EXECUTIVE SUMMARY

The severe drought of 1996 throughout Texas increased State legislators' awareness of the importance of water planning. As a result of that drought – which in some localized areas became the new drought-of-record – several communities experienced dangerously low water supplies and the agricultural industry suffered extreme losses. Legislators became keenly aware that the state was unprepared for severe drought conditions. With a population projected to double in the next 50 years and the possibility of insufficient water supplies to meet the growing demand, State legislators took a bold move during the 75th Regular Legislative Session by enacting Senate Bill 1 (SB1). This landmark water bill emphasized water issues and responsible water planning by enacting several new provisions to the existing Texas Water Code.

The Texas Water Development Board (TWDB), in coordination with the Texas Natural Resource Conservation Commission (TNRCC) and the Texas Parks and Wildlife Department (TPWD), was charged with providing oversight in the establishment of regional water plans developed through local involvement, and the compilation of these plans into a cohesive statewide water plan. The TWDB delineated boundaries for 16 regions that break as few links between demand centers and their existing sources of water supply as possible, that divide as few counties as possible, that divide as few water-supply districts as possible, and that divide as few regional ground-water aquifers as possible.

Each of the 16 designated regions is to engage in a from-the-bottom-up (local) approach to developing a 50-year, drought-contingency, water-supply management plan based on consensus. The plan provides an evaluation of current and future water demands for all water-use categories, and evaluates water supplies available during drought-of-record conditions to meet those demands. Where future water demands exceed available supplies, alternative strategies are considered to meet the potential water shortages. Each unique regional plan is required to be developed from a common task outline and must:

- recognize existing state laws and regulations;
- recognize existing water rights and contracts;
- consider existing plans;

- consider water-supply needs for all water-use categories; and
- come to agreement with adjacent regions on water use across regional boundaries.

The TWDB appointed an initial coordinating body or regional water planning group (RWPG) for each region based upon names submitted by the public for consideration. The RWPG then expanded its membership based on the their knowledge of additional persons who could appropriately represent a water user group. Senate Bill 1 provisions mandate that one or more representatives of the following water user groups be seated on each RWPG: agriculture, counties, electric generating utilities, environment, industries, municipalities, river authorities, public, small business, water districts, and water utilities. An electric generating utility does not exist within the Plateau Region and is therefore not represented. In addition to the other 10 categories, the Plateau RWPG chose to appoint a member to represent the tourism industry because of its prevalence in the region. The Plateau RWPG members themselves are unpaid and voluntarily devote considerable amounts of their time to the planning process.

RWPGs do not have legal standing as a governmental agency or entity – i.e., they do not have regulatory authority of any kind. However, the regional water plans developed by the RWPGs and their consultants exert considerable influence on water planning and future water-related infrastructure via two caveats mandated by SB1:

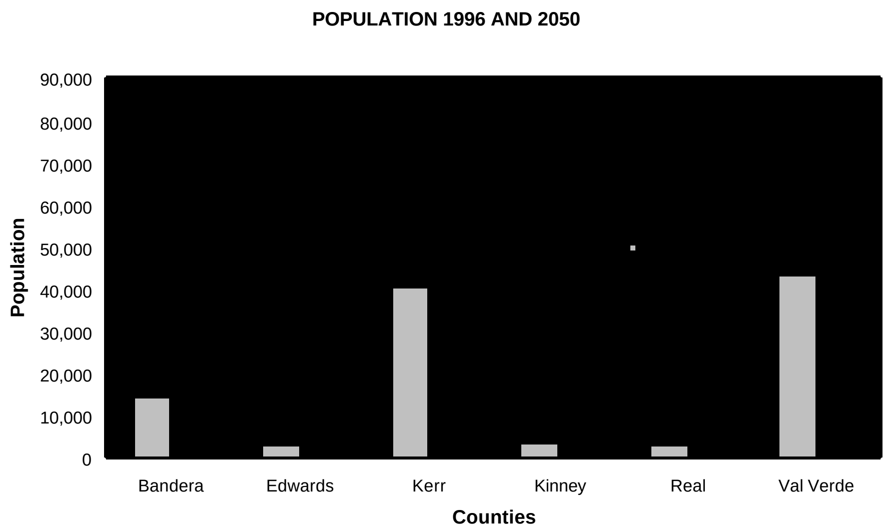
- Water management strategies not contained in the regional water plan will not receive state funding through TWDB.
- Water management strategies requiring surface water permits or amendments from TNRCC will not receive such permits unless the strategies are consistent with the approved regional water plan.

Additionally, locally developed plans based on more detailed local information and public input appear in the regional water plan to a degree unprecedented in previous statewide water plans prepared by TWDB, TNRCC and TPWD.

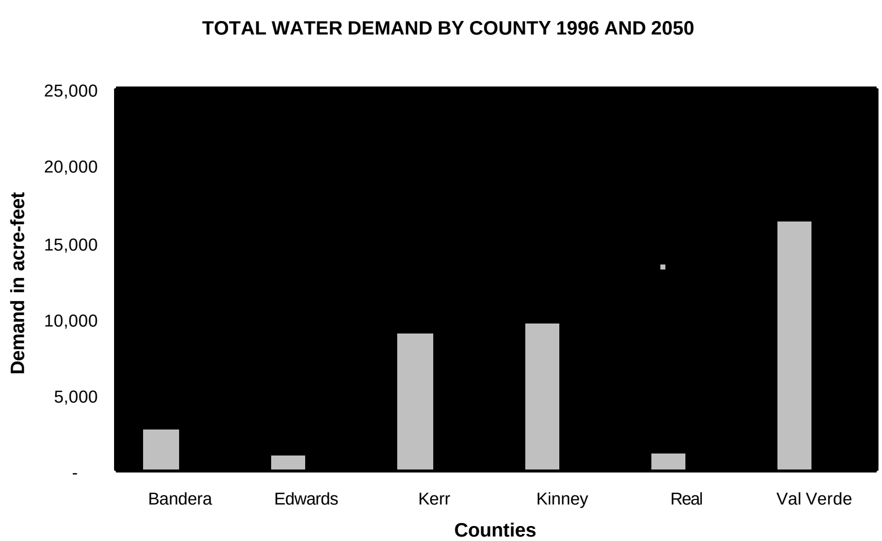
The Plateau RWPG adopted bylaws and submitted a scope of work and associated budget to the TWDB. With SB1 funds administered through TWDB, the RWPG then hired consultants to perform the work of preparing the regional plan. Work required to complete the plan followed well-defined guidelines intended to meet the mandated language of SB1 and to establish a degree of format uniformity between all 16 regional plans. The Plateau RWPG operates its administrative function through the Upper Guadalupe River Authority (UGRA); all billing of expenses goes to TWDB through UGRA. All meetings of the Plateau RWPG are open to the public and meet Open Meetings Act requirements.

Located along the southern boundary of the Edwards Plateau Province, the Plateau Water Planning Region (originally designated as Region J) stretches from the Central Texas Hill Country westward to the Rio Grande and consists of the six counties of Bandera, Edwards, Kerr, Kinney, Real, and Val Verde. The region covers 9,252 square miles and contains a population of approximately 120,500, half of which reside in the cities of Del Rio and Kerrville. The mostly rural nature of this region is reflected in its population density of 13 people per square mile, which is much less than the state average of 72 people per square mile. The City of Del Rio, the Upper Guadalupe River Authority, and the Aqua Source Corporation are designated as major water providers in the region which provide 100 acre-feet or more per year of raw or treated water to other entities in excess of their own use.

Total population of the six counties is expected to increase by 98 percent from the 1996 census count of 107,228 to 212,135 by 2050. The largest increases, with respect to total population and percent gain, are expected to occur in Bandera and Kerr Counties with 218- and 111-percent growth, respectively. Percent growth rates in the other counties are, in descending order, Val Verde, 54 percent; Kinney, 46 percent; Real, 23 percent; and Edwards, 21 percent.

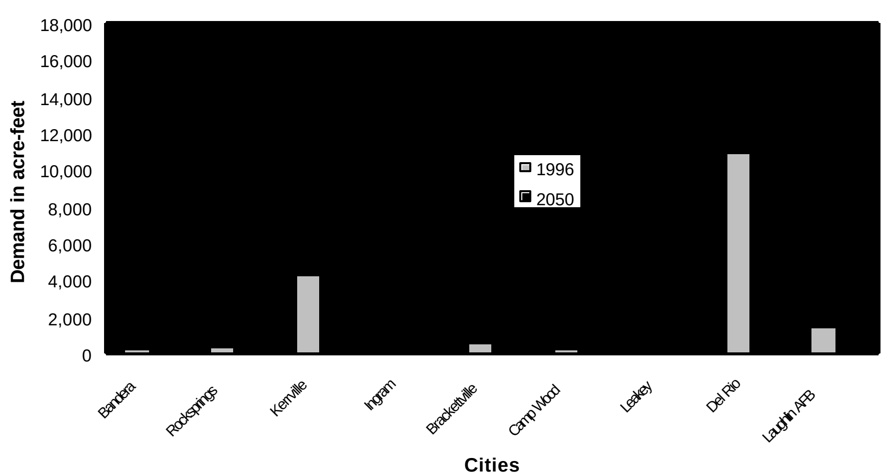


The forecasted demand for total water needed in the Plateau Region will increase by 38 percent or 15,255 acre-feet of water from the historic usage in 1996 to the year 2050. The fastest growing and largest percentage increase will be in Bandera and Kerr Counties with increases of 163- and 75-percent, respectively. The largest total water demand increase by county in descending order will be in Kerr, 6,709 acre-feet; Val Verde, 4,802 acre-feet; and Bandera, 4,416 acre-feet.

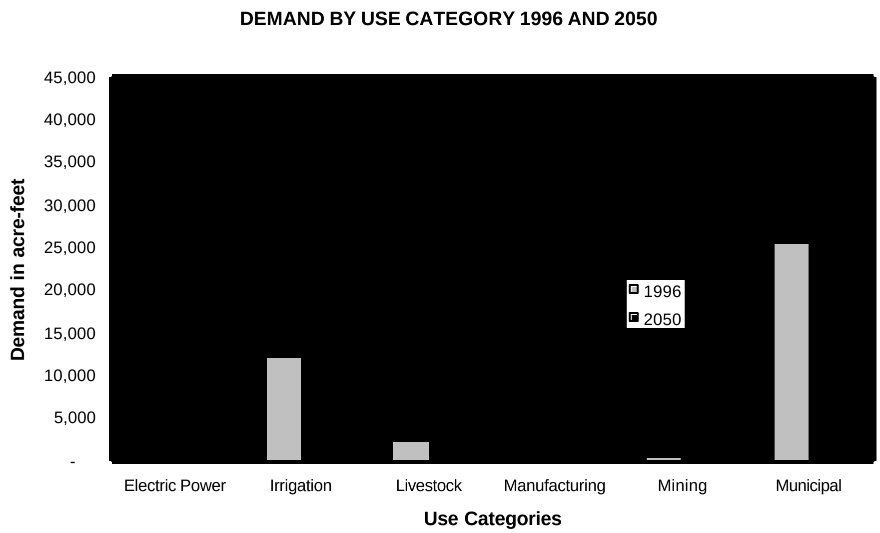


In the Plateau Region, municipal demand is the largest and fastest growing water use category. The demand for water from municipalities is projected to grow to 42,643 acre-feet by the year 2050, which is an increase of 17,246 acre-feet and represents a 68-percent increase over the demand of 25,397 acre-feet in the year 1996. The largest increases are expected to occur in Kerr and Val Verde Counties, where demands are projected to reach 14,335 acre-feet and 18,893 acre-feet, respectively, by the year 2050. The combined municipal demand for Kerr and Val Verde Counties is projected to be 33,228 acre-feet in the year 2050, which is 78 percent of the estimated 42,643 acre-feet of total municipal consumption. The largest percentage increase is expected to occur in Bandera County with a 229-percent change from a demand of 1,922 acre-feet in the year 1996 to 6,515 acre-feet in the year 2050.

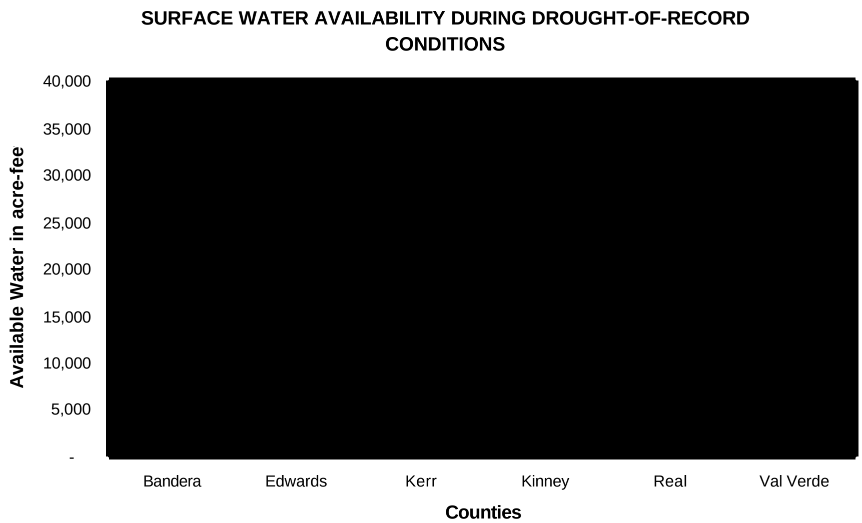
TOTAL WATER DEMAND BY CITY 1996 AND 2050



Irrigation accounts for the largest projected nonmunicipal water demand. Water needed for irrigation is projected to decrease from a high of 12,047 acre-feet in 1996 to 9,290 acre-feet by 2050. This represents a 23-percent reduction (2,757 acre-feet) in demand as reported for the year 1996. Livestock use is expected to increase by 31-percent from 2,279 acre-feet to 2,986 acre-feet by the year 2050. Manufacturing demand is projected to grow from 23 acre-feet in the year 1996 to 66 acre-feet by the year 2050, which is 187-percent growth over that period. Mining is projected to increase by 7 percent from the 1996 total of 301 acre-feet to 323 acre-feet by the year 2050. No demand exists for electric power generation in the region, and none is anticipated in the next 50 years.

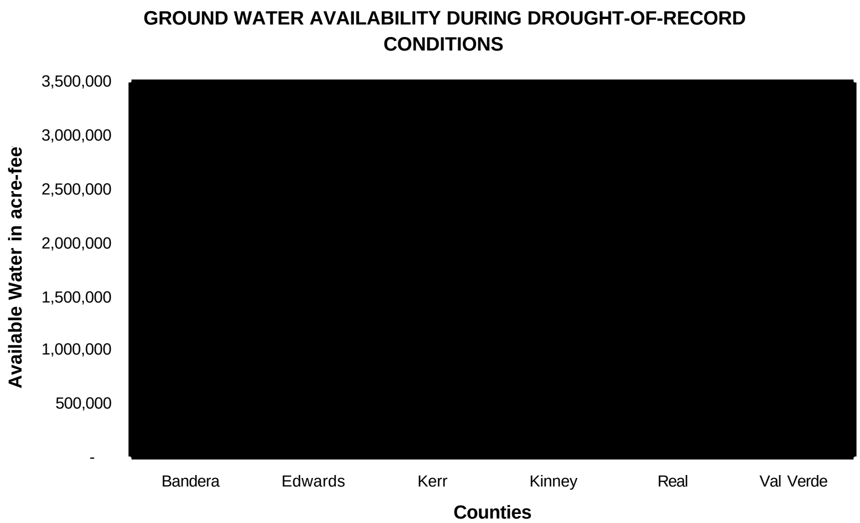


Water resources available to meet the supply needs in the six counties of the Plateau Region during drought-of-record conditions include both surface-water and ground-water sources. Most water used in the region is derived from local and regional ground-water sources. Although rather limited during severe drought conditions, surface-water supplies are important to the region. The Cities of Kerrville and Del Rio currently use surface water from the Guadalupe River and from San Felipe Springs, respectively. Camp Wood in Real County is supplied from springs on a tributary to the Nueces River. Within the Plateau Region, Amistad Reservoir and Medina Lake have been designated as Special Water Resources by the TWDB. Canyon Lake in Comal County, also designated as a Special Water Resource, is outside of the Plateau Region but affects Plateau Region planning considerations.



Ground water is a major source of water for most of the Plateau Region and is stored in and retrieved from aquifers. Aquifers are replenished by recharge that includes precipitation, infiltration of water from perennial or ephemeral streams, inflow of ground water from areas adjacent to an aquifer, and irrigation return flow. Throughout most of the Plateau region, water levels in the aquifers fluctuate with seasonal precipitation. As a result, water levels are highly susceptible to declines during drought conditions.

The principal aquifers in the Plateau Region are the Trinity, the Edwards-Trinity (Plateau), and the Edwards (Balcones Fault Zone). Two undesignated water-bearing aquifers, Frio River Alluvial and Austin Chalk, provide some water to the region in small areas. For purposes of comparing supply to demand, the availability of ground water is defined as the total amount of water retrievable from the designated extent of the aquifer during a 1-year drought period.



As stated previously, the purpose of this plan is to identify municipalities and water-use categories that may, in times of severe drought, be unable to meet expected water-supply needs based on today's ability to capture, treat, and distribute the supply. Recommended alternatives, or strategies, to meet anticipated drought-induced shortages are presented for consideration. It should be acknowledged that the Plateau RWPG has no authority to mandate that any recommended strategies be implemented, and that it is the individual entity's initiative to act on needed changes. The table below lists the cities and water-use categories by county that were determined to have potential future shortages during drought-of-record conditions based on no new infrastructure development. All cities and water-use categories are expected to have sufficient water supplies to meet drought-of-record conditions if one or a combination of recommended strategies is implemented.

WATER SUPPLY SHORTAGES DURING

DROUGHT-OF-RECORD CONDITIONS (Acre-Feet)

WATER USER GROUP	S2000	S2010	S2020	S2030	S2040	S2050
BANDERA COUNTY						
County Other	-1253	-2924	-2815	-3250	-3767	-4336
Mining	-10	-10	-11	-12	-12	-12
EDWARDS COUNTY						
Irrigation	-139	-129	-119	-110	-101	-92
Livestock	-28	-28	-28	-28	-28	-28
KERR COUNTY						
Kerrville	-1547	-2244	-2969	-3840	-4599	-5450
Irrigation	-368	-342	-316	-292	-268	-245
Livestock	-87	-87	-87	-87	-87	-87
Mining	-12					
KINNEY COUNTY						
County Other	-80	-59	-38	-66	-126	-192
Livestock	-163	-163	-163	-163	-163	-163
REAL COUNTY						
Leakey				-15	-37	-63
Mining	-12					
VAL VERDE COUNTY						
Livestock	-64	-64	-64	-64	-64	-64
Mining	-15	-22	-39	-56	-73	-92

Potential municipality drought water shortages are only anticipated for the City of Kerrville and the Town of Leakey. Under drought-of-record conditions, available supplies from the Guadalupe River are nonexistent for Kerrville. The city is considering the following strategies to meet potential shortages:

- Options to obtain additional water rights or modify existing water rights to supplies in Canyon Reservoir.
- Purchase of raw water from UGRA or GBRA.
- Construction of an off-channel reservoir.
- Development of additional ground-water supplies from a new remote well field.

- Increase of water treatment capacity, possibly in cooperation with UGRA.
- In conjunction with the expansion of the existing water treatment plant, expand the current 1-MGD ASR system by adding two additional ASR wells.

The Town of Leakey's water-supply deficit is anticipated to begin in the 2020-2030 decade as a result of increased population. Although the town could consider the purchase of Frio River water rights, its most likely option will be to drill additional wells.

"County Other" water supply shortages appear in Bandera, Kerr, Kinney, and Real counties. The "County Other" category includes water use for rural domestic homes and small communities of less than 500 population. Although the supply/demand analysis indicates a water-supply shortage for this category, in reality the supply will be met in most cases by the drilling of additional private wells. In more densely populated rural areas, considerations may be needed for alternative services where appropriate.

Irrigation shortages in Edwards and Kerr Counties are the result of the lack of available water in specific rivers to meet permitted irrigation water rights. Suggested short-term solutions include the drilling of wells, expanded use of existing wells, and the use of conservation technology and equipment. However, in most cases, irrigators are anticipated to cease irrigation operation for the duration of the water-supply shortage.

Likewise, drought-induced shortages for livestock watering occur as rivers cease to flow and more demand is placed on ground-water supplies. Ranchers may chose to invest in additional wells or expanded use of existing wells during these dry periods. A more critical problem for ranchers during drought periods concerns the ability to maintain adequate forage even when adequate ground-water supplies are available. Ranching operations often resort to herd reductions during these pressing times.

Water used in mining operations in the region is mostly related to the excavation of sand and gravel. Perceived water shortages in the mining industry in Bandera, Kerr, Real and Val Verde Counties is minimal and will likely be met with the drilling of additional wells.

Water-supply sources to meet the future needs of all water-use categories in the Plateau Region are recognized to be limited in comparison to resources available in many other parts of the State. A conscientious effort to maintain an awareness of existing conditions and anticipate future water needs is critical. Besides the individual recommendations listed above, there are a number of regional management strategies that can benefit water supplies needed for both the general public and the environment.

- Brush management practices that reduce the amount of water consumed by phreatophytes, especially juniper (cedar) and mesquite. Effective brush management increases the potential for water to enter streams and to recharge aquifers.
- Water demand management in high population density areas may include requirements for well spacing, lot size restrictions, pumping restrictions, and pricing structures.
- Water conservation management includes the smart use of water at both the community and individual level. Water conservation tips are available for both inside and outside the home.
- Utility system efficiency includes system-wide audits to detect and repair leaks, replace lines and tanks when necessary, and maintain accurate meters.
- Educational programs designed to provide information to help individuals as well as system administrators save water are essential components of effective conservation.
- Rainwater harvesting is an old concept with a renewed emphasis. The procedure involves capturing rainfall from roofs or in small impoundments, thus providing water that is generally lost to the homeowner.
- Aquifer recharge enhancement can occur through the placement of impoundment structures in appropriate locations.
- Land management should be a major component of all regional water-conservation plans. This approach to water conservation requires careful assessment of all land within a region to recommend management practices that will minimize the impact of development on the availability and quality of water resources.

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CHAPTER 1

DESCRIPTION OF THE REGION

1.1 INTRODUCTION

Located along the southern boundary of the Edwards Plateau Province, the six-county Plateau Water Planning Region stretches from the eastern Texas Hill Country westward to the Rio Grande. The region was populated by Apache and Comanche Indians in its early history. Under land grants issued by the Republic of Texas in the 1840's, German immigrants colonized the area. These first immigrants and those to follow settled small towns along many of the spring-fed streams that crossed the area and from these way stations spread out to establish farms and ranches throughout the region. Even today, the area retains some of its original cowboy frontier and German atmosphere. Chapter 1 that follows is a broad introduction to this region and the water-supply challenges it faces.

1.1.1 Definitions

The following definitions are included in Chapter 1 to provide the reader with a reference source for selected technical terms found in this report. In this report, the term "ground water" is used as a noun to refer to all subsurface water. The hyphenated form "ground-water" is used as an adjective.

Acre-ft – A quantity of water equal to 325,851 gallons – or the volume of water required to cover one acre of land to a depth of one ft.

Alluvial - Pertaining to or composed of sediment deposited by running water, such as a stream.

Aquifer - One or more formations that contain sufficient saturated permeable material to conduct ground water and to yield economically significant quantities of water to wells and springs. Refer to definitions of "formation," "hydrostratigraphy" and "stratigraphy."

Arid - A term used to describe a climate characterized by dryness, variously defined as rainfall insufficient for plant life or for crops without irrigation; less than 10 inches of annual rainfall; or a higher evaporation rate than a precipitation rate. Compare with "semiarid."

Demand - The total volume of water required to meet the needs of a water-use category. This quantity may exceed actual usage.

Drought - A period of abnormally dry weather of sufficient length to cause serious hydrologic imbalance as indicated by crop damage, water-supply shortage, etc.

Drought-of-Record - A drought period with the greatest hydrologic/agricultural/public water-supply impact recorded in a region.

Escarpment – A long, more or less continuous cliff or relatively steep slope facing in one direction, separating two level or gently sloping surfaces, and produced by faulting or erosion.

Evaporation - The process by which water passes from the liquid state to the vapor state.

Evapotranspiration - The loss of water from a land area through transpiration by plants and evaporation from the soil.

Formation - The basic stratigraphic unit in the classification of rocks, consisting of a body of rock generally characterized by some degree of compositional homogeneity, by a prevailingly but not necessarily tabular shape over its areal extent, and by mapability at Earth's surface or traceability in the subsurface; a convenient unit, of considerable thickness and extent, used in mapping, describing, or interpreting the geology of a region, and the only formal unit that is used for completely dividing the geologic column in a region.

Holophytic - An adjective describing vegetation that derives its nourishment entirely from its own organs.

Hydraulic interconnection - The degree to which ground water is able to move between different water-bearing rocks or between basins.

Hydrogeology - The branch of the science of geology that deals with subsurface waters and related geologic aspects of surface waters.

Hydrograph – A graph showing water-level changes over time in a monitoring well, a stream, or a reservoir.

Hydrostratigraphy - The identification of formations that have considerable lateral extent and that also form a geologic framework for a reasonably distinct hydrogeologic system.

Intermittent Stream - A stream or reach of a stream that flows briefly only in direct response to precipitation in the immediate locality and whose channel is at all times above the water table.

Compare with "perennial stream."

Irrigation Demand - The quantity of water needed on a field to economically grow crops.

Perennial stream - A stream or reach of a stream that flows continuously throughout the year and whose upper surface generally stands lower than the water table in the region adjoining the stream.

Reuse - The process of recapturing water following its initial use and making it available for additional uses. The process generally requires a level of treatment appropriate for its next intended use.

Riparian - Pertaining to being situated on the bank of a body of water, especially of a watercourse such as a river; situated on or abutting a stream bank.

Semiarid - A climate in which there is slightly more precipitation (10 to 20 inches) than in an arid climate (less than 10 inches), and in which grasses are the characteristic vegetation.

Storage - The volume of water contained within the pore space of an aquifer. Recoverable storage is the percentage of water in storage that can be economically produced.

Stratigraphy - The branch of geology that deals with the definition and description of major and minor formations available for study in outcrop or from the subsurface, and with the interpretation of their significance in geologic history; the geologic study of the form, arrangement, geographic distribution, chronological succession, classification, correlation, and relationships of rock strata.

Topography - (1) the general configuration of a land surface or any part of Earth's surface, including its relief and the position of its natural and man-made features. (2) the natural or physical surface features of a region; the features revealed by the contour lines of a map.

Transpiration - The process by which water absorbed by plants, usually through the roots, is evaporated into the atmosphere.

Tributary - A stream feeding, joining, or flowing into a large stream or a lake.

Water budget - (1) an accounting of the inflow to, outflow from, and storage in a hydrologic unit such as a drainage basin, aquifer, soil zone, lake, or reservoir; (2) the relationship between evaporation, precipitation, runoff, and the change in water storage.

Water-supply availability - The volume of water capable of being withdrawn or diverted from specific sources of supply.

Xerophytic - An adjective describing vegetation adapted to dry conditions.

1.1.2 Counties of the Plateau Region

The six counties that compose the Plateau Region are Bandera, Edwards, Kerr, Kinney, Real and Val Verde (Figure 1-1). With a total area of 9,252 square miles (mi^2), the Plateau Region represents 3.5 percent of the total area of the state of Texas. Counties that make up the Plateau Region are listed with their total area and percentage of the total regional area in the following table.

County	Area (mi^2)	Percentage of Regional Area
Bandera	791.8	8.56
Edwards	2,119.9	22.91
Kerr	1,106.3	11.96
Kinney	1,363.5	14.74
Real	700.0	7.57
Val Verde	3,170.7	34.27

1.1.3 Population and Regional Economy

The total projected year 2000 population in the Plateau Region is 120,510 (Figure 1-2). This population estimate was developed for the 1997 Consensus State Water Plan and includes adopted revisions to county population estimates for Bandera, Kerr, Kinney, and Real. The population density for the region is 13 people per square mile, which is much less than the state average of 72 people per square mile. The following table summarizes population data for the six counties, which is also shown on Figure 1-2.

County	Year 2000 Population	Percentage of Regional Population	People per Square Mile
Bandera	19,212	16.0	24.3
Edwards	2,544	2.1	1.2
Kerr	43,822	36.4	39.6
Kinney	4,615	3.8	3.4
Real	3,041	2.5	4.3
Val Verde	47,276	39.2	14.9

Fifty percent of the total population of the area is located in the two largest cities in the area, Del Rio and Kerrville. In the year 2000, Del Rio, including the population of Laughlin Air Force Base, will have 38,946 residents and Kerrville will have 21,191 residents. The major cities of the region by county with their year 2000 populations in parentheses are: Bandera (1,679) in Bandera County; Rocksprings (1,445) in Edwards County; Kerrville (21,191) in Kerr County; Brackettville and Fort Clark Springs (4,615) in Kinney County; Camp Wood (668) and Leakey (422) in Real County; and Del Rio (36,390) and Laughlin Air Force Base (2,556) in Val Verde County.

