lake Aquilla System) obtains water supply from Lake Aquilla. The Lake Aquilla System is projected to have a shortage of 1,884 acft/yr in 2030 and 6,261 acft/yr in 2060. The projected shortages for the Lake Aquilla System may be overstated. The projected shortages are based on a comparison of supplies and contracts, as opposed to a comparison of supplies and projected demands. Projected demands are less than the contracted amounts for supply. In addition, the yield from Lake Aquilla was computed using estimated sedimentation rates based on a 1995 hydrographic survey. The BRA has noted that recent watershed modeling and hydrographic survey information indicates that sedimentation rates are considerably less, which would increase available supply from the reservoir. The BRA is actively monitoring sedimentation in the reservoir and has participated in programs aimed at reducing sediment load to the reservoir.

Working within established planning criteria, the following water supply plan is recommended to meet the projected shortage of the Brazos River Authority (Lake Aquilla System):

• BRA System Operation Surplus water supply from the Main Stem/Lower Basin portion of the overall BRA System can be used to augment supply at Lake Aquilla, either through direct diversion to and commingling of water, or through meeting Lake Aquilla water supply obligations from Main Stem/Lower Basin sources (Lake Granbury and/or Lake Whitney).

Brazos River Authority (Little River System)

The Brazos River Authority (Little River System) obtains its water supply from Lake Proctor, Lake Belton, Stillhouse Hollow Reservoir, Lake Georgetown, and Lake Granger. Based on the available surface water supply, the BRA Little River System is projected to have a shortage of 5,329 acft/yr in 2030 and 43,690 acft/yr in 2060. Shortages for the BRA Little River System are based on a comparison of supplies and current contractual commitments, not projected demands for those entities holding contracts with the BRA.

Working within established planning criteria, the following water supply plan is recommended to meet the projected shortages for the BRA Little River System:

• BRA Systems Operation and Lake Granger Augmentation

The BRA has applied to the TCEQ for an additional appropriation of water that can be developed by using its system of reservoirs to firm up uncontrolled runoff and return flows entering the basin below its reservoir system. Several of the water management strategies recommended to meet Water User Group needs would use this large potential supply of water. In addition to the firm supply, the BRA has requested appropriation of a large interruptible supply. The Lake Granger Augmentation project would use interruptible water in conjunction with groundwater development to increase firm supply from the reservoir.

• Alternative: Groundwater Development (Volume II, Section 4B.15.1)

The BRA is exploring areas where groundwater resources could be used to serve Little River System needs by providing additional supply.

• Alternative: Millican-Bundic Reservoir (Volume II, Section 4B.12.7)

The BRA would develop the Millican-Bundic Reservoir in coordination with local sponsors/customers to meet future water demands in Region G. Supplies not utilized in Region G could be made available by the BRA to lower basin customers in Region H.

• Alternative: Little River Off-Channel Reservoir (Volume II, Section 4B.13.5)

The BRA would develop the Little River Off-Channel Reservoir in coordination with local sponsors/customers to meet future water demands in Region G. Supplies not utilized in Region G could be made available by the BRA to lower basin customers in Region H.

Brazos River Authority (Main Stem/Lower Basin System)

Description of Supply-The Brazos River Authority (Main Stem/Lower Basin System) obtains water supply from Possum Kingdom Reservoir, Lake Granbury, Lake Whitney, Lake Somerville, and Lake Limestone. Based on the available surface water supply, the BRA Main Stem/Lower Basin System is projected to have a shortage of 395,001 acft/yr in 2030 and 494,566 acft/yr in 2060, including the projected demands on the BRA Main Stem/Lower Basin System from Region H and supplies to Regions C and O. The projected shortages for the BRA Main Stem/Lower Basin System may be overstated. The projected shortages are based on a comparison of supplies and contracts, as opposed to a comparison of supplies and projected demands. Projected demands are less than the contracted amounts for several of the entities supplied by the BRA (HDR, 2005).

Water Supply Plan-Working within established planning criteria, the following water supply plan is recommended to meet the projected shortages for the BRA Main Stem/Lower Basin System:

• BRA Systems Operation

The BRA has applied to the TCEQ for an additional appropriation of water that can be developed by utilizing its system of reservoirs to firm up uncontrolled runoff entering the basin below its reservoir system. Several of the water management strategies recommended to meet Water User Group needs would utilize this large potential supply of water. In addition to the firm supply, the BRA has requested appropriation of a large interruptible supply. Conjunctive use of groundwater or other supplies along the main stem and lower basin similar to the Lake Granger Augmentation strategy could be developed with the interruptible appropriation requested by the BRA. Interruptible supplies at Lake Somerville that are in excess of the firm yield of the reservoir could be firmed up through conjunctive use of nearby Carrizo-Wilcox groundwater.