The regional economy is based primarily on tourism, hunting, ranching agribusiness and government. The beauty of the Hill Country, the solitude of the forested canyons and plateau grasslands, and the gateway to Mexico all support a major tourist trade. Agribusiness is predominantly associated with raising of sheep, goats and beef cattle throughout the region. Apple orchards in Bandera County, oil and gas production and mohair production in Edwards and Real counties, medical services and manufacturing in Kerr County, irrigated cotton, hay and wheat in Kinney County and a military base and trade with Mexico in Val Verde County all contribute largely to the region=s overall economy.

Per capita income in the six counties, based on 1996 figures compiled by the Bureau of Economic Analysis, is below the state average of $20,654 per year. The counties are ranked in descending order by annual per capita income as follows: (1) Kerr, $23,584; (2) Bandera, $19,813; (3) Real, $15,222, (4) Val Verde, $12,356; (5) Kinney, $10,406; and (6) Edwards, $10,191.

1.2 PHYSIOGRAPHY, CLIMATE AND LAND USE

The Plateau Region lies primarily in the Edwards Plateau and Hill Country geographic subregions. The Balcones escarpment generally forms the southern boundary of the Plateau Region. The escarpment is a steep topographic feature that traces the path of a major fault that formed more than 10 million years ago. The escarpment separates the more resistant rocks of the Edwards Plateau to the north from softer and more easily erodible rocks to the south. Erosion by streams has caused the face of the escarpment to migrate toward the north-northwest, and steep canyons have been cut back into the thick limestone beds of the Edwards Plateau.

The region is characterized by its rolling prairies and the large number of spring-fed perennially flowing streams. The uplands are fairly level, but the landscape of the stream valleys is very hilly with steep canyons that provide rapid drainage. Upland soils are dark alkaline clays and clay loams; the river valley soils are gravelly and light colored. Some cultivation takes place in the deep, dark-gray or brown loams and clays of the river bottoms and to a greater extent over the broad flat farming belt of southern Kinney County. The major soil-management concerns are brush control, low fertility and excess lime.

1.2.1 Climate and Precipitation

Climatologists have identified 10 climatic divisions within the state of Texas (Figure 1-3) (Griffiths, 1995). The outlines are generally consistent with the different physiographic or subphysiographic areas of the state. The Plateau Region lies entirely within the Edwards Plateau Division of Figure 1-3.

Precipitation decreases westward across Texas. The average for the Edwards Plateau is 25 inches. The variability with respect to the six counties of the Plateau Region is illustrated by Figure 1-4. Precipitation decreases from approximately 32 inches in the easternmost reaches of Bandera and Real counties to less than 20 inches in western Val Verde County. Measurements of net lake evaporation for the Plateau Region (Figure 1-5) show evaporation increasing from 38 inches in Real and Bandera counties to about 60 inches in western Val Verde County. Net lake evaporation is the difference between total evaporation from a lake and total precipitation. Average monthly rainfall for selected stations is illustrated by Figure 1-6.

Evapotranspiration (ET), defined as the amount of water lost as a result of transpiration by plants and evaporation from the soil, is 24 inches. This is slightly less than the amount of average precipitation for the Region but is also within the midrange of ET values for the different climatic regions of the state. The intermediate value of ET for the Plateau Region is attributable to the combination of potential evaporation of approximately 40 inches and the lower supply of moisture. Potential evapotranspiration is the amount of evapotranspiration that would occur if there was an adequate supply of water available to a fully vegetated surface. The moisture deficit is the amount of water required but not received by plants (Muller and Oberlander, 1984; Muller and Faiers, 1995). The moisture deficit for the Plateau Region is estimated to be 16 inches. This is within the intermediate range of deficits in all climatic regions of the state. It is a function of stresses caused by the difference in potential evapotranspiration and precipitation. The high ET values are driven largely by temperatures that range from a mean low in January of 29° F to 39° F to a mean high in July of 92° F to 96° F.

The divisional precipitation surplus is the component of the water budget available for runoff after accounting for losses by evaporation, transpiration, and recharge. The surplus for the Edwards

Plateau is estimated to be 1.4 inches. The low divisional surplus for this region is attributable to the intermediate rainfall totals and to the occurrence of rainstorms during the hot, dry months of the summer, when most precipitation is exhausted by the heavy demand for potential evapotranspiration.

The ratio of precipitation to potential evapotranspiration provides a comparison of measurable precipitation and the environmental demand for water. In the Plateau Region, precipitation is sufficient to meet approximately 63 percent of the demand for potential evapotranspiration. The ratio of the moisture deficit to potential evapotranspiration represents the demand for water that is not met by precipitation. This amounts to approximately 41 percent of PE in the Plateau Region. Finally, the amount of precipitation that is potentially convertible to runoff is represented by the ratio of the regional surplus to precipitation (S/P). This is approximately 6 percent of regional precipitation in the Plateau Region.

The climate of the Plateau Region is intermediate to the more humid climates of regions to the northeast and east and drier climates of regions to the northwest and west. The combination of high temperatures, high potential evapotranspiration and intermediate rainfall totals combine to produce a semi-arid climate with drought conditions during all or parts of some years (Bomar, 1995).

1.2.2 Rainfall and Recharge of Aquifers

Long periods of below-normal rainfall may have severe impacts on ground-water recharge, spring flow, and stream flow. The effects of low rainfall over long periods of time are most readily reflected in the form of decreased spring flow and stream flow. Under these conditions, the lack of rainfall leads to reduced recharge of aquifers and to lower water levels in wells and sinkholes throughout the region. As water levels fall in aquifers in drought-stricken areas of the Plateau Region, the volume of water discharging from San Felipe Springs, for example, may decrease to levels that are insufficient to supply the City of Del Rio with enough drinking water to meet all municipal, industrial and manufacturing demands for water. Landowners who are dependent on spring-fed stream flow may also find insufficient volumes of surface water needed to support irrigation or other farming and ranching activities. The direct linkage between precipitation and water levels in aquifers of the Plateau Region is indicated by hydrograph records of wells that show rapid increases in water levels as a response to local rainstorms.

1.2.3 Drought

"Drought" is defined as a condition in which the amount of water transpired and evaporated exceeds the amount available in the soil (Thornthwaite, 1947). As such, drought is associated with a sustained period of significantly lower soil moisture and water supply, relative to "normal" levels established within a region (Rasmussen et al, 1993). The following operational definitions of drought (Rasmussen et al, 1993; and Bomar, 1995) are proposed for the Plateau Region:

- Meteorologic drought;
- Agricultural drought; and
- Hydrologic drought.

Meteorologic drought is a shortfall of precipitation, usually over a period of months or years, compared with the expected supply.

Agricultural drought is defined as that condition when rainfall and soil moisture are insufficient to support the healthy growth of crops and to prevent extreme crop stress. It may also be defined as a deficiency in the amount of precipitation required for the support of livestock and other farming or ranching operations.

Hydrologic drought is a long-term condition of abnormally dry weather that ultimately leads to the depletion of surface-water and ground-water supplies; the drying up of lakes and reservoirs; and the reduction or cessation of spring flow or stream flow. The tables developed in this report are based on the concept of hydrologic drought.

Although agricultural drought and hydrologic drought are consequences of meteorological drought, the occurrence of meteorological drought does not guarantee that either one or both of the others will develop. It is important, therefore, to develop a set of criteria that will enable the residents of Plateau Region to recognize the onset of drought.

These criteria may include (adapted from Rasmussen et al, 1993):

- Lower precipitation in key watersheds,
- Extended periods of high temperature,
- Higher levels of evapotranspiration,
- Reduced runoff,
- Stressed plants and grasses,
- Reduced stream flow and spring flow,
- Lower reservoir and ground-water levels, and
- Increased regional water demand.

Trigger criteria to assist the communities of the Plateau Region in determining when to implement drought contingency plans are presented in Chapter 5.

1.2.4 Native Vegetation and Ecology

A biotic province is a considerable and continuous geographic area that is characterized by the occurrence of one or more ecologic associations that differ, at least in proportional area covered, from the associations of adjacent provinces. In general, biotic provinces are characterized by peculiarities of vegetation type, ecological climax, flora, fauna, climate, physiography and soil. Most of the Plateau Region has been classified as belonging to the "Balconian" Biotic Province, but small portions of Val Verde and Kinney counties also lie within the "Tamaulipan" and "Chihuahuan" Biotic Provinces (Figure 1-7).

In the 1800's the area was predominantly savannas of tall native grasses with occasional stands of Live Oak and Spanish Oak. Largely because of the suppression of prairie fires in the last century, most of the area has become blanketed by Ashe Juniper (commonly referred to as "cedar"), which once was found only on steep canyon lands. Another infestation of tree species found in the area is that of Mesquite. Infestation of trees can reduce the quantity and quality of water from watersheds. Dense stands reduce the diversity of plant species beneath the trees' canopies.

Cypress trees line the banks of many of the rivers. Other species of trees that are generally found are Post Oak, Elm, Hackberry, Cottonwood, Sycamore and Willow. Native grass species include Little and Big Bluestem, Indian Grass, Sideoat Grama and Texas Winter Grass. Some of the introduced species of grass include Coastal Bermuda, Plains Lovegrass, Klein Grass and King Ranch Bluestem. In the western portion of the region, a varying growth of prickly pear, other cactus species, sage and other brushy species predominate.

1.2.5 Land Use

Land use in the six-county region is divided into seven categories (Figure 1-8):

- Urban (or developed)
- Agricultural (cultivated)
- Range
- Forest
- Water
- Wetlands
- Barren

Urban lands are the locations of cities and towns. Urban lands make up less than 1 percent of the region's total land area. Agricultural lands are identified as areas that support the cultivation of crops. These lands potentially involve extensive irrigation. Areas designated as agricultural lands comprise less than 1 percent of the total land area of the region. Agricultural lands require access to high volumes of ground water or surface water. Together, urban and agricultural lands comprise the two most significant areas of water consumption in the Plateau Region.

Range land is defined as all areas that are either associated with or are suitable for livestock production. Although this is the largest category of land use in the region, range land accounts for one of the smallest sources of water demand in the Plateau Region. Forest land is limited to areas where topography and climate support the growth of native trees. Forest lands rely exclusively on rainfall as a source of moisture. Areas designated as either water or wetlands are associated with the rivers and their tributaries. Barren lands are defined as undeveloped areas with little potential for use as agricultural land, range land or forest land.

1.2.6 Agricultural and Natural Resources

The agricultural resources throughout the region include beef cattle, sheep, and goat production, including the distinctive mohair goats and Angora goats. Apple and pecan orchards, along with hay, are grown in the eastern part of the region. Kinney County, with its extensive irrigated lands in the southern half of the county, account for twice the amount of water used for irrigation as the rest of the region combined.

The natural resources of the region boast some of the best hunting and fishing in Texas, scenic drives, beautiful vistas, and hill country hiking. Understandably, both local people and tourists make use of these resources in their enjoyment of numerous dude ranches, resorts, recreational vehicle parks and camping facilities. The following protected sites located within the Plateau region depend upon adequate water to supply both environmental and recreational needs:

- Lost Maples State Natural area
- Hill Country State Natural Area
- Devil's River State Natural Area
- Seminole Canyon State Historic Park
- Dolan Falls Ranch Preserve (Nature Conservancy)
- Devil's Sinkhole State Natural Area
- Kickapoo Cavern State Park
- Kerrville-Schreiner State Park
- Heart of the Hills Research Station
- Amistad Natural Recreational Area

Both agricultural and natural resources water-supply needs are directly influenced by the quantity and quality of water available primarily in rivers and tributaries that flow through the region and to a lesser extent in impounded lakes, ponds and tanks. With the exception of the Rio Grande, much of the drainage basins for the headwater of local rivers lie within Plateau Region counties. Springflow emanating from shallow ground-water sources creates the base flow of these streams. As such, these headwater regions are particularly susceptible to drought conditions as the water table naturally drops and springflow diminishes.

Agricultural activities in the region that rely on surface water are designed to accommodate the intermittent nature of the supply. In most cases, this means that agricultural water-supply needs will be switched to ground-water sources, or that irrigation activities will cease until river supplies are replenished. Both plant and animal species endemic to this region have developed a tolerance for the intermittent nature of surface water availability in the region; however, significantly long drought conditions can have a sever effect on these species. Riparian water needs for birding habitat is particularly critical. Of recognized importance to the water planning process is the concern of the effect that future development of water supplies might have on the permanent reduction and diversity of species in the region. Water-supply deficit strategies developed in Chapter 5 of this plan include an evaluation of each strategy's effect on agricultural and environmental concerns.

Water-quality problems sometimes pose potential threats to natural resources and the ecological environments therein. Fecal coliform bacteria, in addition to posing a potential public health threat, tend to upset the microbiological balance of a water system. Generally the presence of fecal coliform bacteria also indicates the presence of other pathogens. Watercourses where high levels of nutrients have been identified have the potential to experience algal blooms, which may consume too much of the available dissolved oxygen in the water leaving less oxygen for fish. High levels of dissolved minerals such as sodium in water used to irrigate crops can harm or kill the crops.

In terms of a primarily agricultural activity, pesticide and fertilizer application poses a potential threat to underlying ground-water supplies. The propensity for pesticides and fertilizers to leach past the root zone depends on which chemicals are chosen and on the soil's leaching potential. The U.S. Natural Resource Conservation Service has developed a Soil-Pesticide Interaction Screening Procedure which evaluates the potential for pesticide loss from a field (and thus into ground water). According to the methodology utilized in the procedure, very little of the region has soils in the "High Soil Leaching Class." Although somewhat lacking in quantity, the quality of water supplies, both ground and surface, are generally acceptable for most agricultural needs within the region.

Water resources developed for municipal consumption are expected to meet "primary" and "secondary" safe drinking-water standards mandated by the U.S. Environmental Protection Agency and the Texas Natural Resource Conservation Commission. “Primary standards” are concerned with dissolved constituents (e.g., heavy metals and organic contaminants) that are known to have adverse effects on human health. “Secondary standards” are concerned with factors that affect the aesthetic quality (e.g., taste and odor) of drinking water. These include dissolved constituents such as chloride, sulfate and iron, along with a variety of suspended components that may require filtration. Within the region, water quality varies widely. In many areas of the rural counties, ground water is of sufficient quality that only chlorination is required as a means of treatment. Surface water requires both chlorination and filtration.

1.3 WATER SUPPLY SOURCES

The two major sources of water are ground water from aquifers and surface water from streams and reservoirs. The availability of water supply from these sources is discussed in greater detail in Chapter 3.

1.3.1 Ground Water

The Texas Water Development Board (TWDB) has identified and characterized nine major and 20 minor aquifers in the state, based on the quantity of water supplied by each (Ashworth and Hopkins, 1995). A major aquifer is generally defined as an aquifer that supplies large quantities of water over large areas of the state. A minor aquifer typically supplies large quantities of water in small areas or relatively small quantities of water over large areas. Within the Plateau Region, the TWDB has identified three major aquifers [(the Trinity, the Edwards-Trinity (Plateau) and the Edwards (Balcones Fault Zone)] and two minor aquifers (the Ellenburger-San Saba and the Hickory) (Figure 1-9). The minor aquifers are only located in Kerr County. For this plan, the Austin Chalk aquifer in Kinney County and the Frio River Alluvium in Real County have also been identified as a ground-water source. Underground water conservation districts in Bandera and Kerr counties provide for local management control of their ground-water resources.

1.3.1.1 Trinity Aquifer

The Trinity aquifer occurs in its entirety in a band from the Red River in North Texas to the Hill Country of south central Texas and provides water in all or parts of 55 counties. Trinity Group formations also occur as far west as the Panhandle and Trans-Pecos regions where they are included as part of the Edwards-Trinity (High Plains) and Edwards-Trinity (Plateau) aquifers. The Trinity aquifer is composed of sand, clay and limestone deposited during the Cretaceous Period. The Trinity Group in this region includes the Glen Rose and underlying Travis Peak Formations. The Glen Rose consists of up to approximately 1,000 feet of limestone with interbedded shale, marl and occasional anhydrite (gypsum). The Travis Peak contains sands, clays and limestones and is subdivided into water-bearing members of the Hensell, Cow Creek, Sligo and Hosston.

1.3.1.2 Edwards-Trinity (Plateau) Aquifer

Rock formations of the Edwards-Trinity (Plateau) aquifer form the Edwards Plateau east of the Pecos River and in its entirety provides water to all or parts of 38 counties. The aquifer extends from the Hill Country of Central Texas to the Trans-Pecos region of West Texas. The aquifer consists of saturated sediments of lower Cretaceous age Trinity Group formations and overlying limestones and dolomites of the Edwards Group. The Glen Rose Limestone is the primary unit in the Trinity in the southern part of the plateau. Springs issuing from the aquifer form the headwaters of several eastward and southerly flowing rivers. Some of the largest springs of the area are located in Val Verde County, such as San Felipe Springs near Del Rio.

1.3.1.3 Edwards (BFZ) Aquifer

The Edwards (Balcones Fault Zone, or BFZ) aquifer in its entirety covers approximately 4,350 mi^2 in parts of 11 counties. It forms a narrow belt extending from a ground-water divide in Kinney County through the San Antonio area northeastward to the Leon River in Bell County. In the Plateau Region, the westernmost end of the Edwards (BFZ) aquifer occurs only in Kinney County. The aquifer, composed predominantly of limestone formed during the early Cretaceous Period, exists under water-table conditions in the outcrop and under artesian conditions where it is confined below the overlying Del Rio Clay. In Kinney County, the Edwards aquifer consists of the Devils River Limestone or the Salmon Peak, McKnight and West Nueces Limestones. Recharge to the aquifer occurs primarily by the downward percolation of surface water from streams draining off the Edwards Plateau to the north and west and by direct infiltration of precipitation on the outcrop. A lesser amount of water may move across the fault zone from the Trinity aquifer. Within the Plateau Region, water in the aquifer generally moves from the recharge zone toward natural discharge points such as Los Moras Springs near Brackettville. Water from this aquifer is used extensively in Kinney County for irrigation.

1.3.1.4 Austin Chalk Aquifer

The Austin Chalk aquifer lies beneath the southern half of Kinney County and beneath the southernmost extension of Val Verde County. The formation is composed of chalky limestone that can be fossiliferous in some areas. Water production from the aquifer is mostly associated with highly fractured areas. In Kinney County, it is the second most important source of water after the Edwards Limestone. Most Austin Chalk wells discharge only enough water for domestic or livestock use but a few wells are large enough to support irrigation.

1.3.1.5 Frio River Alluvium Aquifer

The Frio River Alluvium in central Real County extends over an area of approximately 1,120 acres and contains approximately 2,800 acre-ft of recoverable water. The alluvium is mostly composed of gravels and sands eroded from surrounding limestone hills and deposited along the Frio River. Water supplies for the City of Leakey and other rural domestic homes are derived from this small aquifer.

1.3.1.6 Minor Aquifers

Within the region, the State has identified minor aquifers only in Kerr County. These are the downdip extensions of the Ellenburger-San Saba and the Hickory. According to TWDB records none of their inventoried wells penetrate either aquifer. However, these are potential resources that may be tapped.

The Hickory aquifer in its entirety underlies approximately 5,000 mi^2 in parts of 19 counties in Central Texas. The Hickory Sandstone member of the Cambrian Riley Formation is composed of some of the oldest sedimentary rocks found in Texas. Discontinuous outcrops of the Hickory Sandstone overlie and flank the exposed Precambrian rocks that form the central core of the Llano Uplift. The downdip artesian portion of the aquifer encircles the Uplift and extends to maximum depths approaching 4,500 feet. In the southern and eastern extent of the aquifer, the Hickory Sandstone Member consists of only two units that range in total thickness from about 150 to 400 feet. Both faulting and relief have caused significant variations in the occurrence, availability, movement, productivity and quality of ground water within the aquifer. Occasionally, the aquifer produces water with excessive radioactive alpha particle and total radium concentrations in excess of safe drinking-water standards.

The Ellenburger-San Saba aquifer in its entirety underlies about 4,000 mi^2 in parts of 15 counties in Central Texas. The downdip portion contains fresh to slightly saline water to depths of approximately 3,000 feet below land surface. The aquifer occurs in the various limestone and dolomite facies of the San Saba Member of the Wilberns Formation of Late Cambrian age, and in the Honeycut, Gorman, and Tanyard Formations of the Ellenburger Group of Early Ordovician age.

1.3.2 Surface Water

The Plateau Region differs from other Senate Bill 1-mandated regions in that it straddles several different river basins rather than generally following a river basin or a large part of a river basin. Therefore the drainage of surface waters within the Plateau region runs in several different directions. The different river basins in the Plateau Region are shown on Figure 1-10.

1.3.2.1 Rio Grande Basin

The Rio Grande, or Rio Bravo as it is known in Mexico, forms the border between the United States and Mexico. International treaties govern the ownership and distribution of the water in this river. Under The 1906 Treaty, the United States is obligated to deliver 60,000 acre-feet annually from the Rio Grande to Mexico, except in the cases of severe drought or serious accident to the irrigation system in the United States. The 60,000 acre-feet is delivered at the headworks of the Acequia Madre (International Dam) at Ciudad Juarez across from El Paso according to a monthly distribution schedule and at no cost to Mexico. The International Boundary and Water Commission (IBWC) is the designated international cooperative agency that calculates the yearly allocations of international waters to the two nations.

The 1944 Treaty addresses the waters in the international segment of the Rio Grande from Fort Quitman, Texas to the Gulf of Mexico. The treaty allocates water in the river based on percentage of flows in the river from each country's tributaries to the Rio Grande, which is approximately a 50-50 split. The 1944 Treaty also stipulates that one-third of the flow of the Rio Conchos in Mexico is allotted to the United States. The Conchos is by far the largest contributing tributary. The combined flow of the Rio Conchos and five other tributaries (San Diego, San Rodrigo, Escondido, Salado Rivers and Las Vacas Arroyo) shall have an annual average of not less than 350,000 acre feet.

While the International Boundary and Water Commission is responsible for implementing the allocation of water on the U.S. side, the Watermaster office of TNRCC administers the allocation of Texas' share of the international waters. The two reservoirs located in the middle of the lower Rio Grande, the Amistad and Falcon, store the water regulated by the Watermaster. The Watermaster oversees Texas' share of water in the Rio Grande and its Texas tributaries from Amistad Dam to Fort Quitman, excluding drainage basins of the Pecos River and Devils River.

The 3.4 million acre-feet International Amistad Reservoir is located on the Rio Grande in Val Verde County. The Amistad Reservoir, which is designated as a "Special Water Resource" by the TWDB, is an important flood control, irrigation and conservation facility for the area. Although the City of Del Rio owns permits to a limited quantity of water from San Felipe Creek, a tributary of the

Rio Grande, most of the Rio Grande water is permitted for downstream users in the Lower Rio Grande Valley. The constraints on Amistad Reservoir as a source of water supply for the Plateau Region are the existing water rights held by water rights holders and enforced by the Watermaster.

Val Verde and the western part of Kinney and Edwards Counties lie in the Rio Grande Basin. San Felipe and Las Moras Springs issue from the Edwards aquifer and flow into tributaries of the Rio Grande.

1.3.2.2 Nueces River Basin

Eastern Kinney County, southeastern Edwards County and southwestern Bandera County lie in the Nueces River Basin so that water of the West Nueces and other tributaries of the Nueces River drain southeast to the Gulf Coast, emerging near Corpus Christi.

1.3.2.3 Colorado River Basin

The City of Rocksprings in Edwards County straddles the drainage divide between the Nueces River Basin and the Colorado River Basin. The portion of Edwards County north of Rocksprings, small northern portions of Real County and the northwestern part of Kerr County drain to the Llano River watershed in the Colorado River Basin.

1.3.2.4 Guadalupe River Basin

The remainder of Kerr County lies primarily in the Guadalupe River Basin. The City of Kerrville and Upper Guadalupe River Authority provide municipal water supplies from the Guadalupe River. The Guadalupe is not only an important water supply source for Kerrville and other communities in Kerr County, but is also a major tourist attraction for the region. Although Kerrville and the Upper Guadalupe River Authority own water rights, much of the flow of the Guadalupe is permitted for downstream use.

1.3.2.5 San Antonio River Basin

Most of Bandera County is split between the Nueces and San Antonio River Basins. The Medina River flows through Bandera County and drains to the San Antonio River. Medina Lake, another designated "Special Water Resource," straddles the boundary between Bandera, Medina and Bexar Counties. This reservoir has a volume of 254,843 acre-feet and serves as a major irrigation source for land downstream in Medina County. Bandera County has contracted for 5,000 acre-feet and Bexar Metropolitan Water District has contracted for 6,000 acre-feet. The Bexar-Medina-Atascosa Counties Water Control and Improvement District #1 has a permit to sell 20,000 acre-feet of water diverted from Medina Lake.

1.3.3 Springs

Springs and seeps are found in all six of the counties of the Plateau Region. In two surveys of the springs of Texas, Brune (1975 and 1981), divided springs into seven classes, based on discharge:

Magnitude	Discharge (Cubic Feet per Second)	Discharge (Gallons per Minute)
Very Large	More than 100	_
Large	10 to 100	_
Moderately Large	1 to 10	_
Medium	0.1 to 1	45 to 449
Small	_	4.5 to 45
Very Small	_	0.5 to 4.5
Seeps	_	Less than 0.5

Brune describes two springs in Bandera County, 55 springs in Edwards County, 15 springs in Kerr County, 18 springs in Kinney County, three springs in Real County, and 48 springs in Val Verde County. Brune did not list or describe springs on properties to which he could not gain access. Within the Plateau Region, only Goodenough (submerged by Lake Amistad) and San Felipe Springs in Val Verde County and Las Moras Springs of Kinney County are considered to be within the Very Large to Large categories of springs. Most of the other Plateau Region springs catalogued by Brune range from Moderately Large to Medium. The locations of a number of "former springs" are also identified by Brune. In most cases, the former springs have ceased to flow because of lowered water tables or because of diminished recharge associated with drought (Brune, 1975 and 1981).

Springs have played an important role in the development of the Plateau Region. They were important sources of water for Indians, as indicated by the artifacts and petroglyphs found in the vicinity of many of the springs. These springs were also principal sources of water for early settlers and ranchers (Brune, 1981).

Of the large number of springs in the Plateau Region, San Felipe Springs are the only group of springs that are a source of water for municipal supply. The fourth largest springs in Texas, San Felipe Springs discharge to San Felipe Creek northeast of Del Rio. Springs contribute to the esthetic and recreational value of land in the Plateau Region. Las Moras Springs, for example are the source of water for the large swimming pool and recreational areas at Ft. Clark Springs. Springs are also significant sources of water for wild game, and they also form wetlands that attract migratory birds and other fowl that inhabit the region throughout the year.

1.3.4 Ecologically Unique Stream Segments and Springs

Under the guidelines of SB1, each planning region may recommend certain stream segments for designation as ecologically unique as a means of protecting the segments from activities that may threaten their environmental integrity. A list of stream segments recommended by the Texas Parks and Wildlife Department (TPWD) as potential candidates was reviewed for designation. The information reviewed as part of this program included state and federal threatened and endangered species lists, water resources data, topographic maps, aquifer maps and characteristics, and other environmental resource information.

For each segment, TPWD lists qualities of each segment that support the stream's candidacy. Qualities influencing the potential for listing a stream segment are derived from one or more ecological characteristics that may set a stream apart from other stream segments in the region. These qualities may include but are not limited to biological function, hydrological function, location with respect to conservation areas, water quality, the presence of state- or federally-listed threatened or endangered species, and the critical habitat for such species. All of the proposed stream segments have characteristics that warrant environmental protection. However, these qualities currently offer the streams protection by promoting intense regulatory scrutiny for any and all projects that may be proposed for these areas.

In review of the provisions of SB-1, the effects of designating a stream segment on future uses are not clear. The bill does not outline potential restrictions of uses or development along designated waters. Therefore, the activities that will be allowed or disallowed under designation are unclear. The Texas legislature might attempt to clarify these restrictions during the 2000 session; this is one of the recommendations of the Plateau Region Planning Group in Chapter 6.

Because of the regulatory protection of these sites by other agencies and laws and also because the subsequent ramifications of designation are unknown, representatives of the Plateau Region have chosen to refrain from proposing the sites for designation as ecologically unique stream segments until the state legislature clarifies the actions associated with designation.

1.4 SPECIAL WATER RESOURCES

Within the Plateau Region, Amistad Reservoir and Medina Lake have been designated as Special Water Resources by the TWDB. Canyon Lake in Comal County, also designated as a Special Water Resource, is outside of the Plateau Region but affects regional planning considerations. Special Water Resources are covered within Sections 357.5 (g) and 357.5 (h) of the TWDB's Regional Water Planning Areas and Special Water Resources. The purpose of the Special Water Resource designation is to facilitate planning for surface water supplies currently obligated to meet demands outside the regional water planning area which contains the Special Water Resource. TWDB designates Special Water Resources when considering the following scenarios between two regions:

- Water rights
- Water-supply contracts
- Water-supply option agreements

Under the water rights scenario, a Special Water Resource is designated where a surface water resource is within a region other than the headquarters of the partial/entire owner of the surface water right. Special Water Resources are also designated when a contract gives water to an entity head-quartered in a different regional planning area than the one where the water resource is located. A third scenario occurs when water-supply option agreements give an entity the choice to obtain water from a Special Water Resource in a region other than the region where the entity gaining water is located. The water may then be designated as a Special Water Resource.

The regional water planning group for the region where the Special Water Resource is located is responsible for protecting the water rights, water-supply contracts and water-supply option agreements as discussed in Section 357.5 (h). The planning group shall make sure that water supplies obligated to regions outside of the Special Water Resource region are not impacted.

The TNRCC has a water rights database and the TWDB has a database of water contracts and option agreements. The TNRCC "Water Rights Active Master Database" contains all active water rights and addresses and can be accessed at the following web address: http://www.tnrcc.state.tx.us/water/quantity/wateruses/permits.html. The TWDB Master97 file is the water contracts and option agreements database, which has been updated as of early 1996.

1.5 WATER DEMAND

Water usage for the Plateau Region and its counties for the period since 1980 are shown on Figures 1-11 and 1-12, respectively. The total amount of ground water and surface water used in the region has ranged from 29,000 to 42,723 acre-feet and averaged 36,129 acre-feet. The percentage of the total represented by ground water has ranged from 43 percent to 70 percent and has averaged 59 percent. The following table lists average, maximum and minimum water usage in acre-feet from 1980 through 1997 by the counties in the region with average percentage of ground water as compared to total water usage in parenthesis.

County	Average (% Ground Water)	Highest Water Use Over Period	Lowest Water Use Over Period
Bandera	2,176 (86%)	2,278	1,684
Edwards	1,196 (75%)	1,728	974
Kerr	7,783 (49%)	9,241	6,504
Kinney	8,997 (92%)	14,378	3,773
Real	1,248 (50%)	2,031	847
Val Verde	14,729 (41%)	17,039	12,786

The TWDB has identified six categories of water demand as follows:

- **Municipal**. This category of demand consists of both residential and commercial water uses. Commercial water consumption includes business establishments, public offices, and institutions, but does not include industrial water use. Residential and commercial uses are categorized together because they are similar types of uses, i.e.: they both use water primarily for drinking, cleaning, sanitation, air conditioning, and landscape watering. Public water-supply sources in the Plateau Region are shown in Figure 1-13.
- **Irrigation**. This category of demand consists of all water used by the agricultural industry to support the cultivation of crops. Where ground water is the source of irrigation water, the TWDB defines irrigation use as "on farm demand." Where surface water is the source of irrigation water, the TWDB defines irrigation use as both "on farm" demand and "diversion loss." Diversion loss, also referred to as conveyance loss, is the amount of water lost during the delivery of surface water from the point of diversion on the river or stream to the point of use on the farm. Surface water is typically conveyed by an open canal system, which exposes the water supply to possible loss from seepage, breaks, evaporation, and uptake by riparian vegetation.
- **Livestock**. This category of demand consists of all water used by farms and ranches to support livestock production.

- **Manufacturing**. This category of demand consists of all water used in the production of goods for domestic and foreign markets. Manufactured products in Texas range from food and clothing to refined chemical and petroleum products to computers and automobiles. Some processes require direct consumption of water as part of the manufacturing process. Others require very little water consumption, but may require large volumes of water for cooling or cleaning purposes. In some manner or another, water is passed through the manufacturing facility and used either as a component of the product or as a transporter of waste heat and materials.
- **Steam-Electric**. This category of demand consists of all water used by steam-electric generating plants as part of the boiler feed and cooling requirements in the production of electricity. For plants that use ground water or diverted surface water, the TWDB's survey of water use provided actual reported withdrawals. For plants that use cooling ponds or other water impoundments, water use was calculated by adding reported ground water use for boiler feed and sanitary uses to net natural evaporation and forced evaporation estimates.
- **Mining**. This category of demand consists of all water used in the production and processing of nonfuel (e.g., sulfur, clay, gypsum, lime, salt, stone and aggregate) and fuel (e.g., oil, gas, and coal) natural resources by the mining industry. In all instances, water is required in the mining of minerals either for processing, leaching to extract certain ores, controlling dust at the plant site, or for reclamation. This also includes the production of crude petroleum and natural gas.

Expected total water use in the region in the year 2000 is projected to be 44,624 acre-feet (Figure 1-14) (1997 State Water Plan and adopted revisions). Expected water use for each of the above categories is shown in acre-feet for each county in the table below and is illustrated in Figure 1-15. A more detailed discussion on population and water demand forecasts out to the year 2050 is in Chapter 2.

County	Municipal	Manufac-turing	Mining	Irrigation	Livestock	Steam Electric	Total
Bandera	3,229 *	11	25	278	333	0	**3,876**
Edwards	430	0	8	239	615	0	**1,292**
Kerr	8,601 *	30	176	823	526	0	**10,156**
Kinney	1,607 *	0	0	7,532	675	0	**9,814**
Real	722 *	0	13	835	174	0	**1,744**
Val Verde	15,194	0	114	1,771	663	0	**17,742**
Plateau Region	**29,783**	**41**	**336**	**11,478**	**2,986**	**0**	**44,624**

Source: 1997 Consensus State Water Plan * Adopted revisions

The largest water usage is municipal, followed by irrigation, and much smaller amounts for livestock, mining and manufacturing. The largest center of municipal demand is Del Rio in Val Verde County, where 12,106 acre-feet of water is expected to be used in 2000 to support all areas of residential, commercial, public and military consumption. Fifty-one percent of municipal water is used in Val Verde County, and 29 percent is used in Kerr County.

The municipal per capita demand within the region is 221 gallons per person per day (gals/person/day). Ranked in descending order for per capita municipal water usage, the counties are: (1) Kinney, 311 gals/person/day; (2) Val Verde, 287 gals/person/day; (3) Real, 210 gals/person/day; (4) Kerr, 175 gals/person/day; (5) Edwards, 151 gals/person/day; and (6) Bandera, 150 gals/person/day.

Irrigation represents the second greatest water use in the region (11,478 acre-feet) with Kinney County accounting for 66 percent. Livestock (2,986 acre-feet), mining (336 acre-feet), and manufacturing (41 acre-feet) uses are requiring significantly less. There is no water demand associated with electricity generation.

1.6 MAJOR WATER PROVIDERS

Regional Water Planning Groups are required under 31 TAC Chapter 357 to identify and include Major Water Providers (MWPs) in their regional water plans. The purpose of establishing MWPs in the planning process is to assure that water demands and supplies are tracked from the originating provider to the end user.

1.6.1 Definition of Major Water Providers

The TWDB defines MWP as an entity which delivers and sells a significant amount of raw or treated water for municipal and/or manufacturing use on a wholesale and/or retail basis. The entity can be either public (non-profit) or private (for-profit) and may include municipalities with wholesale customers, river authorities and water districts.

For the purposes of this planning exercise, the Plateau Region defines a MWP as an entity which provides 100 acre-feet or more per year of raw or treated water to other entities in excess of its own use. The Plateau Regional Planning Group identified only the City of Del Rio as meeting this definition. The Planning Group also recognized the Upper Guadalupe River Authority and Aqua Source Water Supply Company as potentially meeting this definition but lacked necessary support data. The Planning Group intends to consider designation of these entities during the next planning period when sufficient data is made available.

1.6.2 Major Water Providers

The City of Del Rio obtains most of its water supply from San Felipe Springs. However, the City is also in the process of developing additional ground-water supplies from other wells. In 1996 the City provided 1,454 acre-feet of water to Laughlin Air Force Base.

The Upper Guadalupe River Authority (UGRA) owns 2,000 acre-feet per year of firm diversion rights from the Guadalupe River. The UGRA is in the process of developing a plan to provide for most of the water and wastewater needs of the unincorporated areas of Kerr County. The Authority plans to replace existing ground-water usage with surface water to the extent possible, and to eventually incorporate ground-water supplies as needed to meet demands.

The Aqua Source Corporation currently supplies water to numerous, primarily rural, subdivisions in Bandera, Kerr and Real Counties, and to numerous other subdivisions outside the region. The supply source is generally water wells located within the subdivision properties.

1.7 WATER MANAGEMENT AND DROUGHT CONTINGENCY PLANS

1.7.1 State Water Plan

The Texas Water Development Board adopted the amended *Texas Water Plan, Water for Texas* on August 20, 1997 as the official water plan for Texas. The Texas Water Code directs the TWDB to update this comprehensive water plan which is used as a guide for the management of the State's water resources. This State plan was the result of a consensus planning process that included efforts by the Texas Natural Resource Conservation Commission (TNRCC), the Texas Parks and Wildlife Department, and community and professional leaders. Based on water-resource availability and for planning purposes, the state was divided into 16 regions. The six Plateau counties occur within Regions 9 (Lower Rio Grande), 11 (Southern Edwards) and 12 (Hill Country).

The State plan provides the following recommendations that address regional water-supply problems specific to the counties of the Plateau Planning Region:

- A better understanding of the local hydraulic nature of the aquifer in the design and siting of water wells is needed to better manage available ground-water supplies.
- Conjunctive use of ground water and available surface water supplies is recommended as a means of extending limited ground-water supplies and improving water quality.
- As the trend toward declining irrigation use and increasing municipal use continues in the Rio Grande River Basin, good planning will be needed to adapt the existing institutional framework to accommodate the trend. The need for additional water treatment facilities will increase.

1.7.2 Local Water Management Studies and Plans

The Plateau Region often experiences periods of limited rainfall, especially compared with more humid areas in the eastern part of the state. Although residents of the region are generally accustomed to these conditions, the low rainfall and accompanying high evaporation underscore the necessity of developing plans to manage resources responsibly and to respond to potential disruptions in the supply of ground water and surface water caused by drought conditions. The entities listed below have water management plans.

- Trans-Texas Water Program – West Central Study Area;
- Springhills Water Management District – Regional Water Supply Study;
- Val Verde County – Regional Waterworks and Wastewater Systems Study;
- Kerr County – Regional Water and Wastewater Planning Study;
- Kerr County – Regional Water Plan, Phase I for UGRA;
- UGRA/Kerrville – Aquifer Storage and Recovery Feasibility Investigation; and
- Nueces River Basin – Regional Water Supply Planning Study.
- Real and Edwards County Conservation and Reclamation Water District

Summaries of the above water management plans can be viewed in Appendix 1A.

Drought contingency plans have been developed by the following:

- City of Del Rio;
- City of Brackettville;
- City of Kerrville;
- Springhills Water Management District;
- Fort Clark Municipal Utility District; and
- City of Bandera.

Summaries of the above drought contingency plans can be viewed in Appendix 1B. All entities required by law to turn in plans to TNRCC have done so. Therefore, any areas without an existing management plan do not have entities within them that are required to have a plan.

Of the drought contingency plans, none are for entities that extend beyond the boundaries of the Plateau Region. This is also true for the water supply and water management plans, with the exception of the Trans-Texas West Central Study Area plan, and the Nueces River Basin Regional Water Supply Planning Study. The Nueces River Basin Regional Water Supply Planning Study focuses on counties that are not Plateau Region counties, even though physically the Nueces River Basin contains portions of counties within the Plateau Region. This report is also focused on recharge to the Edwards Aquifer, which barely extends to the boundary of the Plateau Region at Bandera County. If the report had addressed groundwater-surface water exchange at Medina Lake, this information would have been of interest to the Plateau Region; however, this report does not address this issue. As regards the Trans-Texas West Central Study Area plan, the summarization of this plan addresses nine water supply options which, if they were to be implemented, would impact the Plateau Region.

The Hill Country of Central Texas, which includes Bandera and Kerr counties, is experiencing rapid population growth. With limited ground-water availability in the area, continued rapid population growth is an increasing problem since there are few surface water supplies available. As a result of the potential difficulty in meeting future water demands, the TNRCC declared all or parts of eight counties in the Hill Country as areas of critical concern. In response, two ground-water management districts have been formed in the area: Headwaters Underground Water Conservation

District in Kerr County and Springhills Water Management District in Bandera County. The two districts have submitted comprehensive management plans to TNRCC.

For the purpose of managing the ground-water resources and preventing the over-development of the aquifer system in Bandera AND Kerr Counties, the Springhills Water Management District and the Headwaters Underground Water Conservation District in cooperation with the Bandera and Kerr County Commissioners Courts have adopted rules developed by the TNRCC. Requirements differ in regard to whether the subdivision is or is not served by a central water system. Subdivisions without a central water system are required to perform pumping test to identify the hydrological characteristics of the underlying aquifer.

Because of the critical nature of the ground-water resource in the Hill Country area, management considerations should include several important components. Where appropriate, surface water supplies should be extended to populated areas that have already exceeded available ground-water supplies. New subdivisions should be designed with adequate water-supply sources as a primary consideration, and small lots with individual wells should be discouraged. Rainwater harvesting and water-conservation practices, such as landscape xeriscaping, should be promoted. Drought contingency and water-supply drought monitoring plans should be established. Additional underground water conservation districts should be established where appropriate, and district management plans should be developed that reflect a coordinated regional effort between districts, county commissioners courts and municipalities.

1.8 COLONIAS

Colonias represent a special, and growing, subset of municipal demand in the region and a challenge to water suppliers. Colonias are subdivisions in unincorporated areas that often lack basic services, such as potable water, sewage disposal and treatment, paved roads and proper drainage, and this often results in public health problems. Most are located along the United States/Mexico international border and typically consist of small land parcels sold to low-income people. A total of 16 colonias are recognized in the region. Thirteen colonias are located in Val Verde County. The eastern counties, Kerr, Real and Bandera, do not have designated colonias within their boundaries; however, certain areas within these counties are applying for colonia status to receive public funds.

The Economically Distressed Area Program (EDAP) was created by the Texas Legislature in 1989 and is administered by the TWDB. The intent of the program is to provide local governments with financial assistance for bringing water and wastewater services to the colonias. An economically distressed area is defined as one in which water-supply or wastewater systems do not meet minimal state standards, financial resources are inadequate to provide services to meet those needs, and 80 percent of dwellings in the area were occupied on June 1, 1989. Affected counties are counties adjacent to the Texas-Mexico border, or those that have per capita incomes 25 percent below the state average and unemployment rates 25 percent above the state average for the most recent 3 consecutive years for which statistics are available (TWDB, 1996).

Following is a summary of designated colonias in Edwards, Kinney and Val Verde Counties along with a status of EDAP projects as of October 31, 2000.

- Edwards County
  - Rocksprings
- Kinney County
  - Brackettville
  - Spofford – New water services completed for 66 residents ($400,000).
- Val Verde County
  - Cienegas Terrace – Water and wastewater services completed for 1,412 residents ($3.51 million).
  - Val Verde Park – Water and wastewater services under construction for 2,025 residents ($12.01 million).
  - Los Campos
  - Rio Bravo
  - Owens
  - Payment
  - Langtry
  - Comstock
  - Box Canyon Estates
  - Lake View Estates
  - Amistad Acres
  - Rough Canyon
  - Villarreal

1.9 FUNCTIONS OF STATE AND FEDERAL AGENCIES

1.9.1 Texas Water Development Board (TWDB)

The TWDB is the state agency charged with statewide water planning and administration of low-cost financial programs for the planning, design and construction of water supply, wastewater treatment, flood control and agricultural water conservation projects. The TWDB, especially the Water Resources Planning Division (WRPD), is at the center of the Senate Bill 1 planning effort. The agency has been given the responsibility of directing the effort in order to ensure consistency and to guarantee that all regions of the state submit plans in a timely manner.

1.9.2 Texas Natural Resource Conservation Commission (TNRCC)

The TNRCC strives to protect the state's natural resources, consistent with a policy of sustainable economic development. TNRCC's goal is clean air, clean water, and the safe management of waste, with an emphasis on pollution prevention. The TNRCC is the major state agency with regulatory authority over state waters in Texas and administers water rights of the Lower Rio Grande through the office of the Watermaster. The TNRCC is also responsible for ensuring that all public drinking water systems are in compliance with the strict requirements of the State of Texas.

TNRCC is involved with the TWDB in developing a state consensus water plan. Prior to permit approval, TNRCC is required to determine if projects are consistent with regional water plans.

1.9.3 Texas Parks and Wildlife Department (TP&WD)

The TP&WD provides outdoor recreational opportunities by managing and protecting wildlife and wildlife habitat and acquiring and managing parklands and historic areas. The agency currently has 10 internal divisions: Wildlife, Coastal Fisheries, Inland Fisheries, Law Enforcement, State Parks, Infrastructure, Resource Protection, Communications, Administrative Resources, and Human Resources. Three senior division directors provide special counsel to the Executive Director in the areas of water policy, land policy and administrative matters. The Department has automatic status as a recognized party in any water right contested hearing case.

TP&WD is involved with the TWDB in developing a state consensus water plan. Specifically, the agency looks to see that statewide environmental water needs are included. A TP&WD staff person is a non-voting member of the Plateau Regional Planning Group and provides essential environmental expertise to the planning process.

1.9.4 Texas Department of Agriculture (TDA)

The TDA was established by the Texas Legislature in 1907. The TDA has marketing and regulatory responsibilities and administers more than 50 separate laws. The current duties of the Department include: (1) promoting agricultural products locally, national, and internationally (2) assisting in the development of the agribusiness in Texas; (3) regulation the sale, use and disposal of pesticides and herbicides; (4) controlling destructive plant pests and diseases; and (5) ensuring the accuracy of all weighing or measuring devices used in commercial transactions. The Department also collects and reports statistics on all activities related to the agricultural industry in Texas. A TDA staff person is a non-voting member of the Plateau Regional Planning Group and provides essential agricultural expertise to the planning process.

1.9.5 Texas State Soil and Water Conservation Board (TSSWCB)

The TSSWCB is charged with the overall responsibility for administering the coordinating the state's soil and water conservation program with the state's soil and water conservation districts. The agency is responsible for planning, implementing, and managing programs and practices for abating agricultural and sivicultural nonpoint source pollution. Currently, the agricultural/sivicultural nonpoint source management program includes: problem assessment, management program development and implementation, monitoring, education, and coordination.

1.9.6 International Boundary and Water Commission (IBWC)

The IBWC administers the international waters of the Rio Grande according to the two treaties between Mexico and the U.S., which govern these waters; the treaties are discussed in detail elsewhere in this report. The IBWC is currently involved in discussions with Mexico as to how or when Mexico will be able to make up its "water debt" under the 1944 treaty. Drought within the interior of Mexico, especially the Rio Conchos watershed that flows to the Rio Grande in the vicinity of Presidio, Texas, has in recent years resulted in the inability of Mexico to make the agreed-upon delivery amounts. IBWC staff have provided ground-water data that has been used in the assessment of ground-water resources in the Del Rio area for this planning purpose.

1.9.7 United States Geological Survey (USGS)

The USGS serves the Nation by providing reliable scientific information to (1) describe and understand the Earth; (2) minimize loss of life and property from natural disasters; (3) manage water, biological, energy, and mineral resources; and (4) enhance and protect quality of life.

The USGS's Water Resources Division has played a major role in the understanding of the ground-water resources of Texas. Scientists with the USGS have conducted regional studies of water availability and water quality. Many of these studies have been conducted in conjunction with the TWDB. These studies have provided much of the data for more recent investigations conducted by graduate students and faculty members of the geology departments of many Texas universities.

1.9.8 United States Environmental Protection Agency (EPA)

The mission of the EPA is to project human health and the environment. Programs of the EPA are designed (1) to promote national efforts to reduce environmental risk, based on the best available scientific information; (2) ensure that federal laws protecting human health and the environment are enforced fairly and effectively; (3) guarantee that all parts of society have access to accurate information sufficient to manage human health and environmental risks; and (4) guarantee that environmental protection contributes to making communities and ecosystems diverse, sustainable, and economically productive.

1.9.9 United States Fish and Wildlife Department (USFWS)

The USFWS enforces federal wildlife laws, manages migratory bird populations, restores nationally significant fisheries, conserves and restores vital wildlife habitat, protects and recovers endangered species, and helps other governments with conservation efforts. It also administers a federal aid program that distributed money for fish and wildlife restoration, hunter education, and related projects across the country. The USFWS has provided comments to the draft planning document that are pertinent to wildlife water needs.

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CHAPTER 2

CURRENT AND PROJECTED POPULATION AND WATER DEMAND DATA FOR THE REGION

2.1 INTRODUCTION

An accurate estimation of current and future water needs for all water use categories is necessary in order to wisely plan and manage the existing water resources in the Plateau Region. The TWDB Regional Planning Rules specify in Section 357.5 (d) that in developing regional water plans, the Regional Water Planning Groups shall use one of the following for population and water demand projections:

- State population and water demand projections contained in the state water plan or adopted by TWDB after consultation with the Texas Natural Resource Conservation Commission and Texas Parks and Wildlife Department in preparation for revision of the state water plan; or
- Population or water demand projection revisions that have been adopted by TWDB, after coordination with Texas Natural Resource Conservation Commission and Texas Parks and Wildlife Department, based on changed conditions and availability of new information.

State data provided by the TWDB based on the first criteria was developed during the consensus water planning process involved in the 1997 state water plan, "Water for Texas, A Consensus-Based Update to the State Water Plan" (Texas Water Development Board, August 1997). In accordance with the above Guidelines, the Plateau Region Water Planning Group requested and was given approval to revise specific population and water demand data for use in the regional plan. Thus, the population and water demand projections shown in Chapter 2 are derived from a combination of TWDB data and approved revisions.

2.2 REVISED CONSENSUS POPULATION PROJECTIONS

The Plateau Regional Planning Group members solicited entities within the Region to approach the Planning Group with desired changes to population and water demand projections. Back-up documentation for such desired changes was evaluated as to whether they qualified under TWDB Rules. Documentation and revisions were prepared in “Plateau Region Revisions to Population and

Water Demand Projections" dated July 28,1999 and were presented to the public for final comment. This document was then submitted to TWDB and served as the basis for TWDB approving the population and demand revisions.

Four of six counties within the Plateau Region (Bandera, Kerr, Kinney and Real) made requests to the TWDB to revise the 1997 Consensus Water Plan population and water demand projections. In all four counties, current population estimates based on electrical and water meter connections, school enrollments, voter registrations and recent planning studies were greater in 1999 than the year 2000 estimates in the Water Plan. These estimates are then multiplied by documented growth and per capita water use rates to obtain future population and water demand projections. The following paragraph briefly discusses forecast changes from the 1997 Consensus Water Plan for each of the four counties.

In March 1999, Bandera Electric Cooperative documented 6,504 electrical connections in Bandera County. Applying this to the Census Bureau's average household size in this area of 2.91 persons per household results in a population of 18,297 for the county, which exceeds the Consensus Water Plan year 2000 projection of 14,947 persons. As a result, the revised population projections for the year 2000 and subsequent years are estimated from this new 1999 figure. Per capita municipal water use in Bandera County is based on a 1991 HDR Engineering report, "Regional Water Supply Study", performed for the Springhills Water Management District. Kerr County requested population projections and per capita usage revisions that were documented in "Regional Water and Wastewater Planning Study for Kerr County, Texas" and submitted to the State by HDR Engineering, Inc (1997). Kinney County provided documentation on the number of water connections in the City of Brackettville and Fort Clark and applied an average household size to estimate a 1999 population of 4,468 persons, which exceeds the Consensus Water Plan year 2000 projection of 3,350 persons. The year 2000 and subsequent years' projections are estimated from a documented growth rate. Real County provided documentation of the number of registered voters and school enrollment records to reach a total of 2,897 persons, which exceeds the Consensus Water Plan year 2000 projection of 2,534 persons. This higher population was then increased by a documented five-percent growth rate to determine estimates of future populations.

2.3 PROJECTED POPULATION GROWTH (1996B2050)

The projected population growth for each of the six counties over the period 1996B2050 is listed in Table 2-1 by major city and county other (rural) water-use category for each river basin. Total population growth for the counties is illustrated by Figure 2-1. The total population of the six counties is expected to increase by 96 percent from the 1996 census count of 107,228 to 210,085 by 2050. The largest increases, with respect to total population and percent gain, are expected to occur in Bandera and Kerr counties with 218- and 111-percent growth, respectively. Percent growth rates in the other counties are, in descending order, Val Verde, 54 percent; Kinney, 46 percent; Real, 23 percent; and Edwards, 21 percent.

2.4 CONSENSUS-BASED WATER DEMAND PROJECTION METHODOLOGIES

The following subsections present summaries of the methods and assumptions used in the state's consensus water planning process for each water demand category. This information has been taken from Appendix 3 of the 1997 Consensus State Water Plan, which contains a more detailed discussion of methodologies, assumptions, data sources and modeling scenarios. This document can be found on the Water Development Board=s web page, as follows: http://www.twdb.state.tx.us/wrp/state-plan/wat-plan-iii.htm. The demand categories are identified as (1) municipal, (2) irrigation, (3) manufacturing and industrial, (4) livestock and (5) mining. A discussion on steam electric power generation is not included since there is no water in the Plateau Region used for this category.

2.4.1 Municipal

The quantity of water used for municipal purposes in Texas is heavily dependent on population growth, climatic conditions and water conservation measures. For planning purposes, municipal water use includes both residential and commercial water uses. Commercial water use includes business establishments, public offices and institutions, but does not include industrial water use. Residential and commercial uses are categorized together because they are similar types of use, i.e., both types use water primarily for drinking, cleaning, sanitation, air conditioning and landscape watering. Water use within a city limit that is not included in the quantification of Municipal demand is that used in manufacturing and industrial processes. See Section 2.4.3 - Manufacturing and Industrial for a definition of this water use.

The 1997 Consensus Water Plan gives population projections for all cities and towns with 1,000 or more residents and for the rural populations (County Other) within counties. The development of the consensus population projections for the 1997 plan incorporated data from the State Data Center and from the U.S. Bureau of the Census= 1990 census counts. The population forecasting scenarios identified for use in the state water-planning process during development of the Consensus Water Plan B termed "growth scenarios" B varied in terms of migration rate. The Consensus Technical Advisory Committee identified the *most likely growth scenario* for each county given recent growth rates and likely development trends; regional and state totals termed "recommended" are an aggregated mix of these individual county selections.

The municipal water-use forecasts rely on population, per capita water-use and on potential conservation saving projections. The municipal water-use forecasting scenarios used two different weather assumptions and three different water-conservation assumptions (a total of six possible combinations or scenarios). The weather assumptions involved:

- Per capita water use associated with below normal rainfall, and
- Per capita water use associated with normal rainfall.

For statewide water-supply planning, using the normal rainfall assumption to calculate per capita use is not appropriate, as water demands projected using this average weather statistic will likely fall short of the water demands that may actually occur during dry times, resulting in water-supply shortages. The Consensus Water Plan utilizes per capita uses associated with below normal rainfall.

The water-conservation assumptions involved either expected or advanced conservation:

Expected conservation: Expected conservation assumes levels of water savings that are likely to occur from both market forces and regulatory requirements. It assumes households will use more efficient plumbing fixtures and appliances already on the market, as well as employ more water efficient outdoor irrigation and landscape practices. In addition, expected conservation assumes that plumbing fixture standards required under the 1991 State Water Efficient Plumbing Act will be in place. The Act requires improved water-use efficiency in toilets, shower heads, urinals, faucets and drinking fountains. The expected conservation represents feasible strategies for water conservation savings that are economically sound.

Advanced conservation: Advanced conservation assumes the same improvements in water conservation as listed under expected conservation. The primary difference between the expected and advanced cases is one of timing. The advanced case assumes that municipal utilities and individuals engage in water conservation activities at an accelerated rate. The advanced conservation represents the maximum technical potential for water conservation savings.

Conservation Due to the Plumbing Code only: These scenarios incorporate improvements in water use efficiency due solely to the 1991 State Water Efficient Plumbing Act. It includes improvement in water use efficiency in toilets, shower heads, urinals, faucets and drinking fountains, but does not include conservation resulting from using more water-efficient appliances or employing improved outdoor watering and landscape practices.

The most likely municipal water-use scenario incorporates the most likely population projection, with the per capita water use estimated that reflects below normal rainfall conditions, and the expected level of conservation.