Bell County WCID No. 1

Bell County WCID No. 1 obtains its water supply from a BRA contract for water from Lake Belton. Based on the available surface water supply, Bell County WCID No. 1 is projected to have a shortage of 275 acft/yr in 2030 and 3,051 acft/yr in 2060. Working within established planning criteria, the following water supply plan is recommended to meet the projected shortage of the Bell County WCID No. 1:

• BRA System Operation.

Bell County WCID No. 1 will purchase additional water supplies through an existing contract with BRA to meet the projected shortages.

Bluebonnet WSC

Bluebonnet WSC obtains its water supply through a contract with the Brazos River Authority. No shortages are projected for Bluebonnet WSC and no changes in water supply are recommended.

Central Texas WSC

Central Texas WSC obtains its water supply from a BRA contract for water from Lake Stillhouse Hollow. Based on the available surface water supply, Central Texas WSC is projected to have a surplus of 954 acft/yr in 2030 and a shortage of 266 acft/yr in 2060.
Working within established planning criteria, the following water supply plan is recommended to meet the projected shortage of the Central Texas WSC:
• Increase BRA Contract.

Aquilla Water Supply District

Description of Supply-Aquilla WSD obtains is water supply from Lake Aquilla through a contract with the Brazos River Authority. The district is projected to have shortages of 520 acft/yr starting in 2010, increasing to 1,561 acft/yr in 2030 and 3,123 acft/yr in 2060. The projected shortages for the Lake Aquilla WSD may be overstated. The projected shortages are based on a comparison of supplies and contracts, as opposed to a comparison of supplies and projected demands. In addition, the yield from Lake Aquilla was computed using estimated sedimentation rates based on a 1995 hydrographic survey. The BRA has noted that recent watershed modeling and hydrographic survey information indicates that sedimentation rates are considerably less (Amonett, and. Bednarz, 2001), which would increase available supply from the reservoir. The BRA is actively monitoring sedimentation in the reservoir and has participated in programs aimed at reducing sediment load to the reservoir.
Water Supply Plan-Working within established planning criteria, the following water supply plan is recommended to meet the projected shortages of the Aquilla WSD:
• Increase BRA Contract.
BRA will increase supplies to Lake Aquilla through BRA System Operations, to be implemented: before 2060. Infrastructure is assumed adequate.

Upper Leon Municipal Water District

Upper Leon MWD obtains its water supply from Lake Proctor through a contract with the Brazos River Authority. No shortages are projected for Upper Leon MWD and no changes in water supply are recommended.

Eastland County Water Supply District

Eastland County WSD obtains its water supply from Lake Leon and a run-of-the-river on Leon River. No shortages are projected for Eastland County WSD and no changes in water supply are recommended.

City of Waco (Wholesale Water Provider)

Description of Supply-The City of Waco obtains its water supply from surface water from Lake Waco, in which it owns water rights, and from Lake Brazos on the Brazos River. The City supplies several neighboring communities and has sufficient water supply to meet its municipal and regional needs through the year 2030, but is projected to experience shortages prior to year 2050. The City has demonstrated a commitment to provide regional water supply in McLennan County, and could extend regional water supplies beyond the 2060 planning horizon by actively pursuing a reuse program. The City has recently entered into a contract to supply up to 16,000 acft of reuse water per year to LS

Power to provide cooling water for steam electric power generation, and is exploring other potential reuse water sales.
Water Supply Plan-The Brazos G RWPG recommends that the City of Waco continue to pursue direct and indirect reuse as a water management strategy in order to diversify and extend regional water supplies in the McLennan County area. Accordingly, the following water supply plan is recommended for the City of Waco:

• Develop Reuse Supplies to Extend Lake Waco and Trinity Aquifer Supplies.