2.4.2 Irrigation

The Texas Water Development Board, with technical assistance from the staff of Texas A&M University, developed a linear programming model for use in evaluating the many factors affecting irrigation water demand for the Texas agricultural sector. Linear programming models are based on mathematical techniques for systematically determining solutions for maximizing or minimizing values of linear functions under various variable (resource) constraints. For the development of the irrigation water demand projections, the objective function of the model was structured to solve for the maximization of farm income based on the profitability of specific crops grown in Texas using the resources necessary for the production of these crops. To simplify the modeling process, the

TWDB used the Texas A&M University delineation of major agricultural production regions in the state.

Several types of variables are used in the modeling procedure to determine future irrigation water demands by geographical location. These variables include crop prices, yields, production costs, water costs, and six types of irrigation delivery systems. These data are crop-specific and reflect the major crops grown in Texas, which include cotton, grain sorghum, wheat, corn, rice, peanuts, alfalfa hay, fruits, vegetables, and nuts. As part of the revenue stream, federal farm deficiency payments for specific crops and land set-aside requirements for compliance with federal farm programs are included in the model. Crop enterprise budgets, developed by Texas A&M University, provided crop-specific information such as current crop prices, variable production costs, fixed production costs, yields, deficiency payments, irrigation water applications, land restrictions for participation in federal programs and irrigation delivery systems. Because the Texas A&M University crop enterprise budgets are planning budgets, variable costs for the crops were, in some instances, adjusted (increased or decreased) in the modeling procedure to calibrate the water demand calculated by the model to the actual published water use for each of the 14 agricultural regions. The variable costs were adjusted because these costs were the basic unknown variables in contrast to published crop prices, yields, harvested and planted acres per crop, and water use.

2.4.3 Manufacturing and Industrial

Because of the importance of the state's manufacturing and industrial sector in terms of income and employment to local and regional economies, analyses of future water use and availability of water for these industries are necessary to ensure the continued economic vitality of many regional economies. It is important to note that Manufacturing and Industrial water use is quantified separately from Municipal use even though the demand centers may be located within a city limits. A listing of industries in the region is available from the TWDB web page (http://www.twdb.state.tx.us).

Future manufacturing water use is largely dependent on technological changes in the production process, on improvements in water-efficient technology, and on the economic climate (expansion/contraction) of the market place. Technological changes in production affect how water is used in the production process, while improvements in water-efficient technology affect how much water is used in the production process. As older production facilities and accompanying production processes are modernized or retooled, the new production processes are anticipated to be more resource efficient.

The manufacturing water use projections are based on three specific assumptions regarding industry growth:

- Industry growth assumes future expansions of existing capacity within an industry as well as new manufacturing facility locations within the state.
- Historical interactions of oil price changes and industry activity are assumed to continue over the projection period.
- The types of industries that comprised a county's current manufacturing base are assumed to comprise the county's manufacturing base in the future.

Because of the need to develop manufacturing water use projections at the county level, and because of the absence of pertinent, and often confidential industry production information at the local level, a "top-down" approach was used for developing projections of potential industry growth.

2.4.4 Livestock

Texas is the nation's leading livestock producer, accounting for approximately 11 percent of the total United States production. Livestock production was valued at approximately $8 billion in 1993 and represented more than half of the total value derived from all agricultural operations in Texas. Although livestock production is an important component of the Texas economy, the industry consumes a relatively small amount of water. In 1990, total livestock production consumed approximately 274,000 acre-feet of water in Texas, representing less than two percent of the total water use.

Estimating livestock water consumption is a straightforward procedure that consists of estimating water consumption for a livestock unit and the total number of livestock. Texas A&M University Agricultural Extension Service provided information on water use rates, estimated in gallons per day per head, for each type of livestock: cattle, poultry, sheep and lambs, and hogs and pigs. The Texas Agricultural Statistics provided current and historical numbers of livestock by livestock type and county. Water use rates were then multiplied by the number of livestock for each livestock type for each county. In counties where the number of head of livestock was unavailable, historical livestock distribution patterns were assumed. County livestock water use was then aggregated to the state level to estimate total water consumption by livestock type. The U. S. Department of Agriculture, Soil Conservation Service provided information on the source of water supply for range livestock. Water supplies for confined livestock operations, such as poultry, hogs, dairy and feedlots, are assumed to be supplied by ground-water sources.

2.4.5 Mining

Although the Texas mineral industry is foremost in the production of crude petroleum and natural gas in the United States, it also produces a wide variety of important nonfuel minerals. Texas is the only state to produce native asphalt and is the leading producer nationally of Frasch-mined sulfur. It is also one of the leading states in the production of clay, gypsum, lime, salt, stone and aggregate. In all instances, water is required in the mining of these minerals either for processing, leaching to extract certain ores, controlling dust at the plant site or for reclamation.

Projections of fresh water use for mineral production in Texas were developed for the categories of fuels and nonfuels. Derived from an examination of recent and historical data, trends in production, estimated total mineral reserves currently accessible, and rates of water use, these projections are tabulated by county, river or coastal basin, and climatic zones within basins. They represent the sum of estimated mining water use for the two categories of mineral products: fuels and nonfuels.

For each category of mineral products, the requirements for mining water were determined as a function of production. Estimates of future production were calculated by analyzing both recent data and state and national production trends. A water use coefficient, computed from data collected by the Texas Water Development Board=s 1990 Water Use Survey, which reports the quantity of water used in the production of each increment of output, was applied to estimated mineral production levels. A rate of water consumption derived from U.S. Bureau of Mines data was then applied to the total water use for each mineral industry. In short, tabulations of water use for each basin, zone and county represent the sum of estimated water use for the production of fuels and nonfuels where this mineral production has occurred historically and where the estimated mineral reserves are sufficient to meet the demand.

Finally, the estimates of water use for mining require two basic assumptions. First, it was assumed that the location of mines within the basin zone would remain constant. Second, it was assumed that each region would retain its share of state production. For example, if the Canadian Basin produced five percent of the state=s production of petroleum in 1990, it was assumed that it would produce five percent of state's output through the year 2050.

2.5 WATER DEMAND FORECAST (1996B2050)

The forecast demand for total water needed in the Plateau Region will increase by 38 percent or 15,255 acre-feet of water from the historic usage in 1996 to the year 2050 (Figure 2-2). The fastest growing and largest percentage increase will be in Bandera and Kerr counties with increases of 163- and 75-percent. The largest total water demand increase by county in descending order will be in Kerr, 6,709 acre-feet; Val Verde, 4,802 acre-feet; and Bandera, 4,416 acre-feet (Figure 2-2).

Categories of water demand in the region are (1) municipal, (2) irrigation, (3) manufacturing and industrial, (4) livestock, and (5) mining. The last four categories can be considered together as nonmunicipal water demand. The trends for the forecasted water demand by category are shown in Figure 2-3 for the region and in Figure 2-4 for each county.

2.5.1 Municipal Water Demand

In the Plateau Region, municipal demand is the largest and fastest growing water use category (Figure 2-3). The demand for water from municipalities is projected to grow to 42,643 acre-feet by the year 2050, which is an increase of 17,246 acre-feet and represents a 68-percent increase over the demand of 25,397 acre-feet in the year 1996. The largest increases are expected to occur in Kerr and Val Verde counties, where demands are projected to reach 14,335 acre-feet and 18,893 acre-feet, respectively, by the year 2050. The combined municipal demand for Kerr and Val Verde counties are projected to be 33,228 acre-feet in the year 2050, which is 78 percent of the estimated 42,643 acre-feet of total municipal consumption. The largest percentage increase is expected to occur in Bandera County with a 239-percent change from a demand of 1,922 acre-feet in the year 1996 to 6,515 acre-feet in the year 2050.

The City of Del Rio, Aqua Source, Inc. and the Upper Guadalupe River Authority (UGRA) were identified in Chapter 1 as Major Water Providers (MWP). The City of Del Rio supplies water to Laughlin Air Force Base and adjacent subdivisions. Aqua Source, a privately owned utility, provides water to several subdivisions in counties in the eastern part of the region. The UGRA plans a phased approach to providing water to most of the unincorporated areas of Kerr County and incorporated areas outside of the City of Kerrville. Table 2-3 lists the MWPs and estimates total water demand by decade for the City of Del Rio. Water demands were not initially determined for the UGRA and Aqua Source in sufficient time to be authorized by the TWDB for this plan, but will be provided as an amendment to the plan at a later time.

2.5.2 Nonmunicipal Water Demand

Estimates of nonmunicipal water demand for the period 1996-2050 are presented in Table 2-4 by region and category and in Figures 2-3 and 2-4. Within the four categories, irrigation accounts for the largest projected nonmunicipal water demand. Water needed for irrigation is projected to decrease from a high of 12,047 acre-feet in 1996 to 9,290 acre-feet by 2050. This represents a 23-percent reduction (2,757 acre-feet) in demand as reported for the year 1996.

The other three categories are expected to grow during the next 50 years (Figures 2-3 and 2-4). Livestock use is expected to increase by 31-percent from 2,279 acre-feet to 2,986 acre-feet by the year 2050. Manufacturing demand is projected to grow from 23 acre-feet in the year 1996 to 66 acre-feet by the year 2050, which is 187-percent growth over that period. Mining is projected to increase by 7 percent from the 1996 total of 301 acre-feet to 323 acre-feet by the year 2050. No demand exists for electrical generation in the region, and none is anticipated in the next 50 years.

CHAPTER 3

EVALUATION OF CURRENT WATER SUPPLIES IN THE REGION

3.1 INTRODUCTION

Water resources available to meet the supply needs in the six counties of the Plateau region include both surface-water and ground-water sources. Most water used in the region is ground water derived from regional and local aquifer systems. The Cities of Kerrville and Del Rio currently use surface water from the Guadalupe River and from San Felipe Springs, respectively. Camp Wood in Real County is supplied from springs on a tributary to the Nueces River.

Water supplies available to meet the demands reported in Chapter 2 are shown in Tables 3-1 through 3-4 at 10-year intervals for the planning period from the year 2000 to 2050. Table 3-1 indicates the maximum amount of water supply that could be obtained from each unique supply source based on the assumptions described in the sections below. These quantities, especially in the case of ground water, are often significantly greater than the quantities that can practicably be captured by existing and potential water users. Table 3-2 defines ground-water availability by aquifer subunits. Tables 3-3 and 3-4 list water supplies available to cities and water user categories, and for Major Water Providers based on the abilities of each to obtain water supplies. These abilities primarily include existing infrastructure and water-rights limitations. For Senate Bill 1 planning purposes, the supplies shown in these tables represent the quantities available during Drought-of-Record conditions and should not be confused with the amount of water available during average conditions.

3.2 GROUND-WATER RESOURCES

Ground water is a major source of water for most of the Plateau Region and is stored in and retrieved from aquifers. Aquifers are replenished by recharge that includes precipitation, infiltration of water from perennial or ephemeral streams, inflow of ground water from areas adjacent to an aquifer, and irrigation return flow. Throughout most of the Plateau region, water levels in the aquifers fluctuate with seasonal precipitation. As a result, water levels are highly susceptible to declines during drought conditions.

Most of the rain that falls in the region is lost to runoff, evaporation or transpiration. In the eastern part of the Plateau region, about 4 percent of average rainfall has been estimated as recharge to the Trinity aquifer (Ashworth, 1983). Long-term precipitation records also indicate that rainfall during droughts has been about one-half the normal amount. In order to represent drought conditions, an annual recharge component of only about one-half the normal amount has been added to the availability estimates for the aquifers in the region.

3.2.1 Ground Water in Storage

The volume of ground water in an aquifer is referred to as "storage." Storage is determined by the thickness of the saturated section and by the porosity of the aquifer. Not all of this water is recoverable, however. Much of the water in storage cannot be removed because it is bound by capillary forces within the pore spaces. The amount that is assumed to be recoverable is determined by the "specific yield" of an aquifer. This term refers to the volume of water that will drain, under the force of gravity, from the pore spaces of an aquifer. Specific yield is related to the permeability of an aquifer. Coarse-grained materials and highly fractured rocks may yield higher volumes of water than would fine-grained sandstones or siltstones. Coarse-grained rocks and fine-grained rocks may both hold very large volumes of water, but aquifers that are composed of coarse-grained or fractured rocks may be more productive than aquifers that consist of thick sections of fine-grained sand or silt. "Specific retention" refers to the volume of water that does not drain. Specific yield and specific retention are equal to the effective porosity or storage coefficient of an aquifer.

The volumes of recoverable water in storage for the Plateau region were determined using geographic-information-system (GIS) coverages, which allowed calculation of specific volumes for each aquifer. Volumes were determined by river basin and county from a combination of structure maps and water-level maps. The bottoms of the aquifers were taken from structure maps of contacts between geologic units. These maps were derived from interpretations of geophysical logs of oil test wells drilled to depths below these aquifers. The tops of the aquifers were estimated from historic water-level maps of the area. In general, these maps were derived from static water levels measured in wells completed in the various aquifers.

Many of these water-level measurements were made during the winter, when the wells were not pumped heavily and water levels were at a relatively high level. Based on hydrographs of monitoring wells, the water levels during a drought are about 50 feet lower than during normal months. To represent reduced availability during a drought, 50 feet is subtracted from the thickness of the normal static water levels.

The aquifers within the Plateau region are predominantly fractured limestones, sandstones and shales. A conservative storage coefficient of one percent (0.01) was first applied to the total aquifer volumes of the Trinity age rocks and 2 percent (0.02) to the Edwards limestone because of the relative differences in transmissivities of the two units. Because it is not economical or physically realistic to spread wells evenly throughout the extent of the aquifer, a conservative 30 percent recoverable yield was applied to the calculated aquifer total storage volumes.

3.2.2 Availability by Aquifer

The principal aquifers in the Plateau Region are the Trinity, Edwards-Trinity (Plateau) and Edwards (Balcones Fault Zone) (BFZ) (Figure 3-1). Two undesignated water-bearing aquifers, Frio River Alluvial and Austin Chalk, provide some water to the region in small areas.

The availability of ground water is defined as the total amount of water retrievable from the entire extent of the aquifer during a 1-year drought. This assumes that wells are spread evenly over the entire extent of an aquifer. This is, however, not practical as a well has a finite radius from which it intercepts and pulls water. Availability based on a limited radius around a given well is very useful for actual ground-water evaluation because ground water is shared between wells and not from the entire aquifer. Table 3-3 lists the availability of water under drought conditions by aquifer for cities and water-use categories.

Other than the Trinity aquifer in Kerr County, the same annual values are listed for each 10-year interval from the year 2000 to 2050 because the estimated recharge is greater than the total demand within all the river basins. As a result, no depletion in water storage is anticipated beyond the previously discussed 50-foot decline. The area with its total usage being closest to the estimated recharge is the Trinity aquifer in the Guadalupe River Basin. The following sections provide overview descriptions and availability of ground-water sources in the region.

3.2.2.1 Trinity Aquifer

Located mostly in the Hill Country counties of Bandera and Kerr (Figure 3-1), the Trinity aquifer system is composed of deposits of sand, clay and limestone of the Glen Rose and Travis Peak Formations of the Lower Cretaceous Trinity Group. The water-bearing units include, in descending order, the Glen Rose Limestone, Hensell Sand, Cow Creek Limestone, Sligo Limestone and Hosston Sand. The Glen Rose Formation is divided informally into upper and lower members. Because of fractures, faults and other hydrogeologic factors, the upper, middle and lower Trinity aquifer units often are in hydraulic communication with one another and collectively should be considered a leaky-aquifer system. Based on their hydrologic relationships, the water-bearing rocks of the Trinity Group, collectively referred to as the Trinity aquifer system, are organized into the following aquifer units (Ashworth, 1983).

Aquifer	Formations
Upper Trinity	Upper Glen Rose Limestone
Middle Trinity	Lower member of the Glen Rose Limestone, Hensell Sand and Cow Creek Limestone
Lower Trinity	Sligo Limestone and Hosston Sand

In the Hill Country region, water levels fluctuate with seasonal precipitation and are highly susceptible to declines during drought conditions. Discharge artificially occurs primarily by pumping from wells. Most of the natural discharge from the aquifers is through springs and seeps. Some discharge also occurs from leakage from one unit to another and through natural flow down gradient out of the region.

In the past within the Hill Country, the primary contribution to poor ground-water quality occurs in wells that do not have adequately cemented casing. Water in evaporite beds in the upper Glen Rose has a tendency of being high in total dissolved solids and sulfate which generally needs to be sealed off in a well. Another possible contamination threat is from the surface in the form of bacteria and high nitrate levels possibly from grazing animals or leachate from septic systems. Fecal coliform bacteria can pose a potential public health threat and can also indicate the presence of other pathogens. High nitrate levels in consumed water can cause a disease known as methemoglobinemia especially in small children. The best preventative to answer future concerns for water quality in the aquifers is to have all wells properly completed with adequate amounts of cemented surface casing especially in areas of the region that have a high density of closely spaced wells. Water quality naturally deteriorates in the downdip direction of the aquifer. Also, adequate well spacing can help with both quantity and quality issues.

3.2.2.1.1 Upper and Middle Trinity Aquifer

The upper and middle Trinity aquifer units are divided based on differences in water quality. The upper member of the Glen Rose, when weathered, creates the distinctive "stair-step" topography found at the surface through much of the Hill Country. The upper member of the Glen Rose Limestone, which forms the upper Trinity aquifer unit, contains water with relatively high concentrations of sulfate. Total dissolved solids (TDS) often exceed 1,000 milligrams per liter (mg/l), as compared to the middle Trinity aquifer where TDS generally range from 400 to 800 mg/l.

Upper and middle Trinity aquifer water quality is generally acceptable for most municipal and industrial purposes; however, certain constituents, such as sulfate and fluoride, exceed drinking-water standards for municipal supplies in many places. In some instances, excess levels of constituents are naturally occurring. In the Hill Country region, the primary contribution to poor quality occurs in wells that do not adequately case off water from evaporite beds in the upper part of the Glen Rose (upper Trinity aquifer).

3.2.2.1.2 Lower Trinity Aquifer in Bandera and Kerr Counties

The Hammett Shale (sometimes referred to as the Pine Island Shale) is composed of clay that acts as a confining bed, or barrier to flowing water, and divides the producing sections of the middle and lower Trinity aquifer units. The lower Trinity aquifer is composed of sandy limestones, sand, clay and shale of the Sligo and Hosston members. The lower Trinity thins toward the northeast and is completely missing near the Llano Uplift. The lower Trinity is principally used to provide water supplies for the Cities of Bandera and Kerrville and for a few private water-supply companies.

The water chemistry is generally suitable for most uses in Bandera and Kerr Counties; however, the dissolved solids can occasionally be elevated above 1,000 mg/l especially in the down gradient direction. Yields from wells completed into the lower Trinity also vary greatly. The greater depth, sometimes lower yields and poorer water quality can make completing wells into the lower Trinity less feasible. Recharge to the lower Trinity in Bandera and Kerr Counties likely occurs primarily by lateral underflow from the north and west. The overlying Hammett Shale mostly prevents vertical movement of water downward except possibly in highly fractured or faulted areas.

The availability amounts listed for the Trinity aquifer below and in Table 3-1 include the volume of water calculated for the lower Trinity aquifer. In general, the percentage of total volumes of the estimated available water from the Trinity aquifer are about one-fourth to almost one-half from the lower Trinity aquifer, with the remaining larger percentage from the middle Trinity aquifer. Almost all of the current utilization of the Plateau Region of the lower Trinity aquifer occurs in or very near the cities of Kerrville and Bandera. As a result, the recoverable water per square mile or acre may be a more useful estimate of availability. In Kerr County, the recoverable water from the lower Trinity ranges from 254 to 426 acre-ft per square mile or 0.40 to 0.89 acre-ft per acre. In Bandera County, the recoverable water from the lower Trinity ranges from 151 to 460 acre-ft per square mile or 0.24 to 0.72 acre-ft per acre. A more detailed description of the lower Trinity can be found in the accompanying report titled "The Lower Trinity Aquifer of Bandera and Kerr Counties, Texas."

3.2.2.1.3 Trinity Aquifer Availability

Availability of water from the Trinity aquifer was determined for the middle and lower Trinity units. Although the upper Trinity is a source of water for some wells, the water quality is usually of a poorer nature, and therefore the upper Trinity was not considered to have usable ground-water availability. The availability of water by aquifer and river basin is given in Table 3-1. The availability totals in the year 2000 by county and region for the Trinity aquifer are as follows:

County	Available Water (acre-ft)
Bandera	705,900
Kerr	210,100
Real	10,700
Region	**926,700**

3.2.2.2 Edwards-Trinity (Plateau) Aquifer

The Edwards-Trinity (Plateau) aquifer (Figure 3-1) consists of saturated sediments of Lower Cretaceous age Trinity Group and overlying limestones and dolomites of the Edwards Group. The Glen Rose Limestone is the primary unit in the Trinity in the southern part of the plateau. Springs issuing from the aquifer form the headwaters for several eastward and southerly flowing rivers. The aquifer generally exists under water-table conditions. However, where the Trinity is fully saturated and a zone of low permeability occurs near the base of the overlying Edwards, artesian conditions may exist in the Trinity. Reported well yields commonly range from less than 50 gallons per minute (gpm) where saturated thickness is thin to more than 1,000 gpm where large-capacity wells are completed in jointed and cavernous limestone.

Usable quality water (containing less than 3,000 mg/l dissolved solids) in the Edwards-Trinity (Plateau) aquifer occurs to depths of up to about 3,000 feet. The water is typically hard and may vary widely in concentrations of dissolved solids made up mostly of calcium and bicarbonate. The salinity of the ground water in the Trinity portion of the aquifer tends to increase toward the southwest. There is little pumpage from the aquifer over most of its extent, and water levels have generally fluctuated only with seasonal precipitation. In some instances, water levels have declined as a result of increased pumpage. Water quality from primarily the Edwards portion of the aquifer is acceptable for most municipal and industrial purposes, however, excess concentrations of certain constituents in many places exceed drinking-water standards for municipal supplies. In some instances, excess levels of constituents are naturally occurring.

In terms of agricultural activity, pesticide application poses a potential threat to water quality of the groundwater supply. The propensity for pesticides to leach past the root zone depends on which pesticide is chosen and on the soil's leaching potential. Water quality problems sometimes pose potential threats to natural resources and the ecological environments. Watercourses where high levels of nutrients have been identified have the potential to experience algal blooms, which may consume too much of the available dissolved oxygen in the water, leaving less oxygen for fish. High levels of dissolved minerals such as sodium in water used to irrigate crops can harm or kill the crops. The best preventative for agricultural activities is to minimize usage and not over apply many of the common agricultural chemicals.

Availability for the Edwards-Trinity (Plateau) in the western counties (Real, Edwards and Kinney) was calculated on a reduced historic saturated thickness of just the Edwards Limestone because the Trinity is either too deep or too salty to be practically used. In Val Verde County, the saturated thickness of the Salmon Peak of the Maverick Basin Edwards Limestone was used for calculating availability. The other Edwards (McKnight and West Nueces) and Trinity units are too deep and contain poorer water quality making them impractical for use. A storage coefficient of 0.02 was used for calculations of storage for the Edwards portion of the aquifer, which is twice that used for the Trinity aquifer. This higher storage coefficient was used because, generally, the Edwards is more transmissive than the Trinity. The availability of ground water by aquifer and river basin is given in Table 3-1, and the availability totals by county and region for the Edwards-Trinity (Plateau) aquifer for the year 2000 are shown below. These availability amounts are total retrievable water from aquifer storage with no consideration for environmental factors such as maintaining spring flow.

County	Available Water (acre-ft)
Bandera	262,200
Edwards	1,730,400
Kerr	718,400
Kinney	890,500
Real	543,600
Val Verde	3,199,700
Total Region	**7,344,800**

3.2.2.3 Edwards (BFZ) Aquifer

In the Plateau region, the westernmost end of the Edwards (BFZ) aquifer occurs only in Kinney County (Figure 3-1). The aquifer, composed predominantly of limestone formed during the early Cretaceous Period, exists under water-table conditions in the outcrop and under artesian conditions where it is confined below the overlying Del Rio Clay. In Kinney County, the Edwards aquifer consists of the Devils River Limestone or the Salmon Peak, McKnight and West Nueces Limestones. Aquifer thickness is as much as 1,000 feet.

Recharge to the aquifer occurs primarily by the downward percolation of surface water from streams draining off the Edwards Plateau to the north and west and by direct infiltration of precipitation on the outcrop. Water in the aquifer generally moves from the recharge zone toward natural discharge points such as Los Moras Springs near Brackettville. Water is also discharged artificially from pumping wells. The aquifer is significantly less permeable farther downdip where the concentration of dissolved solids exceeds 1,000 mg/l. Water levels have shown some minor changes through time but have remained relatively constant.

The chemical quality of water in the aquifer is typically fresh, although hard, with dissolved-solids concentrations averaging less than 500 mg/l. The downdip interface between fresh and slightly-saline water represents the extent of water containing less than 1,000 mg/l. Within a short distance downgradient of this "bad water line" the ground water becomes increasingly mineralized.

As with the Edwards-Trinity (Plateau) aquifer, the Edwards BFZ aquifer is primarily used for agricultural purposes and is therefore most susceptible to contamination from the application of pesticides. The propensity for pesticides to leach past the root zone depends on which pesticide is chosen and on the soil's leaching potential. Water quality problems sometimes pose potential threats to natural resources and the ecological environments. Watercourses where high levels of nutrients have been identified have the potential to experience algal blooms, which may consume too much of the available dissolved oxygen in the water, leaving less oxygen for fish. High levels of dissolved minerals such as sodium in water used to irrigate crops can harm or kill the crops. The best preventative for agricultural activities is to minimize usage and not over apply many of the common agricultural chemicals.

A storage coefficient of 0.02 was used for calculations of storage, which is twice that used for the Trinity aquifer. Availability of ground water from the Edwards (BFZ) in Kinney County for the year 2000 is estimated at about 331,200 acre-ft of total volume.

3.2.2.4 Austin Chalk Aquifer

The Austin Chalk (Figure 3-1) is located in the southern half of Kinney County and the southernmost part of Val Verde County. Many wells located south of Highway 90 obtain part or all of their water from the Austin Chalk. A veneer of gravel deposits covers much of the southwest portion of Kinney County; some wells penetrate both these gravels and the underlying Austin Chalk. A wide range of production rates exists for wells completed in Austin Chalk. The best production from the aquifer occurs in areas that have been fractured or contain a number of solution openings. Most wells only discharge enough water for domestic or livestock use, but a few wells are large enough for irrigation purposes. The largest reported yield for an Austin Chalk well in Kinney County is 2,000 gpm (Bennett and Sayre, 1962).

The total thickness of the Austin Chalk in southern Kinney County is about 200 feet. Availability of water from the aquifer is estimated using 100 feet of saturated thickness and a storage coefficient of 0.01. Most of the wells completed in the Austin Chalk are located along Los Moras Creek and other tributaries to the Rio Grande. Much less production is apparent in the Nueces River Basin and, therefore, estimates of ground-water availability are only made for the Rio Grande River Basin. The estimate of ground-water availability in the year 2000 from the Austin Chalk in Kinney County is 67,000 acre-ft total volume of water.

3.2.2.5 Other Aquifers

Located along many of the streams and rivers throughout most of the region are shallow alluvial floodplain deposits. These deposits range in composition from clay and silt to sand, gravel, cobbles and boulders derived upstream from the Edwards Plateau. Wells completed in these deposits supply small to moderate quantities of water mostly for domestic and livestock purposes. The alluvium is in direct hydraulic connection with the rivers and streams that meander through them. However, because these wells are often shallow, many have gone dry during droughts. Because of this drought uncertainty and because the current information on the alluvial systems is not conclusive, an estimate of availability of water from the alluvium was not made.

The Frio River Alluvium in central Real County extends over an area of approximately 1,120 acres and contains approximately 2,800 acre-ft of recoverable water. Recharge to the aquifer is approximately 1,120 acre-ft annually. Water supplies for the City of Leakey and other rural domestic homes are derived from this small aquifer. Because of the limited extent of this aquifer and its shallow water table, the aquifer system is readily susceptible to contamination from surface sources.

The TWDB has identified the downdip extensions of the Ellenburger-San Saba and the Hickory aquifers in northeast Kerr County. Because no known wells have penetrated these aquifers in Kerr County, very little is known about their water-bearing characteristics. These aquifers are only mentioned here as possible resources but are not included in the supply tables.