Lower Colorado River Authority

The LCRA has typically entered into 20-year contracts with its customers for the supply of water. Many of the commitments expire before 2060. In accordance with the TWDB guidance, water provided under these commitments will be shown as not being available to the WUG once the contract has expired. Although the LCRA generally considers these contracts to be commitments to supply water in perpetuity, customers are encouraged to renew their contracts in a timely manner. The majority of these water sales contracts are for stored water from the Highland Lakes System. The only customer within the study area receiving water from the LCRA is the City of Lometa in Lampasas County. Lometa is under contract to purchase 882 acft/yr through 2060.

In addition to these firm commitments for water, the LCRA also provides water to users on an interruptible supply basis. Based on the LCRA Water Management Plan, the LCRA will release water from storage on an interruptible basis when the levels in the Highland Lakes are above a prescribed level at the beginning of the year. During drought conditions, this water may not be available for users. Therefore, in accordance with the TWDB guidance, interruptible water supplied by LCRA is not being considered as a “currently available water supply.”

APPENDIX IX. RECOMMENDED GROUNDWATER CONSERVATION DISTRICT CREATION.

Recommended Name for the Groundwater Conservation District

Heart of Texas Groundwater Conservation District (District)

Purpose for District

The purpose of the proposed District is to provide for the conservation, preservation, protection, recharging, and prevention of waste of groundwater in the Trinity, Brazos River Alluvium, Woodbine, and other aquifers under the authority of Texas Water Code, Chapter 36. The primary problems identified in the proposed District include 1) the historic and continued overdevelopment of the Trinity aquifer; 2) recommended and projected mining of groundwater from aquifer storage to meet existing and future demands; and 3) the potential for competing interest between historic rural groundwater users, urbanizing, and natural gas exploration interests' all using the common resource.

The District would implement the following groundwater management programs and goals for the benefit of the residents to help address identified problems and issues:

- quantify groundwater availability and quality, understand aquifer characteristics, and identify groundwater problems that should be addressed (both quantity and quality) through aquifer- and area-specific research, monitoring, data collection, and assessment programs;

- quantify aquifer impacts from pumpage and establish an overall understanding of groundwater use through a comprehensive water well inventory, registration, and permitting program;

- evaluate and understand aquifers sufficiently to establish spacing regulations to minimize drawdown of water levels and to prevent interference from neighboring wells;

- cooperate and work with the TCEQ, TWDB, TDLR, RCT, and other state agencies to inventory sites, wells, boreholes, or other man-made structures that could potentially impact groundwater supplies;

- establish programs that encourage conservation of fresh groundwater, the use of poorer-quality groundwater when feasible, and facilitate such transitions;

- quantify aquifer and other contributing characteristics sufficiently to evaluate the feasibility and practicability for weather enhancement and aquifer recharge projects in the outcrop areas;

- establish school and public educational programs to increase awareness of the finite water resources and actions that can be taken to conserve the resources;

- protect water quality by encouraging water-well construction to be protective of fresh-water zones and by administering a program to locate and plug abandoned water wells; and

- participate in the Groundwater Management Area #8 and regional water planning processes, groundwater availability model refinements, and regional groundwater management and protection programs with other entities.

Recommended Area and Boundaries

The District's boundaries would be coterminous with the boundaries of Bosque, Coryell, Hill, McLennan, and Somervell counties.

Recommended Board of Directors

The District would be governed by a board of five elected directors. The commissioners' court of each of the five counties would appoint one temporary director for the District. The temporary director from each county would serve until an initial director is elected from the county and has been qualified for office. The initial directors would draw lots to determine the two directors which would serve two-year terms and which three would serve four-year terms. As initial director terms expire, permanent directors would be elected to serve four-year terms.

Recommended Revenue for District

The District could be funded by a combination of ad valorem taxes and well production fees assessed to permitted water wells. Such taxes and production fees are capped by state law at a rate not to exceed 50 cents per $100 assessed valuation and $1 per acre-foot/year for agricultural use, and $10 per acre-foot/year for other uses, respectively. Revenue necessary to manage this five county District is estimated to be at least $1,000,000. Based on year 2002 groundwater use data, and assuming that county-other, livestock, and mining uses would be exempt from potential regulation and fees, about $52,634 of revenue could be generated annually at rates authorized by state law. The remainder of the revenue, $948,466 could be generated by an ad valorem tax. For this five-county area, the total appraised value is approximately $12,174,000,000. A tax rate of $0.00779 per $100 (or $7.79 on $100,000 of property) would annually generate about $948,466. It is anticipated that District revenue needs may decrease once District administrative start-up actions and well inventory, registration and permitting programs are established.