3.2.3 Ground-Water Resources in the Vicinity of the City of Del Rio

The City of Del Rio is supplied with water from San Felipe Springs, which issue from the Edwards aquifer near the city. The water is collected through pumps set in the spring orifices, treated with chlorine and then distributed to the city and to Laughlin Air Force Base. The availability amounts listed in section 3.2.2.2 are total retrievable volumes from the total aquifer storage with no consideration for environmental factors such as maintaining spring flow. With the limitation being minimum flow from San Felipe Springs, the aquifer availability in the Del Rio area would be estimated from the difference between minimum required flow and the instantaneous flow. The average discharge of San Felipe Springs is about 110 cubic feet per second or about 80,000 acre-ft per year. During recent droughts the spring discharge has fallen below 50 cfs or extrapolated over one year would be about 36,000 acre-ft. Recent droughts as compared to the 1950's drought would be appropriate to use because the filling of Amistad Lake has generally increased the springflow after the late 1960's. A minimum flow has not been determined for the threatened species living down stream of the springs and a study is needed to determine the actual amount that would have to be subtracted from the total spring flow for availability.

Occasionally after rainstorms, the water discharging from the springs becomes turbid. The turbidity has caused some concern with regulating agencies about the potential for microbial contamination and the reliability of the current chlorine treatment of the spring water. As a result, a microfiltration plant has been proposed to treat all spring water that will be supplied to the city.

The size of the treatment plant may be reduced if additional water from wells can be used. It is believed that water can be produced from wells that are properly completed with cemented surface casing that would not be under the direct influence of surface water and which would not become turbid or contaminated by runoff. As a result, the produced ground water would not require the treatment prescribed for spring water and could be used as a supply that supplements the treated spring water.

Historically, the ground water in the vicinity of Del Rio has been under utilized. Several very large springs issue from the Edwards aquifer in Val Verde County. Water levels in the aquifer measured prior to the construction of Lake Amistad generally indicated that the flow in the aquifer through Val Verde County was from north to south or southwest. After the filling of Lake Amistad in the 1960's, water levels in the vicinity of the lake rose. However, the flow is still from the northern portion of the county to the south to southwest towards the springs. Goodenough Springs, the largest spring in the county, was submerged below the lake by about 100 feet. However, Goodenough Springs still discharges significant volumes of water. This also supports the concept of flow direction in the aquifer towards the lake and not from the lake to the aquifer. The rise in the aquifer levels near the lake is a result of decreased losses from the springs submerged below the lake, which increases the hydraulic head or pressure and reduces flow from the springs. The reduction of flow causes the pressure in the aquifer to increase.

The Edwards aquifer is composed of three formations in the Maverick Basin near Del Rio, the Salmon Peak, McKnight and West Nueces from top to bottom. All known water wells produce water from the Salmon Peak Formation near the top of the aquifer. Water from the McKnight Formation is known to be of poor quality in this area. However, geophysical logs from wells drilled for the exploration of oil indicate that fresh water may occur in the West Nueces. Deepening of a previous test well located to the north of the city has determined that freshwater does occur near the top of the deeper West Nueces Limestone but in relatively small quantities. More detailed information is available on the local ground-water resources in the report titles "Ground-Water Resources of the Edwards Aquifer in the Del Rio Area, Texas".

Two public-supply wells completed into the Salmon Peak located north of the city were used in the past but were abandoned because of disrepair and have not been utilized in the last 10 years. The City plans to repair the wells and bring them back into service. There are also two other city-owned wells west of Del Rio at Tierra del Lago; one well is in use and the other is not. It is also believed that additional Edwards aquifer wells can be completed in the area north of the city to help meet all increased demands by the City of Del Rio for water in the future.

3.2.4 Public-Supply Use of Ground Water

The TWDB lists 160 public water-supply wells in the Plateau Region (Figure 3-3). Of the 160 supply wells, 104 (65 percent) are located in Kerr County where production is primarily from the Edwards-Trinity (Plateau) and Trinity aquifers. Another 28 wells (17 percent) are listed in Bandera County where production is mostly from formations that make up the Trinity aquifer. Of the remaining 28 wells, three are located in Edwards County, four in Kinney County, six in Real County, and 15 in Val Verde County. Ground-water production in Edwards, Real and Val Verde Counties is mostly from formations that make up the Edwards-Trinity (Plateau) aquifer. In Kinney County, public-supply wells for the Town of Brackettville and the Ft. Clark Municipal Utility District are completed in the Edwards (BFZ) aquifer. The higher concentration of wells in Kerr and Bandera Counties is related to population growth and the need to provide water for new residents.

Historical water-level measurements are only available for public supply wells in the cities of Bandera and Kerrville. Public supply wells serving other communities in Edwards, Kinney, Real and Val Verde Counties are not anticipated to have long-term declines due to the relatively smaller quantities of water that are needed to serve these communities. Only the community of Leakey is anticipated to have a shortage based on drought-of-record conditions in the future (see Chapters 4 and 5). Also, no long-term water-quality deterioration is detected in ground-water supplies for these communities. The principal water supply for Del Rio is not currently produced from wells. Long-term viability of the aquifers serving these other communities appears to be acceptable. However, new wells should be located outside the local areas of pumping influence of the existing wells. Although no evidence of contamination from surface sources have been detected in public-supply ground-water sources in the Plateau Region, a well-head protection program should be considered by all communities.

A City of Bandera well (69-24-202) shows a consistent decline from the 1950's through the 1990's, with a total of approximately 400 feet of water level decline. City of Kerrville wells No. 4 and No. 11 have experienced declines of as much as 200 feet through the early to mid-1980's. Between the early to mid-1980's and the early 1990's, water levels in these two wells increased by as much as 200 feet in response to the decreased pumpage by the City when surface water sources were brought on-line. However, since the early 1990's, water levels have again begun to decline, as much as 100 feet or more in many Kerrville wells. Because there is little data available outside of the Kerrville and Bandera areas, regional declines in lower Trinity aquifer ground-water levels are not able to be determined. Most of the water withdrawn by Bandera and Kerrville public supply wells is produced from the lower Trinity which receives very little vertical recharge and an undetermined amount of lateral underflow from the north and west of the well fields.

The only long-term water-quality degradation trend observed in City of Bandera and Kerrville public-supply wells is noted in the increase in sodium, chloride and total dissolved solids in City of Kerrville Travis Well #14 during the late 1960=s to mid-1970=s. The well showed steady increases in sodium (18 to 72 mg/L), chloride (55 to 200 mg/L), and total dissolved solids (417 to 624 mg/L) between 1968 and 1976. This corresponded with the time period that large drawdowns in water levels were occurring in the Kerrville area. This indicates that large withdrawals of lower Trinity ground water in the Kerrville area may cause degradation in water quality. The city mixes this water with water from other wells to maintain acceptable overall quality.

Both cities must compete for water from the lower Trinity with numerous other private wells in the counties. Long-term viability of the Trinity aquifer as a supply source for these cities will require implementation of management policies aimed at establishing withdrawals based on the sustainable yield of the aquifer. Sustainable yield of the lower Trinity has not been established due to lack of available hydrologic data; additional studies based on evaluation of continuous water-level trends is needed. Because of the continuous water-level decline in these well fields, both cities should monitor levels to anticipate production reductions. Specific strategies to meet Kerrville’s future water needs are addressed in Chapter 5. If additional wells are needed for increasing supply needs, the cities should consider locating new wells outside the local area of pumping influence. Both cities should also cooperate with efforts of the local groundwater conservation districts to establish aquifer management policies. More detailed information about the lower Trinity aquifer is contained in the report “The Lower Trinity Aquifer of Bandera and Kerr Counties, Texas”.

3.2.5 Agricultural Use of Ground Water

Because of the arid conditions and lack of well-developed soils over much of the region, irrigated agricultural activities are generally limited in most of the counties. Low well yields common throughout much of the region limit the development of large-scale irrigation. Water quality through most of the region, however, is not a limiting factor for irrigation. Kinney County has the greatest amount of agricultural use of water. The acreage of land irrigated by ground water in each county surveyed by the TWDB in 1994 is, from most to least, Kinney, 4,735 acres; Kerr, 225 acres; Bandera, 181 acres; Val Verde, 160 acres; Real, 60 acres; and Edwards, 40 acres. In Kinney County, about one-half of the irrigated acreage is supplied by water from the Edwards-Trinity (Plateau) aquifer, about one-fourth of the irrigated acreage for the county is supplied water from Edwards (BFZ) aquifer and the remaining one-fourth of the irrigated acreage is supplied by water from the Austin Chalk. Irrigation in the other counties in the region is supplied water from the Edwards-Trinity (Plateau) aquifer or the Trinity aquifer.

A review of historical and current data suggests that there has been no long-term change in regional water levels or water quality as a result of agricultural pumping. Local water-level declines occur during the irrigation season but generally recover during the off season. Although irrigation conservation efficiencies could be improved, currently used equipment and practices are not resulting in depletion of the aquifers. At the current rate of agricultural use, ground water of sufficient quantity in the Edwards-Trinity (Plateau), Edwards BFZ, and Austin Chalk aquifers should remain available for future agricultural use. However, the competition for Trinity aquifer water between municipal and agricultural needs in Bandera and Kerr Counties is increasing. The Springhills water Management District and the Headwaters Underground Water Conservation District are both actively involved in managing the use of this critical aquifer in these counties.

3.3 SURFACE-WATER SUPPLIES

Surface-water supplies available under Drought-of-Record conditions depend on two components: water that is physically present (usually substantially reduced since the Drought-of-Record is by definition the most severe) and the water diverted as per existing water right authorizations. The Texas Natural Resource Conservation Commission (TNRCC) water-availability models simulate the hydrology of the watershed and calculate naturalized streamflows, then perform accounting of simulated diversions for each water right. The TNRCC's "Legacy" Revised Guadalupe-San Antonio Water-Availability Model, 1983, Run 1, has been recently updated. The "Legacy" Water-Availability Model for the Nueces River Basin has likewise been updated. The updated model became available in February 2000. In most instances, the surface-water Drought-of-Record supply amounts for the Plateau Region have been extracted from the updated water-availability models.

For localized areas of the Plateau Region, the recent drought evidently exceeds the 1950s drought, and therefore these localized areas have a new Drought-of-Record as exemplified in recent years. These areas are the Sabinal River and Hondo Creek in Bandera County and the West Nueces River in Edwards and Kinney Counties. These geographic areas lie within the Nueces River Basin. Whereas the updated water-availability model for the Guadalupe-San Antonio River Basin does not include recent-year data, the updated water-availability model for the Nueces River Basin does include these recent data through 1996. The new Drought-of-Record of recent years, then, can be properly represented by the Nueces River Basin Water-Availability Model for the localized areas within the Nueces River Basin. Data sources used for Drought-of-Record amounts are discussed in the report sections corresponding to each source of surface-water supply.

Drought-of-Record supply amounts have been determined for run-of-the-river on several watercourses deemed to be "major watercourses" within the Plateau Region. Supply amounts on river segments have always been difficult to assess due to the lack of a reservoir to catch the supply. For purposes of this plan, the Drought-of-Record supply amounts for watercourses have been determined at the water right on the watercourse that is the most downstream yet still within the Plateau Region.

Drought-of-Record supply amounts for reservoirs are on a firm-yield basis. To understand firm yield, one must understand the concept of "mass balance" - the simple but true principle of physics that mass can neither be created nor be destroyed (i.e., what goes in has to come out). In practical terms as applied to a reservoir, the water going in (inflows from drainage areas of tributaries feeding the reservoir site) equals the water going out (evaporation off the lake surface plus water spilled over the dam plus any water allowed to pass through the dam to satisfy senior water rights downstream plus the demand placed on the reservoir plus other factors which may exist). Engineers and hydrologists simulate the operation of a reservoir under various demands placed on the reservoir, iterating the simulation to find a demand that the reservoir can supply consistently throughout a repeat of the historical hydrologic regime. Demand is termed the "firm yield" of the reservoir if for every year of the historical hydrologic regime (even during the Drought-of-Record) the reservoir can supply the demand placed on it.

Canyon Reservoir and the Medina/Diversion system are key water supply reservoirs for the Plateau Region's future water needs. Although neither reservoir currently serves a water need within the region, both reservoirs will likely do so in the near future.

Although recreational use of streams and lakes serves an important function in the Plateau Region, its use has no impact on reservoir yields, as these uses are nonconsumptive. However, in some instances, recreational use may harm the water quality of a water supply (e.g., aluminum cans thrown into a lake or fuel byproducts from boat engines).

3.3.1 Medina River

The term "run-of-the-river" is used to distinguish water rights with diversion points directly on a watercourse from water rights with diversion points on a reservoir. Generally speaking, run-of-the-river water rights, also referred to as "direct diversions," are less dependable than are water rights on reservoirs (i.e., during drought the river might become dry). However, run-of-the-river diversions are often very convenient, especially for irrigators and small entities, because a diversion point on a watercourse can be located extremely close to the location where the water will actually be consumed, thereby negating the need to pipe the water over long distances.

Run-of-the-river authorizations exclude authorizations on Medina Lake itself. Eight authorized water rights on the Medina River main stem total 236 acre-ft/yr. Of these eight water-right holders on the river, six use the water for irrigation. The sum of these six irrigation rights totals 227 acre-ft/yr. Of the remaining two water-right holders, one is for 9 acre-feet of water per year used by an individual for municipal purposes, and the other is for a nonconsumptive recreation reservoir owned by the City of Bandera. This recreation-only reservoir is for nonconsumptive use only.

For portions of the Plateau Region lying within the Nueces River Basin, the recent drought evidently exceeds the 1950s drought. Determining if this is true for the localized area on the Medina River, is appropriate and necessary. USGS gage 08178880 on the Medina River at Bandera just downstream of State Highway 173 gives a lowest annual streamflow amount at 33.7 cubic feet per second (cfs) (approximately 24,600 acre-ft/yr) in 1996. However, this gage did not begin recording until 1982, and therefore records from the 1950s drought are missing and cannot be compared to the low flows of 1996. In the absence of data to the contrary, it is assumed that the 1950s are still the Drought of Record for the localized area on the Medina River in the Plateau Region.

For the Medina River in Bandera County, the Drought-of-Record supply amount is extracted from the updated Guadalupe-San Antonio River Basin Water-Availability Model (February 2000, Run 3). The model gives 3,367 acre-ft as the minimum amount of regulated streamflow in the river at a control point upstream of Medina Lake, but otherwise downstream of all other water rights on the river.

3.3.2 Medina Lake on the Medina River

Medina Lake was constructed in 1911 to provide irrigation water for farmers to the southwest of San Antonio. Although commonly referred to as Medina Lake, the lake is actually a system consisting of Medina Lake and Diversion Lake. Impounded in 1913, Diversion Lake is approximately 4 miles downstream of Medina Lake. Diversions are authorized only from Diversion Lake, as per the water right held by Bexar-Medina-Atascosa Water Control and Improvement District #1 (BMAWCID#1).

BMAWCID#1's Adjudication Certificate No. 19-2130C authorizes the District to divert up to 65,830 acre-ft/yr of water for irrigation, municipal and industrial use, up to 750 acre-ft/yr specifically for domestic and livestock purposes, and up to 170 acre-ft/yr specifically for municipal use. At one time this Adjudication Certificate had been amended to Certificate No. 19-2130D; this amendment was contested in a lawsuit and remanded back to the TNRCC for revision. The new amendment then contained a Special Condition stating that it would expire on January 1, 2000 without further Commission consideration. Since that amendment has now indeed expired, the Adjudication Certificate No. 19-2130C is back in effect.

BMAWCID#1 has signed contracts to supply several irrigators and a development corporation with water. In January 2000 BMAWCID#1 signed a contract with Bexar Metropolitan Water Authority indicating that BMAWCID#1 will sell 20,000 acre-ft/yr to Bexar Metropolitan Water Authority for municipal use.

Bandera County currently has a Water Supply Agreement with BMAWCID#1 for purchase of up to 5,000 acre-ft/yr; however, this agreement is not currently associated with the infrastructure necessary to carry out the purchase and subsequent distribution of the water.

Loss of impounded water from both Medina Lake and Diversion Lake, to the Trinity aquifer and the Edwards aquifer, respectively, reduces the firm yield of the system. This loss has long been known to be substantial. Quantification of water recharging the aquifers has been elusive – different estimates of recharge have resulted in different firm-yield estimates for the system. In 1957 a Bureau of Reclamation study estimated the firm annual yield of the Medina Lake/Diversion Lake system. The Bureau estimated the firm yield as 27,500 acre-ft/yr if the lake system were operated under an agricultural (irrigation) demand only scenario, but it estimated 29,700 acre-ft/yr as the firm yield for municipal and industrial demand. Due to effects of seepage around the dam and of recharge to ground water, Espey Huston estimated a firm yield of zero for Medina Lake in 1994, based on the relationship Espey Huston found between the stage of Lake Medina and recharge. HDR modified the Espey Huston stage-recharge curves for its Trans-Texas report and cited 8,770 acre-ft/yr as the firm yield in the report. According to personal communication with HDR, HDR assumed, for the Trans-Texas study, diversions would be from Medina Lake rather than from Diversion Lake and that all irrigation use would be curtailed. This assumption does not comply with existing conditions as regards water- rights authorizations.

The latest USGS report, "Assessment of Hydrogeology, Hydrologic Budget, and Water Chemistry of the Medina Lake Area, Medina and Bandera Counties, Texas," maintains that earlier methods of estimating recharge (Lowry, Espey-Huston curves as modified by HDR for the Trans-Texas report) overestimate recharge. Overestimation of recharge would result in values too low for firm yield of the system. The USGS report did not include a firm-yield estimate for the reservoir system.

The TNRCC's updated water-availability model for the Guadalupe-San Antonio River Basins became available in February 2000. This model intrinsically incorporates the HDR Trans-Texas method of estimating recharge, which some persons in both Plateau Region J and Region L have questioned in the wake of the latest USGS report. However, the water-availability model probably provides the best overall data (water rights, inflows determined by water rights) available at this time. The model was used to determine a firm yield of the Medina/Diversion system of 0 acre-ft/yr.

3.3.3 Guadalupe River

The Guadalupe River is an extremely important surface-water resource for the Plateau Region, because surface-water sources are so scarce in the region. Although the Plateau Region contains portions of five different river basins, the portions contained in every case are the headwaters. Only limited runoff accumulates in the small drainage areas associated with headwaters. The segment of the Guadalupe River within the Plateau Region drains approximately 510 square miles at Kerrville, and drains approximately 839 square miles at Comfort (which is near the Kerr/Kendall County Line and thus just outside Plateau Region boundaries).

For the segment of the Guadalupe River within the Plateau Region, the total amount of water rights authorized is for 12,128 acre-ft/yr. Municipal use accounts for the highest authorization for the water rights, at 7,932 acre-ft/yr. Holders of these water rights include independent persons, the City of Kerrville, and the Upper Guadalupe River Authority.

Industrial uses are authorized for 17 acre-ft/yr; separate individuals own these water rights. The amount of water authorized for irrigation is 4,026 acre-ft/yr. Water-rights holders for irrigation use consist of irrigators, the City of Kerrville and several companies.

The remaining water-rights holders use their water for mining, hydroelectric power, and recreation. Mining accounts for 153 acre-ft/yr of water; these water-rights holders are separate individuals and one corporation. Although one individual holds a water right for hydroelectric use, this right has not been exercised. Kerr County holds the rights for three nonconsumptive recreation-use reservoirs in and near Kerrville.

The Upper Guadalupe River Authority and City of Kerrville are both authorized to divert from an 840-acre-ft impoundment on the Guadalupe River within the city; this impoundment was originally UGRA's impoundment as authorized in its water right Permit No. 3505. The City of Kerrville has authorization to divert 761 acre-ft/yr on a firm- yield basis for injection into the lower Trinity aquifer for municipal use, and 339 acre-ft/yr on a run-of-the-river basis for injection into the aquifer for municipal use, and 1,069 acre-ft/yr on a run-of-the-river basis for injection into the aquifer for maintenance of the firm yield of the system and for subsequent retrieval for municipal use. The Upper Guadalupe River Authority is authorized to divert 1,661 acre-ft/yr on a firm-yield basis for injection to the lower Trinity aquifer for municipal use by Kerr County entities other than the City of Kerrville, and 339 acre-ft/yr on a firm-yield basis for injection into the aquifer for maintenance of firm yield of the system and for subsequent retrieval for municipal use.

Both the City of Kerrville and the Upper Guadalupe River Authority have within their authorizations (Permits Nos. 5394B and 5394A respectively) a Special Condition addressing the seasonal distribution of allowed diversions. The Special Condition stipulates that during the months October through May, the permittees may divert only when the flow of the Guadalupe River exceeds 40 cfs, and during the months of June through September, the permittees are authorized to divert only when the flow of the Guadalupe River exceeds 30 cfs. Another Special Condition common to both permittees is that, when inflows to Canyon reservoir are less than 50 cfs, each permittee is to restrict diversions to allow a flow of at least 50-cfs to pass through. Yet another Special Condition imposed on both permittees is that diversions may be made only when the level of Canyon reservoir is above 1,608 feet above mean sea level.

Kerr County has a Memorandum of Understanding with Guadalupe-Blanco River Authority (GBRA) indicating that GBRA is placing 6,000 acre-ft/yr of water in reserve for the county, dependent on GBRA's obtaining an amendment to its water right for Canyon Reservoir. Similarly, Upper Guadalupe River Authority is currently negotiating water-purchase contracts with GBRA for water from Canyon Reservoir.

The TNRCC’s "Legacy" Revised Guadalupe-San Antonio Water-Availability Model, 1983, Run 1, has been recently updated. Even though updated, this model does not include data for years beyond 1989; therefore, an investigation as to whether the Drought-of-Record for the Guadalupe River area occurred in the 1950s or in the 1990s is appropriate and necessary. Measured flows at stream gages are use in this regard.

The USGS gage 08166200 on the Guadalupe River at Kerrville 300 feet below the dam gives a lowest annual streamflow amount at 63.6 cfs in 1996; this equates to 46,428 acre-ft/yr and is greatly influenced by the presence of the dam and Special Conditions of the water rights authorized to the City of Kerrville and the Upper Guadalupe River Authority. Additionally, this gage has been recording only since July 1986. Other gages on the Guadalupe River near Hunt and on the North Fork Guadalupe near Hunt have been recording since April 1965 and August 1967, respectively. Therefore, none of these gages recorded the flows during the 1950s and it cannot be stated from these gaged flows that the Drought-of-Record for Kerr County occurred at some time other than the 1950s.

The USGS gage 08167000 on the Guadalupe River at Comfort gives a lowest annual streamflow amount of 14.5 cfs (approximately 10,585 acre-ft/yr) occurring in 1956. This gage has been recording since 1939. Interestingly, statistics for the gage include the fact that, for water years 1939 through 1997, the mean annual runoff was 157,800 acre-feet or approximately 216 cfs, and that 90 percent of these flows exceeded 25 cfs. This puts the 1956 occurrence of 14.5 cfs into the 10 percent nonexceedance category. In calendar year 1996 the annual mean was 151 cfs and the median was 85 cfs. The mean and median for 1997 exceeded the 1996 values. These facts seem to substantiate that the Drought-of-Record for Kerr County occurred not in 1996, but in 1956, as consistent with most other areas of the state. Therefore, for purposes of Table 3-1, data extracted from the updated water-availability model should be adequate because its exclusion of flows for recent years is irrelevant. The Drought-of-Record supply amount for the Upper Guadalupe River is 6,867 acre-ft/yr.

3.3.4 Canyon Reservoir

The construction of Canyon Reservoir was completed and impoundment commenced in June 1964. This reservoir controls approximately 1,425 square miles of drainage area and serves to impound water for various uses (mostly appropriated to the GBRA, for use primarily in Region L). Canyon is also an Army Corps of Engineers (COE) Reservoir and as such operates under the Army COE Operations Manual as occasionally modified by request of GBRA (and agreed to by county judges of the downstream counties). Canyon Reservoir is also subject to the

Federal Emergency Management Agency's (FEMA) requirements as to daily releases. The Army COE and FEMA operations and release requirements are incorporated into the updated TNRCC Water-Availability Model for the Guadalupe-San Antonio River Basin. The firm yield of Canyon Reservoir is 36,000 acre-feet, as developed from the updated TNRCC water-availability model (Run No. 3).

3.3.5 Amistad International Reservoir on the Rio Grande

The Amistad International Reservoir is located on the border between the United States and Mexico, constructed jointly between the two nations, near the City of Del Rio. It was completed in 1968 with a maximum capacity of 5,250,000 acre-feet - 3,505,000 acre-feet of which is used for water conservation. The water is distributed among downstream users of Mexico and the United States. However, Amistad is not a source of supply for the Plateau Region, as the City of Del Rio obtains its supply primarily from San Felipe Springs.

3.3.6 Sabinal River, Hondo Creek and West Nueces River of the Nueces River Basin

Headwater tributaries of the Nueces River located in the Plateau Region include the Sabinal River and Hondo Creek in Bandera County and the West Nueces River in Edwards and Kinney Counties. Noted previously was the observation that, for this river basin, the Drought-of-Record occurred not in the 1950s, but in recent years. USGS gages on the Sabinal River, Hondo Creek and West Nueces River seem to substantiate this assertion; flows at these gages during recent years were significantly reduced from expected historical flows.

The locations of gages USGS 08198500 (Sabinal River at Sabinal in eastern Uvalde County) and USGS 08200700 (Hondo Creek at King Waterhole near Hondo in central Medina County) are outside the Plateau Region, but the gages themselves measure flows from drainage areas lying within counties of the Plateau Region. The location of USGS gage 08190500 on the West Nueces River is near Brackettville in Kinney County within the Plateau Region.

An internal TWDB memorandum dated May 26, 1998 cites the Sabinal and Hondo gages as having experienced streamflows in calendar years 1994 through 1996 significantly reduced from expected historical flows, and cites the West Nueces gage as having experienced streamflow in calendar years 1994 and 1995 significantly reduced from expected historical flows. The memorandum defines "significantly reduced" as showing a 40 percent or more difference between the historical and the recent year nonexceedance probabilities. (It should be noted that for all three of these gages 1997 flows were improved over the 1994 through 1996 flows.)

Several water-right holders within the Plateau Region depend on these watercourses for their water supply. The total of the authorized amounts for water rights on the Sabinal within Bandera County is 141 acre-ft/yr. All but 4 acre-feet of this total authorized amount are for irrigation. There is only one water right on Hondo Creek within the Plateau Region, and the authorized amount is 24 acre-ft/yr, for irrigation use. The total amount authorized for consumption on the West Nueces River within Edwards and Kinney Counties is 200 acre-ft/yr, for a single irrigation use water right in Edwards County. Two other nonconsumptive water rights on the West Nueces are for recreation and "other" use.

The updated TNRCC Water-Availability Model for the Nueces River Basin became available in February 2000. This model includes data through the year 1996, and therefore addresses the Drought-of-Record for the localized areas on these watercourses occurring in recent years (rather than in the 1950s.) The Drought-of-Record supply amounts in Table 3-1 for Sabinal River, Hondo Creek and West Nueces River are, as extracted from this model (Run No. 3), for the most downstream water right lying on the watercourse within the county of interest. The Drought-of-Record supply amount for the Sabinal River in Bandera County is 3,943 acre-ft/yr and for Hondo Creek in Bandera County 0 acre-ft/yr. The Drought-of-Record supply amount for the West Nueces in Edwards County is 267 acre-ft/yr and for the West Nueces in Kinney County 443 acre-ft/yr.

3.3.7 Nueces River Main Stem and Frio River of the Nueces River Basin

The main stem Nueces forms a portion of the border between Real County and Edwards County, while the Frio River snakes through central Real County. Flows for the mainstem Nueces River are gaged at USGS 08192000 near Uvalde in Uvalde County. These gaged flows for a period of record of 1939 through 1997 indicate a low annual flow of 3.63 cfs (approximately 2,650 acre-ft/yr), occurring in 1956. Flows for the Frio River are gaged at USGS 08195000 at Concan in Uvalde County. These gaged flows for a period of record of 1930 through 1997 indicate a low annual flow of 8.8 cfs (approximately 6,424 acre-ft/yr), occurring in 1956. For these areas, the 1950s drought was evidently the Drought-of-Record.

Water rights on the Nueces River mainstem within the Plateau Region are all for irrigation use; the total amount is 993 acre-ft/yr, with the amount divided into 820 acre-feet in Real County and 173 acre-feet in Edwards County. Water rights on the Frio River mainstem within the Plateau Region are likewise all for irrigation use; the total amount is 2,296 acre-ft/yr.

Drought-of-Record supply amounts entered in Table 3-1, as extracted from the TNRCC Water-Availability Model, are for the most downstream water right lying on the watercourse within the county of interest. The Drought-of-Record supply amount for the Nueces River in Real County is 7,001 acre-ft/yr; for the Nueces River in Edwards County the amount is only 1 acre-foot per year. The Drought-of-Record supply amount for the Frio River in Real County is 1,294 acre-ft/yr.

3.3.8 South Llano River of the Colorado River Basin

The South Llano River headwaters lie in Edwards County in the Colorado River Basin. The TNRCC "Legacy" Water-Availability Model for the Colorado River Basin has not been updated; the latest version, dated 1979, includes water rights through April 1978. Run No. 3 of this model gives annual outflow amounts on the South Llano River at a location approximately at the Edwards/Kimble County Line. The minimum amount of 2,632 acre-feet (equivalent to 3.6 cfs) occurs in 1956. This seems to indicate that for this area of the Plateau Region, the drought of the 1950s was truly the Drought-of-Record. Flows for the South Llano River are not gaged. USGS gage 08150000 on the Llano River near Junction in Kimble County is the gage nearest to the South Llano. These gage records are discontinuous and do not include the period 1994 through September 1997, so they cannot provide any evidence on the drought of recent years.

There is only one water right on the South Llano River within the Plateau Region. This right is for irrigation use, and the authorized amount is 88 acre-ft/yr.

In the absence of data to the contrary, the appropriate value for the Drought-of-Record amount for the South Llano River lying within the Plateau Region is 2,632 acre-ft/yr. For the next regional water-planning cycle, the TNRCC will have an updated Water-Availability Model for the Colorado River Basin, and data extracted from the updated model should be available for use at that time.

3.3.9 Pecos River and Devils River of the Rio Grande Basin

The Pecos River forms a portion of the boundary between Terrell County in the Far West Texas Region and Crockett County in Region F before reaching Langtry in Val Verde County in the Plateau Region. The Devils River headwaters originate in Sutton County; the river then proceeds through Val Verde County before reaching Amistad International Reservoir.

Since the Pecos River is regulated by Red Bluff Reservoir – which in turn is directly affected by delivery of water from New Mexico as per the Pecos River Compact – its flows are fairly constant. The USGS gage on the Pecos River at Girvin in Pecos County shows that flows of the river generally vary only about 4 to 15 cfs diurnally; however, a single rainfall event may result in a "spike" which peaks and dissipates within a matter of 2 to 6 hours. The USGS gage on the Pecos River at Langtry does not record streamflows but gives only water-quality data. There are no surface-water rights on the Pecos and Devils rivers within the Plateau Region.

When Pecos waters are delivered to Texas by New Mexico as per the Compact, these waters are stored in Red Bluff Reservoir and further allocated by a master irrigation control district to seven other irrigation districts downstream. The irrigation districts are located in Loving, Ward, Reeves and Pecos Counties, which lie in the neighboring Region F. Substantial losses of water from the Pecos River to ground water reduce flows reaching Val Verde County. Water that does reach Val Verde County is considered too saline for irrigation use. The Drought-of-Record amount of supply for the Pecos River within the Plateau Region is approximately zero, with livestock watering apparently being the only use made of whatever little water that may remain in the river. During drought conditions no water reaches the Girvin gaging station.

Flows of the Devils River are gaged by USGS 08449400 at Pafford Crossing near Comstock in Val Verde County. This gage began recording in 1978 and was discontinued in 1985. Therefore, it does not record flows for the 1950s. However, from 1978 through 1985 the flows are consistently between approximately 100 and 300 cfs, with rare spikes ranging from 4,000 cfs up to 50,000 cfs. These spikes result from unusually intense but short rainfall events. In absence of data for the 1950s drought period, and considering the generally low and undependable flows within the Devils River, a realistic estimate of the Drought-of-Record amount of supply from the Devils River within the Plateau Region is approximately zero.

3.3.10 San Felipe Springs

The City of Del Rio has a water right authorizing it to divert 11,416 acre-ft/yr from the springs for municipal use. San Felipe Manufacturing and Irrigation Company has a water right authorizing it to divert 4,962 acre-ft/yr for irrigation use and 50 acre-ft/yr for industrial use. The total authorized amount is 16,428 acre-ft/yr. No data exist for flows during the drought of the 1950s. The only available records are from USGS gage 08452800 maintained by the IBWC, San Felipe Springs near Del Rio; these records cover the period of record February 1961 to present. The minimum annual amount during this time period was 36,580 acre-ft/yr (occurring in 1963).

3.3.11 Water Quality of Reservoirs

Section 314 of the Federal Clean Water Act of 1987 requires all states to classify lakes and/or reservoirs according to that water body's trophic state (essentially its nutritional status). Poorly nourished reservoirs are referred to as oligotrophic, whereas overnourished reservoirs are termed hyper-eutrophic. Typically, phosphorous is the nutrient of concern, as an increase in its concentration may trigger a responding increase in the amount of algae (estimated by the level of chlorophyll a). With increased algal biomass, water transparency would be expected to decease.

The reservoirs within the Plateau Region – Amistad Reservoir, Medina Lake and Medina Diversion Lake – happen to be some of the clearest (most transparent) water bodies in the state of Texas. Amistad Reservoir is the third clearest water body in Texas. Medina Lake is the fifth clearest, while Medina Diversion Lake is the ninth clearest water body (TNRCC, 1996, Table 41,

p. 171). TNRCC compared chlorophyll a values for 104 Texas reservoirs from the 1994 and 1996 reporting cycles. Of these, reservoirs that showed the most improvement in nutrient status, as evidence by decreases in algal biomass, included Medina Lake (TNRCC, 1996, p. 177).

However, TNRCC also identified the levels of diazinon in Medina Lake as exceeding both the chronic and acute criteria for protection of aquatic life (TNRCC, 1996, Table 52, p. 217). These criteria are defined in terms of toxic substances in ambient water.

The TNRCC has also defined criteria in terms of toxic substances found in fish tissue harvested from water bodies. In the Plateau Region, the water-quality segment of concern for toxic substances found in fish tissue is the Rio Grande above Amistad Reservoir; selenium is the toxin identified (TNRCC, 1996, Table 55, p. 222).

It is possible that if recreational use increases on these reservoirs, particularly water sports involving motorboats or jet skis, the impact may be negative. Byproducts from fuel combustion may become a problem on the reservoirs.

The state's clean Water Program administers federal Clean Water Act directives through TNRCC's Water Quality Inventories. TNRCC is the responsible agency for identifying water-quality problems within the Water Quality Inventory. However, the Inventory does not identify sources of water-quality problems, as in most cases, the problems are "non-point source" pollutants. TNRCC, EPA and other agencies have discussed and researched methodologies by which non-point source pollution could be modeled, but thus far modeling efforts have been less than satisfactory. Detailed excerpts from the Water Quality Inventory are included in the Chapter 3 Appendices; these excerpts address potential water-quality threats to river systems in the Plateau Region, including Medina Lake, citing no known water quality problems (i.e., Plateau rivers are clear of the parameters which the agency monitors). Water-quantity threats are discussed elsewhere in Chapter 3 and in Table 3-1. Generally, under drought-of-record conditions, Hondo Creek, Nueces River, West Nueces River, Pecos River, and Devils River are dry or very low.

The impact of water-quality problems on public health varies depending on parameters and levels identified. Treatment costs associated with reducing biochemical parameters may increase depending on the parameters and levels identified. In addition, agricultural yields may be impacted based on the type of chemical in question. For example, diazinol may interfere with the herbs-pesticides farmers apply.

3.3.12 Surface Water Rights

The right to use water from the navigable streams and lakes is permitted through the State of Texas. Current permit holders in the region and expiration dates are listed in the Chapter 3 appendices along with reported diversions from 1990 through 1999. The following permits are due to expire during the 50-year planning period:

- WR # 5401 a nonconsumptive recreational use, on Turtle Creek in Kerr County (Guadalupe Basin), expires 12/31/2012
- WR # 5097 a consumptive irrigation use for 120 AF/yr, on West Prong of Medina River in Bandera County (San Antonio Basin), expires 02/02/2016
- WR # 3853 a nonconsumptive recreational use, on Spires Creek in Bandera County (San Antonio Basin), expires 04/12/2018

Major downstream water rights include those in Region L supplied by the Guadalupe-Blanco River Authority out of Canyon Lake and by the Bexar-Medina-Atascosa WCID#1 out of the Medina-Diversion Lake System. The firm yields of Canyon and Medina limit the amount of water available for appropriation in both the Plateau Region and Region L. Major downstream water rights in Region M (i.e., cities and irrigators on the Rio Grande downstream from Amistad Reservoir) do not limit the amount of water available for appropriation in the Plateau Region because currently the Plateau Region does not depend on the Falcon-Amistad system. TNRCC's Lower Rio Grande Watermaster allocates water rights on the Rio Grande according to the supply in the Amistad Reservoir and in accordance with the 1944 international treaty with Mexico.

3.4 GROUND-WATER/SURFACE-WATER RELATIONS

One component of recharge to ground-water systems is stream losses from surface water that may occur. Conversely, aquifers can lose water to the surface through springs or through stretches of streams that gain additional flow from the aquifer. The main criteria for surface-water gains or losses to aquifers are the geology underlying the streams and the water level in the aquifer being either lower or higher than the stream. This results in water flowing either to the stream from the aquifer or to the aquifer from the stream.

The largest springs in the region are Goodenough and San Felipe Springs (Val Verde County) and Los Moras Springs (Kinney County), which issue from the Edwards Limestone. However, numerous smaller springs throughout the region issue from either the Edwards or Glen Rose Limestones. These are areas where the aquifers are losing water to the surface. Many of the springs in the northern portion of the region in the Edwards-Trinity (Plateau) issue near the contact between the Edwards and the upper Glen Rose Limestones. These discharges from springs are the primary source of continuous flow to the rivers downstream. Protection of these springflows is important to the continued flow of many of the rivers in the region. Also, these springflows are important environmentally because the springs are the primary source of water to wildlife in the area.

Much of the stream lengths in Kerr, Bandera, Real and Edwards Counties are located over the upper Glen Rose. In general, because of the alternating sequence of limestone with marly clays, the upper Glen Rose often rejects most infiltration. Any water lost to the upper Glen Rose usually exists as seeps or small springs at the contact between the clays and limestone. The Edwards Limestone and lower Glen Rose Limestone are better candidates geologically for streams losing water to the aquifers. Examples of these areas are along the Medina River and Medina Lake in Bandera County where lower Glen Rose Limestone is exposed, and at higher elevations where tributaries of the Colorado, Guadalupe, Nueces and Rio Grande traverse over Edwards Limestone. Figure 3-4 shows segments of streams in which the base flow is most likely to be gaining or loosing.

Gain/loss studies are needed to identify stream segments that are critical to aquifer recharge and spring discharge. The studies can be used to identify where recharge structures would be most efficient and where most river base-flow gain occurs. Specific candidate areas occur over the plateau area that is underlain by Edwards Limestone, especially in the upper tributaries of all the rivers. Studies in western Kerr County would identify critical recharge zones that contribute to springs further downdip that maintain flow to the Upper Guadalupe River. Gain/loss studies of tributaries in the vicinity of Del Rio would be beneficial in understanding the recharge areas that contribute to San Felipe Springs. Also recommended are areas of Bandera County where the Medina River and its tributaries (i.e., Bandera Creek, Masons Creek, Privilege Creek, Pipe Creek and Red Bluff Creek) near the city of Bandera are underlain by the lower Glen Rose Limestone.

Most of the springs located in the headwaters of rivers that traverse the eastern part of the region issue from the contact between the Upper Glen Rose Limestone (Upper Trinity) and the Edwards Limestone. Most of the well production in the Hill Country is from the middle Trinity aquifer with some additional usage from the lower Trinity aquifer. Only small domestic and stock wells are completed into the Upper Glen Rose or Plateau Edwards Limestone and therefore have minimal impact on the springflow to the headwaters of the streams. The only possible impact to the shallow ground water (Upper Trinity) from pumping of the middle and lower Trinity is that leakage between the upper and middle Trinity might increase with the drop in head levels between the aquifers. However, this leakage component is currently thought to be relatively small as compared to other hydrologic factors.

Springs located in the western part of the region issue primarily from the Edwards Limestone. Because of very little use of ground water from wells in the Del Rio area, San Felipe Springs has not had to compete for source water. A significant increase in ground-water pumpage immediate updip of the springs would likely lower the water table sufficiently to affect flow from the springs. Historically, greater rates of irrigation pumpage north of Las Moras springs have had some effect on the springs. Because much of the recharge areas for the contributing zones of these western springs occur in remote areas, very little information is available concerning the relationship between the springs and the underlying aquifers.

3.5 WATER SUPPLY AVAILABILITY SUMMARY

The source of water supplies in the Plateau Region is principally from five aquifers and, to a lesser extent, from numerous streams and rivers. Across much of the region, ground-water sources are the only supply option. Available supplies from these aquifers may be limited by small well yields and, in some cases, by poor quality. Where water needs are relatively low, recharge to the aquifers is usually sufficient to meet the demands without depleting water held in storage in the aquifer. However, where ground-water demand is increasing, such as in Bandera and Kerr Counties, water shortages may occur, especially during drought conditions.

Surface-water supplies in the region are derived from run-of-the-river, reservoir and springflow. These supplies are only available by state permit and are significantly reduced during periods of extreme drought.

Table 3-1 provides an approximate quantification of the amount of water available from each unique water-supply source under the condition of a Drought-of-Record. Quantities listed for ground-water sources include both the amount of retrievable water held in storage and the reduced amount of recharge. If demands on these aquifers are in excess of natural recharge, depletion of the source occurs as indicated by falling water levels. Many of the surface-water source flows listed in the table are significantly reduced or even completely depleted as a result of the drought condition placed on it. Under these conditions, Cities such as Del Rio and Kerrville that depend heavily on these sources may experience supply deficiencies.

Table 3-3 lists the maximum amount of water that each city and water-use category in the region might expect from currently used sources during drought conditions based on their current infrastructure status. In the following chapter, Chapter 4, this supply table is compared to the water-supply demand table in Chapter 2 to identify which cities and water-use categories appear to have insufficient supplies during severe drought conditions.

CHAPTER 4

COMPARISON OF WATER DEMANDS WITH WATER SUPPLIES TO DETERMINE NEEDS

4.1 Introduction

The objective of Chapter 4 is to identify the communities and nonmunicipal water-use groups in the counties of the Plateau Region that are likely to experience either water surpluses or shortages over the period 2000 through 2050 during Drought-of-Record conditions (Table 4-1). This is based on comparison of the demand projections of Table 2-2 with the supply projections of Table 3-3. The comparison of supply and demand by major water provider is shown in Table 4-2. The results of the comparisons by county are shown in Tables 4-3 through 4-8. The quantities represent annual projections and are predicated on the following assumptions:

- Drought-of-Record conditions are characteristic for each of the years shown in Tables 4-3 through 4-8. Normal climatic conditions are characteristic of intervening years.
- No new infrastructure development over the period 2000 through 2050. All demands must be serviced by current infrastructure.
- No changes in water rights occur over the period 2000 through 2050.
- The total supply is terminated when it exceeds the supply source in Table 3-1.

Tables 4-3 through 4-8 were constructed by subtracting demand from supply. Positive numbers indicate surpluses (acre-ft), and numbers in parenthesis indicate shortages (also in acre-ft). An entry of "0" (zero) indicates that supply and demand are either balanced for that year, or that demand is no more than 10 acre-feet greater than supply. In such cases, these deficits were balanced out to zero to show no shortage of water. This was based on concern that deficits of 10 acre-ft or less probably lie within the margin of error of the estimates in Chapters 2 and 3, and, as such, may not indicate real shortages under Drought-of-Record conditions.

Tables 4-3 through 4-8 should be regarded as a general guide to the amount of potential shortages within the counties of the Plateau Region. As such, each table provides a basis for the development of strategies (Chapter 5) that will ensure access to adequate quantities of water for all users in the region.

Table 4-1
Comparison of Water Demand and Water Supply Capacities
by City and Category (Acre-Ft/Year)

WATER USER GROUP NAME	RIVER BASIN	S2000	S2010	S2020	S2030	S2040	S2050
BANDERA COUNTY							
Bandera	San Antonio	1309	1241	1236	1199	1158	1106
County Other	Guadalupe	-18	-41	-40	-46	-53	-61
County Other	San Antonio	-1138	-2655	-2556	-2951	-3421	-3937
County Other	Nueces	-97	-228	-219	-253	-293	-338
Irrigation	San Antonio	20	27	35	41	48	54
Irrigation	Nueces	0	5	9	14	17	21
Livestock	Guadalupe	0	0	0	0	0	0
Livestock	San Antonio	0	0	0	0	0	0
Livestock	Nueces	40	40	40	40	40	40
Manufacturing	Nueces	32	30	28	27	24	21
Mining	San Antonio	-10	-10	-11	-12	-12	-12
Mining	Nueces	8	8	8	8	8	8
EDWARDS COUNTY							
Rocksprings	Colorado	621	606	600	590	583	574
Rocksprings	Nueces	68	66	65	64	63	62
County Other	Colorado	8	7	7	6	5	4
County Other	Nueces	18	15	14	13	11	9
County Other	Rio Grande	3	3	2	2	2	1
Irrigation	Colorado	-139	-129	-119	-110	-101	-92
Irrigation	Nueces	23	23	23	23	23	23
Irrigation	Rio Grande	20	20	20	20	20	20
Livestock	Colorado	35	35	35	35	35	35
Livestock	Nueces	-28	-28	-28	-28	-28	-28
Livestock	Rio Grande	0	0	0	0	0	0
Mining	Colorado	0	2	4	5	7	8
Mining	Nueces	2	2	2	2	2	2
Mining	Rio Grande	2	2	2	2	2	2
KERR COUNTY							
Kerrville	Guadalupe	-1547	-2244	-2969	-3840	-4599	-5450
Ingram	Guadalupe	146	158	168	171	174	175
County Other	Colorado	7587	7575	7567	7556	7542	7523
County Other	Guadalupe	21437	21090	20875	20573	20185	19668
County Other	San Antonio	908	908	907	907	906	905
County Other	Nueces	431	426	424	419	414	407
Irrigation	Guadalupe	-368	-342	-316	-292	-268	-245
Livestock	Colorado	-62	-62	-62	-62	-62	-62
Livestock	Guadalupe	79	79	79	79	79	79

Livestock	San Antonio	-25	-25	-25	-25	-25	-25
Livestock	Nueces	8	8	8	8	8	8
Manufacturing	Guadalupe	136	133	130	128	125	122
Mining	Colorado	-12	-8	-4	0	1	1
Mining	Guadalupe	10	60	68	71	71	68
Mining	San Antonio	1	1	1	1	1	1
Mining	Nueces	1	1	1	1	1	1
KINNEY COUNTY							
Brackettville	Rio Grande	1442	1446	1473	1499	1499	1503
County Other	Nueces	-28	-21	-13	-23	-45	-68
County Other	Rio Grande	-52	-38	-25	-43	-81	-124
Irrigation	Nueces	1464	1472	1480	1488	1495	1502
Irrigation	Rio Grande	29	344	645	933	1209	1472
Livestock	Nueces	163	163	163	163	163	163
Livestock	Rio Grande	-163	-163	-163	-163	-163	-163
REAL COUNTY							
Camp Wood	Nueces	140	157	175	187	193	196
Leakey	Nueces	23	24	4	-15	-37	-63
County Other	Colorado	1	0	1	0	1	1
County Other	Nueces	5	4	10	3	4	13
Irrigation	Colorado	35	35	35	35	35	35
Irrigation	Nueces	704	740	774	807	838	869
Livestock	Colorado	0	0	0	0	0	0
Livestock	Nueces	78	78	78	78	78	78
Mining	Colorado	-12	-8	-4	-1	1	1
Mining	Nueces	5	5	5	5	5	5
VAL VERDE COUNTY							
Del Rio	Rio Grande	4450	3563	2908	2331	1660	840
Laughlin AFB	Rio Grande	23	75	126	138	149	152
County Other	Rio Grande	219	363	531	669	328	1
Irrigation	Rio Grande	3553	3552	3687	3751	3811	3870
Livestock	Rio Grande	-64	-64	-64	-64	-64	-64
Manufacturing	Rio Grande	50	50	50	50	50	50
Mining	Rio Grande	-15	-22	-39	-56	-73	-92

* Water supply demands are not estimated in Table 2-2 for UGRA and Aqua Source in the Guadalupe River Basin of Kerr County. Therefore, for this table, these entities are grouped together with all of the "County Other" category.

Table 4-2
Comparison of Water Demands with Water Supply Capacities by Major Water Providers (Acre-Ft/Year)

Major Water Provider	County	S2000	S2010	S2020	S2030	S2040	S2050
City of Del Rio	Val Verde	4,459	3,624	3,020	2,455	1,795	978

4.2 Bandera County

- Demand and supply summaries are shown for all six water-use categories (Table 4-3).

Demand

- Water Demand for the Town of Bandera is expected to increase from 303 acre-ft in the year 2000 to 506 acre-ft in the year 2050. This represents a 67 percent increase in demand over a 50-year period.
- County-Other water demand is projected to increase from 2,926 acre-ft in the year 2000 to 6,009 acre-ft by the year 2050. This is a projected increase of 105 percent in the demand for water.
- Demand attributable to irrigation is expected to decrease from 278 acre-ft to 223 acre-ft over the 50-year planning period.
- Demand from the livestock sector is expected to remain at 333 acre-ft throughout the planning period.
- Manufacturing water demand will increase by 100 percent, from 11 acre-ft to 22 acre-ft.
- Demand for water from the mining sector will increase from 25 acre-ft in 2000 to 27 acre-ft by the year 2030, and will remain flat through the year 2050.

Supply

- The Trinity aquifer will be the principal source of supply for each category of use.
- Surface water will make up a significant component of supply only for the livestock sector. Much of this water will come from three sources – the Medina and Sabinal rivers and Hondo Creek.

Comparison of Demand and Supply

- The county summary shows surpluses for the Town of Bandera, and the irrigation and manufacturing sectors.
- Demand and supply in the livestock and mining sectors are balanced.
- Shortages are projected for County Other. The shortages increase from 1,253 acre-ft in the year 2,000 to 4,336 by the year 2050.

Table 4-3
Bandera County Water Demand and Supply
(Acre-Ft/Year)

	2000	**2010**	**2020**	**2030**	**2040**	**2050**
Bandera Demand	303	371	376	413	454	506
Supply	1,612	1,612	1,612	1,612	1,612	1,612
Ground Water	1,612	1,612	1,612	1,612	1,612	1,612
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	1,309	1,241	1,236	1,199	1,158	1,106
County Other	2,926	4,597	4,488	4,923	5,440	6,009
Supply	1,673	1,673	1,673	1,673	1,673	1,673
Ground Water	1,672	1,672	1,672	1,672	1,672	1,672
Surface Water	1	1	1	1	1	1
Surplus/(Shortage)	(1,253)	(2,924)	(2,815)	(3,250)	(3,767)	(4,336)
Irrigation Demand	278	266	254	243	233	223
Supply	290	290	290	290	290	290
Ground Water	290	290	290	290	290	290
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	12	24	36	47	57	67
Livestock Demand	333	333	333	333	333	333
Supply	373	373	373	373	373	373
Ground Water	301	301	301	301	301	301
Surface Water	72	72	72	72	72	72
Surplus/(Shortage)	40	40	40	40	40	40
Manufacturing Demand	11	13	15	16	19	22
Supply	43	43	43	43	43	43
Ground Water	43	43	43	43	43	43
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	32	30	28	27	24	21
Mining Demand	25	25	26	27	27	27
Supply	23	23	23	23	23	23
Ground Water	23	23	23	23	23	23
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	(2)	(2)	(3)	(4)	(4)	(4)

4.3 Edwards County

- Demand and supply summaries are shown for Rocksprings and the County-Other, Irrigation, Livestock, and Mining sectors in Table 4-4.

Demand

- Demand for Rocksprings is projected to grow from 293 acre-ft to 346 acre-ft over the 50-year planning period. The County-Other category shows an increase from 137 acre-ft to 152 acre-ft over the same period.
- Irrigation demand decreases from 239 acre-ft to 192 acre-ft.
- Livestock demand remains constant at 615 acre-ft.
- Mining demand decreases from 8 acre-ft in 2000 to 1 acre-ft by the year 2040. No demand is shown for this sector for the year 2050.

Supply

- The Edwards-Trinity (Plateau) aquifer is the source of water for Rocksprings, County Other, Irrigation, and Mining supply.
- The Edwards-Trinity aquifer is the principal source of water for Livestock supply.
- The West Nueces and South Llano rivers are also significant source of water for Livestock supply.

Comparison of Demand and Supply

- Rocksprings and County Other are shown to have surpluses over the 50-year planning period.
- The irrigation sector is projected to be in a deficit position for each of the six planning decades.
- Demand and supply are balanced for the Livestock sector.
- Demand and supply are balanced for the Mining sector for the years 2000 and 2010, and then is in a surplus for the rest of the planning period. This is attributable to the reduction of demand and to a constant source of supply.

Table 4-4
Comparison of Edwards County Water Demand and Supply
(Acre-Ft/Year)

	2000	2010	2020	2030	2040	2050
Rocksprings Demand	293	310	290	328	336	346
Supply	982	982	982	982	982	982
Ground Water	982	982	982	982	982	982
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	689	672	692	654	646	636
County-Other Demand	137	141	143	145	148	152
Supply	166	166	166	166	166	166
Ground Water	166	166	166	166	166	166
Surface Water						
Surplus/(Shortage)	29	25	23	21	18	14
Irrigation Demand	239	229	219	210	201	192
Supply	143	143	143	143	143	143
Ground Water	143	143	143	143	143	143
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	(96)	(86)	(76)	(67)	(58)	(49)
Livestock Demand	615	615	615	615	615	615
Supply	615	615	615	615	615	615
Ground Water	492	492	492	492	492	492
Surface Water	123	123	123	123	123	123
Surplus/(Shortage)	0	0	0	0	0	0
Mining Demand	8	6	4	3	1	0
Supply	12	12	12	12	12	12
Ground Water	12	12	12	12	12	12
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	4	6	8	9	11	12

4.4 Kerr County

- Demand and supply summaries are shown for all six water-use categories (Table 4-5).

Demand

- Demand is expected to grow for the City of Kerrville and County Other. Kerrville's demand is shown to increase from 4,747 acre-ft in 2000 to 8,650 acre-ft by the year 2050. County-Other demand is projected to increase from 3,854 acre-ft to 5,685 acre-ft over the same period of time.
- Demand is also expected to increase for the Manufacturing sector. The growth is projected to rise from 30 acre-ft to 44 acre-ft over the 50-year planning period.
- Demand decreases in both the Irrigation and Mining sectors. Demand from the Irrigation sector is projected to decrease from 823 acre-ft to 700 acre-ft. Demand attributable to the Mining sector is shown to fall from 176 acre-ft to 105 acre-ft.

Supply

- Under Drought-of-Record conditions, ground water is the only source of supply for Kerrville, County Other, Manufacturing and the Mining sectors.
- Ground water is the principal source of supply for the Irrigation and Livestock sectors.
- Surface water is also a source of supply for the Irrigation and Livestock sectors.

Comparison of Demand and Supply

- Due to the lack of available surface-water supply during Drought-of Record conditions, the City of Kerrville shows an increasing supply deficit.
- Despite the projected growth in demand, the County-Other sector is projected to have surplus supplies of water under Drought-of-Record conditions. The surplus, however, is expected to decrease along with the increase in demand over the 50-year planning period.

- The Livestock, Manufacturing, and Mining sectors are all shown to be in surplus positions. Demand and supply for the Manufacturing sector are projected to be balanced by the end of the planning period. Surpluses show up within the Mining sector over the period 2010 through 2050.
- The Irrigation sector is projected to be in a deficit position for all planning period decades.

Table 4-5
Comparison of Kerr County Water Demand and Supply
(Acre-Ft/Year)

	2000	2010	2020	2030	2040	2050
Kerrville Demand	4,747	5,444	6,169	7,040	7,799	8,650
Supply	3,200	3,200	3,200	3,200	3,200	3,200
Ground Water	3,200	3,200	3,200	3,200	3,200	3,200
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	(1,547)	(2,244)	(2,969)	(3,840)	(4,599)	(5,450)
Ingram Demand	144	132	122	119	116	115
Supply	290	290	290	290	290	290
Ground Water	290	290	290	290	290	290
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	146	158	168	171	174	175
County-Other Demand	3,710	4,074	4,300	4,618	5,026	5,570
Supply	34,073	34,073	34,073	34,073	34,073	34,073
Ground Water	34,073	34,073	34,073	34,073	34,073	34,073
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	30,363	29,999	29,773	29,455	29,047	28,503
Irrigation Demand	823	797	771	747	723	700
Supply	455	455	455	455	455	455
Ground Water	406	406	406	406	406	406
Surface Water	49	49	49	49	49	49
Surplus/(Shortage)	(368)	(342)	(316)	(292)	(268)	(245)
Livestock Demand	526	526	526	526	526	526
Supply	526	526	526	526	526	526
Ground Water	421	421	421	421	421	421
Surface Water	105	105	105	105	105	105
Surplus/(Shortage)	0	0	0	0	0	0
Manufacturing Demand	30	33	36	38	41	44
Supply	166	166	166	166	166	166
Ground Water	166	166	166	166	166	166
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	136	133	130	128	125	122

Mining Demand	176	122	110	103	102	105
Supply	176	176	176	176	176	176
Ground Water	176	176	176	176	176	176
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	0	54	66	73	74	71

4.5 Kinney County

- Demand and supply summaries are shown for the Town of Brackettville, County-Other, Irrigation and Livestock water-use categories (Table 4-6).

Demand

- Demand is expected to increase only for the County-Other sector (711 acre-ft to 823 acre-ft).
- Water demand for the Town of Bracketville is projected to decrease from 896 acre-ft to 835 acre-ft over the planning period.
- Irrigation will account for the largest source of demand. However, the trend will decrease from 7,532 acre-ft in 2000 to 6,051 acre-ft by the year 2050.
- Demand for water to support the livestock industry is projected to remain at 675 acre-ft for each of the six Drought-of-Record years.

Supply

- Ground water is the major source of supply for all water-use categories. The major aquifers are the Edwards, Edwards-Trinity (Plateau), and Austin Chalk aquifers.
- The West Nueces River is a secondary but significant source of water for the Livestock sector.

Comparison of Demand and Supply

- Under Drought-of-Record conditions, the Town of Brackettville and the Irrigation sector are shown to have surpluses throughout the planning period. The surplus for Brackettville increases from 1,442 acre-ft to 1,503 acre-ft, while the surplus for the Irrigation sector increases from 1,493 acre-ft to 2,974 acre-ft. The increase in each case is attributed to decreasing demand over time.

- Demand and supply for the Livestock sector are balanced in each of the six Drought-of-Record years.
- The County-Other sector shows shortages increasing from 80 acre-ft in 2000 to 192 acre-ft in 2050. The increasing shortage is related to the greater demand foreseen over the planning period.

Table 4-6
Comparison of Kinney County Water Demand and Supply
(Acre-Ft/Year)

	2000	2010	2020	2030	2040	2050
Brackettville Demand	896	892	865	839	839	835
Supply	2,338	2,338	2,338	2,338	2,338	2,338
Ground Water	2,338	2,338	2,338	2,338	2,338	2,338
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	1,442	1,446	1,473	1,499	1,499	1,503
County-Other Demand	711	690	669	697	757	823
Supply	631	631	631	631	631	631
Ground Water	631	631	631	631	631	631
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	(80)	(59)	(38)	(66)	(126)	(192)
Irrigation Demand	7,532	7,209	6,900	6,604	6,321	6,051
Supply	9,025	9,025	9,025	9,025	9,025	9,025
Ground Water	9,025	9,025	9,025	9,025	9,025	9,025
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	1,493	1,816	2,125	2,421	2,704	2,974
Livestock Demand	675	675	675	675	675	675
Supply	675	675	675	675	675	675
Ground Water	540	540	540	540	540	540
Surface Water	135	135	135	135	135	135
Surplus/(Shortage)	0	0	0	0	0	0

4.6 Real County

- Demand and supply summaries are shown for the towns of Camp Wood and Leakey, along with the County-Other, Irrigation, and Livestock water- use categories (Table 4-7).

Demand

- Water demand for Camp Wood is expected to decrease from 180 acre-ft in 2000 to 124 acre-ft by the year 2050. Demand for the Town of Leakey, however, will increase from 157 acre-ft to 243 acre-ft over the same period of time.
- County-Other water demand will remain approximately constant between 2000 and 2040, ranging from a low of 380 acre-ft to a high of 388 acre-ft. Demand estimated for the year 2050 is 377 acre-ft.
- Irrigation demand will decrease from 835 acre-ft to 670 acre-ft over the planning period.
- Demand for water to support livestock will remain constant at 174 acre-ft.

Supply

- Kreuger Spring is the source of water for Camp Wood. Leakey relies on the Frio River Alluvium aquifer.
- The County-Other sector will be dependent of ground water from the Edwards-Trinity (Plateau) aquifer and the Frio River Alluvium aquifer.
- Irrigation demand will be met by supplies from the Frio river and ground water from the Edwards-Trinity (Plateau) aquifer.
- The livestock industry will be dependent primarily on the Edwards-Trinity (Plateau) aquifer. The Nueces and Frio rivers will provide additional water.

Comparison of Demand and Supply

- All of the water-use categories within Real County will be in a surplus position throughout the planning period. Increasing surpluses are noted for Camp Wood and the County-Other and Irrigation sectors.
- Leakey will experience supply deficit conditions beginning in the 2030 decade under Drought-of-Record conditions.
- The surplus for the Livestock sector is shown to be 70 acre-ft for each of the six Drought-of-Record years.
- The surplus for Irrigation will increase as a result of a decrease in demand.

Table 4-7

Comparison of Real County Water Demand and Supply (Acre-Ft/Year)

	2000	2010	2020	2030	2040	2050
Camp Wood Demand	180	163	145	133	127	124
Supply	320	320	320	320	320	320
Ground Water	0	0	0	0	0	0
Surface Water	320	320	320	320	320	320
Surplus/(Shortage)	140	157	175	187	193	196
Leakey Demand	157	156	176	195	217	243
Supply	180	180	180	180	180	180
Ground Water	180	180	180	180	180	180
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	23	24	4	(15)	(37)	(63)
County-Other Demand	385	387	380	388	386	377
Supply	391	391	391	391	391	391
Ground Water	391	391	391	391	391	391
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	6	4	11	3	5	14
Irrigation Demand	835	799	765	732	701	670
Supply	1,574	1,574	1,574	1,574	1,574	1,574
Ground Water	349	349	349	349	349	349
Surface Water	1,225	1,225	1,225	1,225	1,225	1,225
Surplus/(Shortage)	739	775	809	842	873	904
Livestock Demand	174	174	174	174	174	174
Supply	244	244	244	244	244	244
Ground Water	195	195	195	195	195	195
Surface Water	49	49	49	49	49	49
Surplus/(Shortage)	70	70	70	70	70	70
Mining Demand	13	9	5	2	0	0
Supply	6	6	6	6	6	6
Ground Water	6	6	6	6	6	6
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	(7)	(3)	1	4	6	6

4.7 Val Verde County

- Demand and supply summaries are shown for the City of Del Rio, Laughlin Airforce Base, and all other water-use categories (Table 4-8).

Demand

- Del Rio is the largest source of demand within the county. Demand is expect to increase from 12,106 acre-ft in 2000 to 15,716 acre-ft by 2050.
- Demand from Laughlin is projected to slightly decrease from 1,446 acre-ft to 1,317 acre-ft.
- County-Other demand will grow from 1,642 acre-ft to 1,860 acre-ft.
- Irrigation demand will decrease from 1,771 acre-ft to 1,454 acre-ft.
- Livestock demand is expected to remain unchanged at 663 acre-ft over the planning period.
- Mining demand will rise from 114 acre-ft to 191 acre-ft.

Supply

- San Felipe Springs and ground water from the Edwards-Trinity (Plateau) aquifer will continue to be the source of water for Del Rio and Laughlin.
- The County-Other sector will rely on the Edwards-Trinity (Plateau) aquifer.
- The needs of the Irrigation sector will be met by flow from San Felipe Springs. The Edwards-Trinity (Plateau) aquifer will account for about seven percent of total supply.
- Under Drought-of-Record conditions, the Livestock and Mining sectors will be dependent on production from the Edwards-Trinity (Plateau) aquifer.

Comparison of Demand and Supply

- Flow from San Felipe Springs and local ground water will be sufficient to meet all of the demand for Del Rio and Laughlin. The City is projected to have a surplus supply for each of the six Drought-of-Record years. The surplus decreases from 4,450 acre-ft in 2000 to 840 by the year 2050.
- Laughlin is in a surplus position during the planning period. The surplus increases from 23 acre-ft to 152 acre-ft.
- County-Other is projected to have surpluses ranging from 219 acre-ft in 2000 to 669 acre-ft in 2030. The surplus for this sector is projected to decrease to 1 acre-ft by the end of the planning period.
- Decreasing demand and an expected constant supply of water should generate increasing surpluses for the Irrigation sector. The surpluses are shown to increase from 3,553 acre-ft to 3,870 acre-ft over the 50-year period.
- The shortage for the Livestock industry is projected to be 64 acre-ft for each drought year. The deficit for the Mining sector will increase from 15 acre-ft to 92 acre-ft.

Table 4-8
Comparison of Val Verde County Water Demand and Supply
(Acre-Ft/Year)

	2000	2010	2020	2030	2040	2050
Del Rio Demand	12,106	12,993	13,648	14,225	14,896	15,716
Supply	16,556	16,556	16,556	16,556	16,556	16,556
Ground Water	6,595	6,595	6,595	6,595	6,595	6,595
Surface Water	9,961	9,961	9,961	9,961	9,961	9,961
Surplus/(Shortage)	4,450	3,563	2,908	2,331	1,660	840
Laughlin Demand	1,446	1,394	1,343	1,331	1,320	1,317
Supply	1,469	1,469	1,469	1,469	1,469	1,469
Ground Water	14	14	14	14	14	14
Surface Water	1,455	1,455	1,455	1,455	1,455	1,455
Surplus/(Shortage)	23	75	126	138	149	152
County-Other Demand	1,642	1,498	1,330	1,192	1,533	1,860
Supply	1,861	1,861	1,861	1,861	1,861	1,861
Ground Water	1,861	1,861	1,861	1,861	1,861	1,861
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	219	363	531	669	328	1
Irrigation Demand	1,771	1,702	1,637	1,573	1,513	1,454
Supply	5,324	5,324	5,324	5,324	5,324	5,324
Ground Water	362	362	362	362	362	362
Surface Water	4,962	4,962	4,962	4,962	4,962	4,962
Surplus/(Shortage)	3,553	3,622	3,687	3,751	3,811	3,870
Livestock Demand	663	663	663	663	663	663
Supply	599	599	599	599	599	599
Ground Water	599	599	599	599	599	599
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	(64)	(64)	(64)	(64)	(64)	(64)
Manufacturing Demand	0	0	0	0	0	0
Supply	50	50	50	50	50	50
Ground Water	0	0	0	0	0	0
Surface Water	50	50	50	50	50	50
Surplus/(Shortage)	50	50	50	50	50	50

Mining Demand	114	121	138	155	172	191
Supply	99	99	99	99	99	99
Ground Water	99	99	99	99	99	99
Surface Water	0	0	0	0	0	0
Surplus/(Shortage)	(15)	(22)	(39)	(56)	(73)	(92)

4.8 Social and Economic Impact of Not Meeting Water-Supply Needs

A major task of this regional water plan is to describe the sociological and economical implications of not acting to meet anticipated water-supply needs, or conversely, the potential benefit to be gained from devising a strategy to meet a particular need. Collectively, the summation of all the impacts gives the region a view of the ultimate magnitude of the impacts caused by not meeting the entire list of needs. These summations should be considered a worst-case scenario for the region, since the likelihood of not meeting the entire list of needs is very small. The Regional Water Planning Group received technical assistance from the Texas Water Development Board (TWDB) in quantifying this socioeconomic impact through the methodology described below in Section 4.8.1.

Each water-user group with a need is evaluated in terms of direct and indirect economic and social impact on the region resulting from the shortage. Economic variables chosen by the TWDB for this analysis include gross economic output (sales and business gross income), employment (number of jobs) and personal income (wages, salaries and proprietors net receipts). The effects of shortages on population and school enrollments are the social variables of the analysis. Declining populations indicate a deprecation of social services in most, but not every case, while declining school enrollment indicates loss of younger cohorts of the population and possibilities of strains on the tax bases, when combined with economic losses. The Regional Water Planning Group has the opportunity of identifying other impacts which may not be quantifiable but which certainly are important to the region.

Upon completion, the social and economic impact assessment was included in a draft copy of the plan and presented to the public for comment. Impacted entities and industries were particularly requested to review the analysis and the plan. Public comments are discussed in Chapter 7.

4.8.1 Methodology

The Plateau Regional Water Planning Group submitted the identified water shortages - by user group, in terms of acre-feet of water per year and the year in which the shortage first appears - to the Texas Water Development Board. The user groups evaluated were irrigation, livestock, mining, steam-electric, manufacturing and municipal water users. The Plateau Region listed specific user groups within each county/river basin combination that would likely experience a shortage (Table 4-1). TWDB staff then determined production responses by sector, or water use type. In the case of irrigation, impacts of irrigation water shortages are determined through the use of a linear programming model called GAMS developed by Texas A & M University. This model projects the number of acres that would be profitable (under the more ideal condition of adequate water) and therefore gives a baseline of comparison to the number of acres that cannot be profitable due to lack of irrigation water. For the other water-use types, TWDB staff calculated water-use coefficients specific to each water-use type based on in-house data or data provided by the firm of Minnesota Implan Group. This firm also developed a model used by TWDB, the IMPLAN regional socioeconomic model, which gives the impact of the water shortage on employment (in terms of number of persons who would lose jobs if the water shortage were not met) and the impact of the water shortage on gross business output (in terms of 1999 US dollars).

These impacts are compared to baseline. Another Texas A & M University model, called TAMS which was developed by the Department of Rural Sociology, outputs the impact of the water shortage on population and on school enrollment. These impacts are purely social. The final economic impact of lost income is also quantified. The Regional Water Planning Group has the opportunity to identify other impacts which may not be quantifiable but which certainly are important to the region.

4.8.2 Impacts of Unmet Water Needs for the Region

The Plateau Regional Water Planning Group identified individual water user groups that showed an unmet need during drought-of-record supply conditions for each decade from 2000 to 2050. The region projected that total water demands would grow from 45,000 acre-feet in 2000 to 50,000 acre-feet in 2030, rising steadily to 56,000 acre-feet in 2050.

Under extreme supply limitations and with no management strategies in place, water shortages would amount to 9,000 acre-feet in 2000, rising to 18,000 acre-feet in 2030, then increasing to 25,000 acre-feet by 2050. The water needs of the region amount to about 31 percent of the forecasted demand by 2020, rising to 40 percent of demand in 2040, and to 45 percent of demand in 2050. This means that by 2050 the region would be able to supply only 55 percent of the projected needs unless supply development or other water management strategies are implemented. Table 4-9 and Figure 4-1 identify regional impacts based on water supply, employment, population, and income. Table 4-10 summarizes impacts by decade and water-use category.

Economic Growth Limitations

The difference between expected future growth, unrestricted by water shortage, and expected growth restricted by unmet water needs provides the measure of impact.

Employment

Left entirely unmet, the level of shortage in 2010 results in 13,000 fewer jobs than would be expected in unrestricted development (without water needs) by 2010. The gap between unrestricted and restricted job growth grows to nearly 19,000 by 2030, and to 27,500 jobs that the restricted economy could not create by 2050.

Population

The forecasted population growth of the region would be economically restricted by curtailed potential job creation. This in turn causes both an outmigration of some current population and an expected curtailment of future population growth. Compared to the baseline growth in population, the region could expect 28,000 fewer people in 2010, growing to 39,000 fewer in 2030 and 58,000 fewer in 2050. The expected 2050 population under the severe shortage conditions would be 27 percent lower than projected in the region's most likely growth forecast.

Income

The potential loss of economic development in the region amounts to about 28 percent less income to people in 2010 and 34.5 percent less than expected in 2030. By 2050 the region would have 44 percent less income than is currently projected assuming no water restrictions.

Water User Groups with Shortages

The economic and social impact of an unmet water need varies greatly depending on the type of Water User Group for which the shortage is anticipated. On a per acre-foot basis, the largest impacts will generally result from shortages in manufacturing and municipal uses, while shortages for irrigation will typically result in the smallest impact. Table 4-10 presents the impacts of unmet water needs summarized for each of the six types of Water User Group.

Virtually all of the economic and social impacts of unmet water needs in the Plateau Region result from municipal water shortages. In 2010, municipalities have unmet needs of about 12,000 acre-feet. The economic impacts of this shortage include 13,000 jobs, $941 million in output, and $298 million of income. By 2050, unmet municipal needs total 24,000 acre-feet resulting in 27,000 jobs not created, and reductions of $1.9 billion in potential output and $625 million in potential income.

The region also projects small unmet needs in mining, irrigation and livestock, with impacts of less than 500 jobs in any given year.

4.8.3 Interpretation of the Results

Users are cautioned not to assume that the entire list of needs with impacts is a prediction of future water disasters. These data simply give regional planners one source of information by which to develop efficient and effective means to meet the needs and avoid calamities.

Some clarification is needed to understand the impact numbers. The following points must be kept in mind when using the data:

- The impacts are expressed in terms of regional impact. Thus, individual water user group shortages are shown as they influence the entire region's economy and not just the limits of the direct impact. The total impact of municipal shortage for a particular city, for example, includes the direct impact within the city limits and the impact indirectly through the region. The indirect linkages were derived from regional economic models. There are no models for individual water user groups.

- Water supplies are calculated on drought-of-record levels. Shortages that show up for the 2000 decade and beyond are considered to be mostly the result of severe dry conditions; this contributes to the apparent abnormally large size of some impacts. This approach to supply analysis results in a worst-case scenario. Historically, most water user groups have at least partially met their needs through management of the remaining supplies, either by conservation, limitations on lower-valued uses such as lawn watering, or finding alternative sources of water. The results in this report assume no applied management strategies. The entirety of the needs is not met in any fashion.
- The analysis begins by calculating water use coefficients–defined as production (dollars of sales to final customers, or final demand) resulting from use of an acre-foot of water. This measure is considered an average, not marginal, measure of water use. Thus, the analysis does not attempt to measure the market forces that would tend to drive the price of water higher or reserve limited water for the highest-valued uses, as it becomes scarce. The average value approach was used because the analysis is intended to show the present value in today's regional economies of differing amounts of water use. With this information analysts can answer the question, "How much water does it take to support the current level and structure of economic activity and population?" The baseline projections for the future of regional economies assume a continuation of this known relationship of volumes of water use to economic output, under current structures of use. The models do not attempt to estimate the market allocation of the resource among competing activities because this change in structure is considered a possible management strategy–relying on market forces to work in a water-marketing system. Marginal cost analysis would be necessary for evaluating such an approach.

- The Municipal water use category includes commercial establishments. The impacts from even small shortages in many such establishments are considerably higher on a per-acre-foot basis than in any other category. Thus, relatively small Municipal shortages can have a very large amount of economic impact, since the analysis assumes a direct relationship between curtailed water use and lost economic production. Since this analysis is intended to provide impacts without assuming any strategies, the normal response of conservation programs is not assumed. The impact data appear to overstate the Municipal category, but the results are consistently measured, since no response to the shortage is assumed that would mitigate loss of critical water used in commercial and residential settings.
- The sizes of the projected impacts do not represent reductions from the current levels of economic activity or population. That is, the data are a comparison between a baseline forecast, assuming no water shortages, and a restricted forecast, based on the assumption of future water shortages. In some cases, with severe water shortages the regional economy could actually decline, dropping employment below current levels. For most regions, however, the measurement of impact represents an opportunity cost, or lost potential development that would be foregone in the absence of water management strategies.

CHAPTER 5

IDENTIFICATION, EVALUATION AND SELECTION OF WATER MANAGEMENT STRATEGIES

5.1 INTRODUCTION

In Chapter 4, cities and water-use categories were identified that, under drought-of-record conditions, have water demands in excess of currently available supplies. The purpose of this chapter is to provide an evaluation of potential strategies that might be used by each of these entities and categories to meet potential supply deficits. The evaluation of each strategy presented in this chapter is an estimate of the potential benefit that might result from its implementation. Strategy evaluations are preliminary and, in most cases, have not had the benefit of a full feasibility study. Cost estimates in particular should be considered preliminary. Strategies presented in this plan represent recommendation; it remains the responsibility of each entity to implement the strategy if it so chooses. Strategies involving the conversion of water rights, voluntary redistribution of water rights and land management are specifically recognized as voluntary and/or incentive based.

5.2 STRATEGIES AVAILABLE FOR CONSIDERATION

Several strategies are available for water supply planning. While some strategies are designed to reduce water use, others are intended to produce additional supplies, or to transfer the existing right to use the water. A combination of these strategies often leads to the greatest benefit. In addition to strategies identified in the state water plan, the following general strategy alternatives were considered during the evaluation and selection process. A degree of overlap may be observed in a number of the strategies.

5.2.1 Water Demand Reduction Strategies

- Water conservation - Water conservation includes those practices, techniques, and technologies that reduce the consumption of water, reduce the loss or waste of water, and improve the efficiency in the use of water. Examples of water conservation may include such practices as the use of water-efficient irrigation equipment, the use of water-saving plumbing fixtures in the home, and the detection and repair of leaks in water conveyance systems. TWDB water-use projections listed in Chapter 2 incorporate per capita water use estimates that reflect below normal rainfall conditions and an expected level of conservation. Expected conservation assumes levels of water savings that are likely to occur from both market forces and regulatory requirements. Advanced conservation measures are thus required under this strategy to generate additional water savings beyond those generated by expected conservation measures.

- Drought response planning – Water use can be reduced at critical times by establishing low-supply indicators and supply curtailment procedures. A drought response plan developed in advance will allow the public to anticipate expected water shortages.
- Irrigation conservation technology and equipment – Latest innovations in irrigation equipment combined with current knowledge of crop water needs allows for irrigation management practices that make the most efficient use of water supplies without generating unnecessary waste.
- Covering stock tanks and watering troughs – Covering stock tanks (e.g., with screens) and placing watering troughs under shaded areas may reduce the amount of evaporation loss.

5.2.2 Additional Supply Development Strategies

- Construction and improvement of surface-water reservoirs – The construction of surface-water reservoirs in suitable areas may increase the amount of available surface water in the region. Improvements to existing reservoirs may add to current storage capacities and reduce seepage loss.
- Expanded use or acquisition of existing ground-water supplies – Additional water may be available by drilling additional wells in existing well field areas or in undeveloped areas of the region. Drilling new wells may alleviate the stress on older fields by distributing ground-water production over a wide area. With regard to the City of Del Rio, municipal supply wells would provide additional water to offset the City's reliance on San Felipe Springs, especially during periods

of diminished discharge from the springs. Ground water may also be acquired through purchase or lease from existing well field areas.

- Enhancement of yields of existing supplies – Altering current delivery procedures may generate additional water. For ground water, additional pumping time or resizing pumps may increase the amount of water generated from existing wells. Coordinated reservoir operations can increase surface-water yields by reducing surface evaporation, capturing flood flows normally lost as spills, or reducing stream-bank losses. This strategy also includes any practice that may result in increasing the volume of water within a specific source. This may include brush control or rainfall enhancement.
- Ground-water recharge structures – Structures designed to impound surface water in canyons and streambeds cut into fractured rock may increase the volume of water available for recharge by slowing the amount of surface runoff during flood events.
- Conjunctive use of resources – The use of both surface and ground water may provide for the extended use of each source. Waters from the two sources may be blended to enhance overall quality of the combined supply. Conjunctive use can also increase water-supply availability by using surface supplies as much as possible and using ground-water supplies to meet peak demands and when surface water is not available.
- Brush management – Certain land-management practices such as brush management, native grass seeding, and prevention of over-grazing may benefit water supplies by increasing natural recharge to aquifers and sustained spring flows that generate higher base flows in surface water tributaries.
- Rainfall harvesting – The capture of rainfall from roofs or in small surface impoundments can provide water not normally available.
- Precipitation enhancement – The artificial inducement of precipitation by injecting silver iodide crystals into potential rain-producing clouds from flares attached to planes that fly through potential clouds. Increasing evidence suggests

that this technology may generate additional rainfall under appropriate climatic conditions. The cloud-seeding process is being tested and funded by the Edwards Aquifer Authority in Region L. Some of the area under investigation overlaps into the Plateau Region that constitutes a portion of the runoff area for the Edwards recharge zone.

- Desalination – Technologies exist for treating water of marginal quality to a level of acceptability. Significant quantities of brackish water exist in Texas that can be effectively desalinated. Current limitations to the technology include increased cost of fresh-water generation and the disposal of the byproduct.
- Development and use of modern water treatment facilities – The development and use of state-of-the-art treatment technology can make available significant quantities of marginal quality water.
- Aquifer storage and recovery – ASR is a method of discretely storing surplus water harvested during periods of low demand or peak availability and later retrieved to meet peak demand. With ASR, water is captured when it is abundant, rather than when it is needed. ASR does not increase the total available water supply but allows greater flexibility of when it is used. This technology is being used in Kerrville.
- Reuse of wastewater – Water is capable of being used numerous times before it moves out of the current system of use. Treated effluent may be reused for various purposes including industrial and power generating water supply, landscaping and agricultural irrigation, direct recharge of aquifers, and aesthetic and environmental uses.
- Protection of ground and surface water from contamination – Significant quantities of potentially usable water can be lost by activities that lead to the contamination of water. Management practices aimed at protecting water supplies from potential contamination are an effective form of water conservation.

- Control of naturally occurring dissolved solids – Proper casing of wells may prevent high-sulfate water of the Upper Glen Rose Limestone from mixing with low-TDS ground water of other aquifer units.

5.2.3 Water Use Transfer Strategies

- Conversion of rights to use water - the existing use of surface water may be converted to alternative uses by the voluntary alteration of the permit. This practice often occurs when the current permit holder chooses to market all or a portion of his water right. Voluntary redistribution of water resources - this strategy is similar to "conversion of rights" but may include any water source including ground water.
- Interbasin transfer of ground water – Ground water pumped from wells in specific aquifers may be transported to areas of need outside the boundary of the aquifer.
- Reallocation of reservoir storage
- Subordination of existing rights through voluntary agreement

5.3 REGIONAL STRATEGIES

Certain water management strategies are of importance to the entire region in that they create benefits to the general population. Environmental benefits also result from some of the regional strategies. Although these regional strategies do not appear in the required TWDB tables, it is the intent of the Regional Planning Group to recognize these regional strategies as equal in importance as the specific user-group strategies.

5.3.1 Brush Management

This strategy involves brush management practices to reduce the amount of water consumed by phreatophytes. Effective brush management increases the potential for water to enter streams and to recharge aquifers. Most brush management measures require six to seven years to implement, as they are multi-staged programs involving initial mechanical or chemical treatment followed by prescribed burns and/or chemical treatment several years later. Brush management programs are continuing processes that involve prevention of unwanted herbaceous species that may negate the water yield benefits.

According to the Texas Parks and Wildlife Department (TPWD), phreatophytes are common throughout the Plateau Region (Figure 5-1). Juniper and mesquite are widely established in Bandera, Edwards, Kerr, and Real Counties. Mesquite and smaller communities of juniper are more common in Kinney and Val Verde Counties; and ceniza (sage) and creosote are dominant in southern Val Verde County and southwestern Kinney County.

If removal of all brush from areas classed as moderate brush canopy were accomplished, resulting in open rangeland cover condition, an average of 41 acre-feet of water per square mile per year, based on normal rainfall conditions, could be yielded. However, the corresponding drought-of-record rainfall conditions would yield an average amount of approximately 35 acre-feet of water per square mile per year.

If removal of all brush from areas classed as heavy brush canopy were accomplished, resulting in open rangeland cover condition, an average of 52 acre-feet of water per square mile per year, during normal rainfall years, could be yielded. The corresponding drought-of-record rainfall conditions would yield an average amount of approximately 45 acre-feet of water per square mile per year.

Studies performed to this date give the water yield based on an average of several years. However, this Regional Water Plan must be based on water supply amounts that could be yielded during a drought-of-record. Therefore, average water yields given in pertinent studies should be adjusted by means of a Climatic Index Adjustment, or an empirically derived relationship between mean peak evapotranspiration (ET) and the mean monthly ET. Adjustment results in the quantities given above. ET during a drought year is greater than ET during years with average or above-average precipitation.

Cost of Strategy

If removal of all brush from areas classed as moderate brush canopy were accomplished, resulting in open rangeland cover condition, the cost ranges from $23.60 per acre (mesquite) to $28.60 per acre (juniper). If removal of all brush from areas classed as heavy brush canopy were accomplished, resulting in open rangeland cover condition, the cost would be approximately

$59.60 (mesquite), and would range from $32.20 to $78.60 (juniper, dependent on treatment alternative chosen).

Proper range management after brush removal should be implemented at little or no cost and will preclude future proliferation of cedar and mesquite. Proper livestock stocking rates, rotational grazing systems, and control of deer and exotic species numbers will help promote growth of desirable plants. Periodic hand cutting and grubbing of young cedar and mesquite seedlings can preclude having to deal with a much larger and costlier problem later. Prescribed burns can be used on ranges with adequate ground cover and fuel loads.

Environmental Issues

Possible aquifer recharge and associated increased surface water flows that may result could reduce de-watering during droughts, strengthen the integrity of riparian habitats and help maintain strong, healthy aquatic communities. If done properly, brush management can greatly increase the diversity of terrestrial habitats, which in turn will generally help a variety of plant and animal species and increase species richness. In particular, federally endangered species such as the black-capped vireo and tobusch fishhook cactus could be benefited.

Impact of Strategy on Water Resources, Agriculture and Natural Resources

Soil erosion caused by improper brush removal could result in loss of topsoil and subsequent degradation of aquatic habitats through increased water turbidity. Negative impacts on agriculture, through the potential for soil erosion, could occur if cover seeding, controlled burning and proper grazing practices are not implemented.

The impact on wildlife of reducing brushy, woody cover should be considered. The amount and type of cover needed varies between species. Wide-ranging species like deer or turkey would not have to leave the general area, if connecting blocks or strips of brush were left between adjacent tracts of lands. Care must be taken in removing brush from steep slopes, especially removal of ashe juniper along steep canyons, which are important habitats preferred by federally endangered species such as golden-cheeked warblers and Texas snowbells.

Social and Economic Impacts

Generally, rural economies are based more and more on nature tourism and outdoor recreation including hunting, fishing, camping, birdwatching and wildlife viewing. Therefore, the habitat needs of wildlife at each specific site should be taken into consideration before brush management work is performed. Properly done, brush management programs could provide substantial and important additional income to a ranching operation via the wildlife populations.

Recommendations for Implementation of Brush Management

- Brush management should always be planned and prescribed for each individual site. Staff of the Texas Parks and Wildlife Department, U.S. Natural Resources Conservation Service, Texas Agricultural Extension Service or private consultants can provide assistance.
- To avoid conflicts with laws regulating species of concern, technical guidance from professionals should be utilized as early as possible. An excellent handbook for land managers that provides information on life history, distribution and management guidelines for species of concern is “Endangered Species and Threatened Animals of Texas” by Linda Campbell and published by the Texas Parks and Wildlife Department.
- Brush management should be as selective as possible with minimal disturbance of soils.
- To abate impacts on nesting songbirds and species of concern, brush management should ideally be performed from September through February.
- Brush management should only be performed on sites where the most good can be gained and avoided wherever erosion problems can result.
- Land managers involved with brush management should seek training in brush sculpting. Visits to the Kerr Wildlife Management Area and the Walter Buck Wildlife Management area should be encouraged to view demonstrations of proper brush and range management practices. The Texas Agricultural Extension Service sponsors “Brush Sculpting” seminars that provide excellent training for land managers and biologists.

5.3.2 Water Demand Management

Four approaches to the management of water demand are discussed in this section: (1) well spacing; (2) restricting lot sizes; (3) pumping restrictions; and (4) pricing structures.

Well spacing

When a well is pumped and water is withdrawn from an aquifer, water levels in the vicinity are drawn down to form an inverted cone with its apex located at the pumping well. This is referred to as a cone of depression. Ground water flows from higher water levels to lower water levels and, therefore, in the case of a pumping well, toward the well or the center of the cone of depression. The shape and size of the cone is directly related to the aquifer parameters. When more than one well is pumped, each well superimposes its cone of water-level depression on the cones created by the pumping of neighboring wells. When the cone of one well overlaps the cone of another, interference occurs and the lowering of water levels is additive because both wells are competing for the same water in the aquifer. The amount of additional water-level decline depends on the rate of pumping from each well, the spacing between wells and the hydraulic characteristics of the aquifer. So in order to minimize well interference the space between wells should be maximized. The optimal spacing for wells is determined by the aquifer parameters such as transmissivity and storativity.

Lot size restrictions

Restricting the minimum size of a private lot that are dependant on ground water for supplying the household is a useful tool to help with well spacing and distances between wells and septic systems. With a prescribed minimum size for lots, the space between neighboring wells and septic systems can be maintained. Also, regulating the minimum distance between lot lines or boundaries and the well and septic system is needed. Regulating the lot size and distance to lot lines will help protect the water well from excessive interference and possible contamination from septic systems. Additional regulations on minimum construction standards for wells and septic systems are also needed to safeguard the ground water.

Pumping restrictions

Pumping restriction is a potential technique for reducing the demand under critical drought conditions when peak demand might equal or exceed the capacity of a water system. The restrictions might prescribe the number of hours in a day the pumping can occur or the time of day or the number of days in a week that pumping can occur. Restrictions can also be placed on the rate of withdrawal. In wells, the size of the pump can be restricted to a certain horsepower or yield. The restrictions can be accomplished in stages that may start with minor restriction progressing to more severe restriction as the need arises.

Pricing structure

Free-Market economists often describe “price” as the principal means by which goods and services are allocated among consumers. Recognizing that the demand for water may be affected by price, many cities have developed pricing structures (block structures, inverted pyramid structures, etc.) designed to encourage conservation. The assumption underlying many rate structures is that demand for water is relatively elastic (that is, responsive) to changes in price. Thus, economic theory suggests that increasing the price of water may discourage most or all non-essential uses, especially in areas where water resources are considered to be relatively scarce. However, the degree of responsiveness, measured by what is referred to as the “price elasticity of demand”, may not be the same among all income groups. Individuals with higher and more discretionary incomes may be willing and able to pay higher rates to maintain desired levels of use than would be the case for many persons in middle-to-lower-income groups. Because of differences in income and in the willingness and ability to absorb higher unit costs of water, the burden of conservation may be borne principally by persons whose incomes would be most negatively affected by higher unit rates. This may lead to complaints of inequity in the distribution of the resource.

5.3.3 Water Conservation Management

Two approaches to water conservation management are considered in this section: (1) xeriscaping, and (2) conservation management methods for residences and yards.

Xeriscaping

Xeriscaping (derived from the Greek word "xeros" – meaning "dry") is an alternative to conventional landscapes that require high volumes of water for maintenance. It is especially efficient and economic in climates that range from arid to semi-arid. Texas A&M University reports that residential and commercial landscapes accounts for more than 25 percent of total water consumption in urban areas of Texas. It also is estimated that incorporating xeriscape principles into residential or commercial landscapes can reduce water consumption by as much as 50 percent. Xeriscaping involves the selection of appropriate plants, the installation of efficient irrigation systems, the use of mulches, and regular and appropriate maintenance to minimize the amount of water applied and the amount of water lost by evaporation. This is generally accomplished by limiting turf areas and using native plant species that have adapted to a particular climate and that can withstand periods of lower than normal rainfall.

Water conservation (home and yard)

Water conservation can also be accomplished by identifying, and repairing or replacing leaky plumbing fixtures, replacing inefficient appliances with low-use appliances, and the use of landscaping and xeriscaping techniques. Water conservation plans adopted by cities and counties should include provisions to encourage conversion of older plumbing systems to modern low-use systems, and requirements for low-use systems in new houses and commercial buildings.

5.3.4 Utility System Efficiency

Public and private utilities can play a major role in water conservation by maintaining efficient storage and distribution systems. This involves leak-detection and repair programs, regular maintenance of lines, replacement of lines and tanks whenever necessary, the installation of accurate meters at all connections, periodic tests of meters to ensure accuracy, and regular system-wide audits. System administrators (operators) may often benefit from receiving additional education in the efficient management of utility systems.

5.3.5 Education

Programs designed to provide information to help users and system administrators conserve water are essential components of effective regional conservation programs. Public education programs may involve door-to-door distribution of materials, public-service announcements on local television and radio stations, public meetings, and presentations at meetings of private clubs and civic organizations, the publication of articles in widely distributed newspapers and magazines, and programs designed for elementary and secondary schools. Public education should provide information on the desirability of water conservation, the necessity of public participation, and the long-term consequences of the failure to conserve water. Materials distributed as part of a public education program should include practical advice to help individuals identify and repair potential problems, along with information on long-term cost savings.

5.3.6 Rainwater Harvesting

This strategy involves capturing rainfall from roofs or in small surface impoundments, providing water that is usually lost to the rural homeowner. This strategy could be implemented relatively easily, inexpensively and quickly for immediate to short-term benefit. The strategy would continue in place as long as the homeowner desired and/or the home remained intact.

Quantity of Water

The Texas Water Development Board's "Texas Guide to Rainwater Harvesting" gives the methodology to calculate rainfall harvest amounts using average precipitation for the time period 1940 through 1990 at selected rain stations across Texas. The quantity of water collected on an annual basis for a 2,000 square-foot residence near Del Rio is estimated to be 18,240 gallons. The quantity given above is on an annual basis; the above estimate assumes 80 percent collection efficiency and 19 inches of average annual precipitation.

Estimated Cost

The ongoing cost of water is negligible, as operation and maintenance would involve nothing more than regular application of chlorine, iodide or other sanitizing chemicals or methods, regular inspection of the system for leaks or deterioration, and costs for operating a small pump. The cost of a typical residential system using metal roofing and aboveground polyethylene cisterns was $3,500 in 1995.

Impact on Other Water Resources

Possible loss of water to aquifer recharge and an associated decrease in surface water flows may result, as the water reaches the homeowner rather than the region in general.

Social and Economic Impacts

This could be a highly beneficial water management strategy in terms of reviving a local economy and/or encouraging people to settle in a very water-scarce area.

5.3.7 Recharge Potential and Recharge Structures

The potential for precipitation recharge of the aquifers of the Plateau Region is influenced by factors such as soil permeability, soil thickness, bedrock permeability, and average transpiration rates. The properties of the soil and bedrock influence recharge by limiting the amount of and the residence time of moisture in the soil zone, where moisture is vulnerable to the effects of evapotranspiration. Vegetation influences recharge because average transpiration rates are influenced by the widespread occurrence of plants that have high rates of transpiration (e.g., mesquite and juniper).

As a basis for determining recharge potential, each factor was assigned a “favorability rating” of 1, 2, 3, or 4. A rating of 1 represents conditions least conducive to recharge while a rating of 4 represent the most effective set of conditions. The overall recharge potential, as shown in Figure 5-2, is the weighted sum of ratings for the respective factors.

Although the favorability rating is an indication of the potential for recharge attributable directly to precipitation and runoff, it is not a basis for estimating the amount of recharge. In any area, the potential for recharge is greatest wherever there is a combination of factors that are most conducive to recharge. In Region J, the areas with the lowest recharge potential (Figure 5-2) are characterized by relatively low-permeability rocks at or near the surface. These areas are (1) southern Kinney County (the Austin Chalk); (2) west central Kinney County and southeastern Val Verde County (the Eagle Ford Shale, the Buda Limestone, and the Del Rio Clay; and (3) eastern Bandera and Kerr Counties (the upper Glen Rose Formation). The areas with the greatest potential for recharge (Figure 5-2) are in northern Val Verde and Kinney Counties and southwestern Edwards County. A smaller area with favorable potential for recharge is located in southeastern Val Verde County, in the vicinity of the City of Del Rio. The recharge potential in these areas is attributed to the relatively higher permeability of topsoil. Other factors, such as average soil permeability, soil thickness, and average transpiration rates, play minor roles in determining the spatial distribution of recharge potential because they are relatively uniform throughout the region and are generally favorable for the occurrence of recharge.

Recharge Structures

The natural recharge of aquifers can be enhanced by the placement of impoundment structures in drainages where geologic properties are conducive to the rapid infiltration of water. Figure 5-2 delineates not only those areas identified as being most suitable for recharge, but also the courses of perennial and intermittent streams in the Plateau Region. Intermittent streams are especially important, as water flows through these drainage features only when there is enough precipitation in a watershed to generate flow in channels that are dry between significant precipitation events. Because intermittent streams typically lie above the local water table, these drainage features are potentially significant focal points of recharge in watersheds. Impounding runoff at one or more locations along the course of an intermittent stream may prevent water from flowing out of the watershed to other locations where it can be carried off by perennial streams or removed by ET. This may increase the amount of recharge to local aquifers enough to augment the discharge of ground water to streams and springs in others areas of a ground-water basin.

The selection of locations for the placement of recharge structures in the Plateau Region should be based on studies designed to identify suitable watersheds. This would require water-balance studies as a basis for calculating the amount of additional recharge expected from the installation of impoundment structures.

5.3.8 Land Management

Land management should be a major component of all regional water-conservation plans. This approach to water conservation requires careful assessment of all land within a region to recommend management practices that will minimize the impact of development on the availability and quality of water resources. Land management strategies may include (1) zoning restrictions that limit the amount and type of development in recharge areas, (2) provisions for brush control and removal, (3) programs to minimize erosion, (4) construction of settling ponds and traps to cut down on the amount of sediment transport, and (5) pollution prevention and response plans. Ideally, an effective land management program should respect private property rights, but should provide landowners with incentives to comply with sensible management strategies.

Seco Creek Water Quality Improvement Demonstration Project

The Seco Creek Water Quality Demostration Project of Bandera, Medina, and Uvalde Counties is an example of a land management program. Conducted by the Texas Agricultural Extension Service, the Natural Resources Conservation Service, the Farm Service Agency, the Texas State Soil and Water Conservation Board, and local soil and water conservation districts, the project was designed to:

- Demonstrate to urban and rural land users the potential to reduce the transport of agricultural chemical and sediment;
- Maintain and improve the quality of ground water and surface water;
- Conserve water resources;

- Improve the quality and abundance of vegetative cover; and
- Encourage adoption of demonstrated best-management practices to reduce non-point source water pollution.

Selected benefits of the Seco Creek project are the following:

- The sediment load to streams, ponds, and lakes was reduced by of 250,000 tons;
- Pesticide and herbicide applications were reduced by 45,000 pounds, while desired levels of pest management and brush control were maintained;
- Irrigation requirements were reduced by 54,000 gallons for each acre of cropland connected to LEPA irrigation systems;
- Spring flows were increased by as much as 20 percent following selective brush management, despite a 35 percent reduction the amount of rainfall;
- Average water yield increased by 40,000 gallons/acre/year following the removal of all ashe juniper from a 40-acre watershed;
- Increased recharge of 650,000 gallons per year from a 1,500-cubic-yard water and sediment control structure designed to hold a one-inch runoff from a 40-acre rangeland watershed; and
- Grazing management experiments demonstrated that rainfall infiltrates deeper and faster in areas grazed for shorter periods with adequate residue and rest periods subsequent to grazing.

5.4 REGIONAL WATER SUPPLY STRATEGY OPTIONS BY WATER-USE CATEGORY

While all water-use strategies are important, not all strategies are appropriate for all water-user needs. Various water-use categories have different quantity and quality requirements. Even within a single water-use category the strategy needs may vary. Likewise, there is variability in the ability to finance the implementation of certain strategies. The following discussions summarize significant strategies appropriate to each water-use category as they pertain to the Plateau Planning Region.

5.4.1 Municipal and County Other

Of all use categories, water used for human consumption generally has the most critical limitations. Water required for public supply and rural domestic consumptive use must meet relatively stringent quality standards. The volume of water needed is directly related to the population served, although, this quantity can be modified to a degree by effort placed on conservation. Strategies of importance for municipal and rural domestic use can be divided into two categories. The first category represents those strategies concerned with the acquisition of sufficient water supplies of acceptable quality. These strategies may include expanded use or acquisition of existing ground-water supplies, ground water transport, desalination, and conversion of rights to use water. Water requirements for new homes established in rural areas are typically achieved by the drilling of domestic wells. The second category includes those strategies that make more efficient use of existing supplies, such as water conservation, drought response planning, conjunctive use of resources, aquifer storage and recovery, and reuse of wastewater.

In order to provide additional water supply for rural areas of Bandera County, the Springhills Water Management District is considering the purchase of Medina River water from Bexar-Medina-Atascosa WCID. Springhills would divert and treat this surface water, and inject it into the Trinity Aquifer in an Aquifer Storage and Recovery (ASR) facility for later retrieval and use. The original quantity of water discussed is 2,000 acre-feet per year with the recent negotiations for a total of 5,000 acre-feet per year.

5.4.2 Manufacturing and Industrial

Although some manufacturing and industrial activities require extremely pure water, quality requirements for most uses are less stringent. Strategies thus include consideration of acquiring needed quantities that meet specific minimal quality limitations. The acquisition and treatment cost of the water supply is of considerable concern to most industries. Water supply acquisition may be self-supplied from privately held sources or may be purchased from municipal or private water suppliers. The improvement of water use systems within the manufacturing process may conserve water. Some industries may be able to use treated reuse supplies generated from municipal suppliers or may be able to develop techniques of reusing their own supply.

5.4.3 Mining

Most mining operations develop their own water supplies primarily to be used for washing and dust suppression purposes and thus have less stringent quality restrictions. Strategies of importance to the mining industry are those associated with the acquisition of sufficient water supplies at reasonable cost and, if appropriate, the reuse of supplies to lessen the economic impact of generating new water supplies.

The Texas Water Development Board Reported Use Section provided total water reported used in year 1997 for mining purposes. For the counties that may experience shortages in the mining sector, the total water reported used is as follows: Bandera County, 23 acre-feet of water (all groundwater), Real County, 6 acre-feet of water (all groundwater), Val Verde County, 99 acre-feet of groundwater and 89 acre-feet of surface water. The type of mining operation most likely to realize water conservation savings through re-use is the sand and gravel aggregate type of mining; these operations use the same water for washing the material, over and over again, so that up to 85% of the water is recycled. For most of the counties cited above, the Texas Water Development Board was unable to determine how much of the reported use amounts were used by sand and gravel aggregate operations versus other types of mining operations. However, in the case of Val Verde County - which uses the most water for mining – a single mining operation near the City of Del Rio was responsible for the entire amount of surface water used in 1997. Since this operation already utilizes extensive on-site recycling, including plastic linings in the ponds so as not to waste any water, little to no more conservation savings could be realized.

Although on-site recycling/re-use is an effective water management strategy, apparently the majority of sites where this recycling can take place within the Plateau region is already taking place. Often the limiting factor for being able to recycle onsite is the areal extent of the particular mining site (the ponds and recycling structures that transport water from the outfall of "dirty wash" to the wash areas across the site occupy a lot of space). Another limiting factor is the nature of the material being washed (e.g., clay simply absorbs the water applied, so is not a good candidate material).

5.4.4 Irrigation

The quantity and quality of water needed for agricultural irrigation is dependent on the type of crop grown and on soil characteristics. Although a minimal amount of agriculture can persist on limited water supplies, most crops require significantly larger water applications to remain profitable. When water is limited or not available, most farming temporarily ceases until water supplies once again become available. Irrigation strategies principally involve various forms of conservation. Irrigation application equipment has been developed to insure that greater amounts of applied water reach the root system while minimizing loss to the atmosphere through evaporation. Proper application timing is also critical in avoiding over-watering. The lining of canals that transport water from its source to the fields can prevent loss due to seepage. Drought tolerant crop selection is also important when faced with limited water supplies.

In the original on-farm irrigation demands developed by the Texas Water Development Board, certain irrigation conservation methodologies and technologies are included in the level of conservation built-in to the demands. In order to determine how much water could be gained from an aggressive or advanced level of conservation, it was first necessary to understand what was involved in the expected level of conservation incorporated as an element to the original on-farm irrigation demands. A TWDB data file "Irrigcoba" used in generating the original on-farm irrigation demands gives three levels of conservation: 1) no change in technology, 2) most likely level of conservation, and 3) aggressive change in water use efficiency. As per page 2-21 of the 1997 Consensus Water Plan "Water for Texas", Volume 2, the conservation level incorporated in the on-farm irrigation demands was Level 2. Subtracting demands incorporating Level 3 from demands incorporating Level 2 within the Irrigcoba data file yields possible additional amounts of water that could be conserved if farmers in the county practiced extremely aggressive conservation technology "above and beyond" the technologies built-in to the original demand amounts.

These amounts of water that could theoretically be conserved are:

- Bandera County – One acre-foot of water per year in decades 2000 and 2010, zero acre-feet per year in decades 2020 and 2030, and one acre-foot of water per year in decades 2040 and 2050
- Edwards County – Zero acre-foot per year in decades 2000 through 2020 and one acre-foot of water in each of the decades 2030, 2040, 2050
- Kerr County – One acre-foot of water per year in each of the decades 2000 through 2030; two acre-feet of water per year in 2030 and 2040; three acre-feet per year in 2050
- Kinney County – six acre-feet of water per year in decade 2000, 12 acre-feet per year decade 2010, 17 acre-feet per year in 2020, 21 acre-feet per year in decade 2030, 26 acre-feet per year decade 2040, and 31 acre-feet per year in decade 2050
- Real County – One acre-foot of water per year in decades 2000 and 2010, two acre-feet per year in decade 2020, and three acre-feet per year in decades 2030 through 2050
- Val Verde County – One acre-foot of water per year in decade 2000, two acre-feet per year in decade 2010, four acre-feet per year in decades 2020 and 2030, and six acre-feet per year in decades 2040 and 2050

As can be concluded from the data above, the level of conservation practiced in most areas is already approaching that of aggressive. The exception to this is Kinney County; however, that county is not expected to undergo an irrigation shortage during the planning period.

It should be noted that future surface water permitting decisions by the Texas Natural Resource Conservation Commission (TNRCC) will be based partly on whether a need to be met is consistent with the approved regional water plan. In the case of an irrigator's application to the TNRCC for the right to use surface water, the application would <u>not</u> be inconsistent with this regional plan even though this regional plan does not specifically cite as a strategy such an application. The reasoning for this assertion is simple. The Plateau regional water plan is required to identify shortages and associated strategies based on drought-of-record amounts of supply available. On this drought-of-record basis, some surface water sources of supply within the region show zero to little water available (e.g., Upper Guadalupe River and Hondo Creek). However, the TNRCC for years has had a policy by which, if 75% of the amount of water requested by a non-municipal applicant is available for appropriation in 75% of the requested months of the studied time period, the TNRCC grants the application. In recent years this policy – informally termed "the 75% / 75% rule" - has actually been codified into law. Since the "75%/ 75% rule" obviously is based on amounts greater than drought-of-record amounts used within the regional plan, there are likely many irrigators or other non-municipal applicants who may wish to obtain surface water diversion permits from streams that are dry during drought but adequate at other times. TNRCC's lawful authority to grant such permits is in no way abridged by a regional water plan that does not specifically cite as a strategy these potential permit applications.

5.4.5 Livestock

Range livestock require water principally for drinking, while dairy operations require additional water for washing purposes. Additional water needed for range livestock can often be met by additional withdrawals from existing wells or the drilling of new wells. An important point to note is that during times of sever drought, livestock forage may become significantly diminished resulting in the necessity to reduce the size of herds. Herd reductions will obviously result in reduced water demands. To a degree, effectively applying brush control and other appropriate land-use measures may ease this situation. Effective land-use practices, including clearing of brush, may generate such benefits as increasing recharge potential, enhancing the growth of desirable grasses, and providing easier access to forage at higher elevations.

Wildlife also require an unquantified but significant amount of water for survival. Historically, perennial spring-fed streams provided adequate. With ever-increasing stress on available water supplies, wildlife needs may require specific consideration. As an example, in some parts of the region, certain wildlife species have grown to depend on water available at livestock watering facilities. Land-use practices should certainly include wildlife habitat maintenance as a standard part of the properties overall design.

5.5 WATER SUPPLY STRATEGY OPTIONS BY COMMUNITY

Although water shortages are not expected for many of the areas of the Plateau Water Planning Area, based on the water demand and supply projections, the region could experience unanticipated shortages. In fact, since the Plateau Region is semi-arid, unanticipated shortages may occur. This water plan specifically recognizes the need to include strategies to meet unanticipated shortages. The discussion and table that follows for each county incorporates that assumption.

The Plateau Regional Planning Group has identified the inadequacy of data as a principal factor accounting for unanticipated shortages. This problem will be addressed more directly in Chapter 6, which addresses recommended legislative and regulatory changes. In the meantime, the Planning Group believes that each entity and area within the Plateau Region must have the flexibility to deal with shortages as they arise, without being penalized because the available data leads to a false sense of security.

5.5.1 Bandera County

Town of Bandera

Population and water demand in Bandera are expected to increase by 91 percent and 70 percent, respectively, between 2000 and 2050. Until recently, the City operated two municipal wells that produce water from the lower Trinity aquifer. A third lower Trinity well was recently completed to add more productive capacity to the system. The wells will produce enough water to satisfy municipal demand for at least five years. The City expects to require mandatory water rationing every summer, and will evaluate the need to add other wells after about five years.

To cut down on the amount of water loss, the city has replaced much of its distribution system. "Unaccounted for" water has been estimated to be as much as 34 percent of daily pumpage. The replacements were financed by $1.5 million in certificates of obligation and an additional $250,000 Community Development Block Grant. Another $1.5 million project will add a 500,000-gallon storage tank to the system.

The City estimates that there are approximately 800 connections. Of this amount, about 33 percent (or 266 connections) are outside of the City Limits. The City has been discharging treated effluent to the Medina River, but is looking into the possibility of selling effluent to two privately owned golf courses. The City has also obtained a permit to use treated effluent for dust suppression.

Town of Medina

The Medina Water Supply Corporation (MWSC) has about 210 metered connections serving the town of Medina. The MWSC currently has a 100,000 gallon elevated storage tank and a 50,000 gallon ground-level storage tank, which provide between 1.5 and 2 days of supply to the town. The MWSC estimates that the system can supply at most 250 connections. This capacity may be exceeded in the next five to 10 years. Population and water demand for rural water supplies in Bandera County, which includes the town of Medina, are expected to increase by 143 percent and 105 percent, respectively, between 2000 and 2050.

Medina produces water from two wells. In the past there have been three wells, although only two wells are now operational, one in the Upper Trinity aquifer and one in the Middle Trinity aquifer. The town does not plan to put the third well back into production. Medina is trying to find funding to finance the installation of another well and storage facility to meet future demand. The new well and storage tank will be enough to double the capacity of the system.

The town has been approved for a colonia grant of $269,000 to install new, larger water mains. The town does not have an estimate for "unaccounted for" losses in the system. Meters at the connections are 30 years old and are being replaced at a rate of five to 10 per month.

The town is also looking at the possibility of a sewer system in the future. However, because the system is member-owned and unincorporated, there is no tax base and the system will have to rely on grants to make improvements.

5.5.2 Edwards County

Town of Rock Springs

The town of Rock Springs owns and operates two municipal wells that supply water to about 600 connections. The Town plans to add another well to augment the current level of production. The distribution lines are in good shape and the town has adequate storage, with one 500,000-gallon elevated storage tank and a 250,000-gallon ground-storage tank. The smaller tank was recently refurbished. The Town also has a new wastewater plant.

5.5.3 Kerr County

City of Kerrville

The City of Kerrville has developed a conjunctive-use policy for both surface water and ground water. The policy specifies that (1) surface water will be used to the maximum extent that it is available, and (2) ground water will be a supplemental source of supply.

The City's 1997 Regional Water and Wastewater Planning Study performed by HDR Engineers, Inc. concluded that 3,727 acre-ft of surface water is available during a prolonged drought. For planning purposes, the City proposes the use this estimate of available surface water, even though the estimate is significantly less than the permitted amount based on availability during a drought-of-record. Kerrville will develop additional surface water rights, storage options or modifications to the existing permits, if it can be shown that there are periods when the City will not be able to use the permitted water.

Based on work done in 1973 by W.F. Guyton Associates and referenced in the 1997 Regional Water and Wastewater Planning Study, the firm yield of the lower Trinity aquifer was estimated at 3,361- 4,481acre-ft in the area of Kerrville. The City uses a figure of 3 mgd, or 3,360 acre-ft/year as the ground-water supply during a drought year. In the last 10 years, the City has not had to curtail surface water use; therefore, groundwater production has been significantly below what could have been pumped. The City continues to rely on the lower Trinity aquifer as a dependable source of water. Through the conjunctive use policy, ground water is reserved for meeting peak demand in a normal year and base demand in a drought year.

For planning purposes, the estimates of available ground water available are 5 mgd (5,600 acre-ft/year) for peak demand and 3 mgd (3,360 acre-ft/year) for average demand.

The city has developed an "Aquifer Storage and Recovery" (ASR) system that allows treated surface water to be injected into the Lower Trinity aquifer for use when demand exceeds surface water supply. While this is not a separate source of supply, it allows the city to store water in the same manner as in a surface water impoundment. It is estimated that 384 ac-ft of water can be stored per year in the existing ASR well. The city plans to double the capacity of the system by the year 2003. In an extended drought, the ASR system is limited by the total amount of available surface water. For planning purposes the City does not consider stored water as an addition to the firm yield from either surface water or ground water.

The City has identified its need to develop agreements with GBRA that will provide for subordination of GBRA's Canyon Reservoir authorization to the City of Kerrville's existing permits. The City has also identified the possibility of modifying its own existing water permits. Currently the City's ability to divert under its existing permits is dependent on whether more senior water right holders exercise their rights, and is also affected by the City's Special Conditions written into its permits. If the City had more reliability from the Guadalupe River flows, and more latitude in its ability to divert during certain months of the year, the City could more fully utilize its ASR facility.

The City of Kerrville's water treatment capacity also limits its utilization of its ASR facility. The City needs a combined ASR/treatment system with capacity to treat and store 2 mgd during periods of higher streamflow, while the current system is limited to 1 mgd. The City has included an expansion to this system in its five-year capital improvement program. The City and UGRA have developed a Memorandum of Understanding by which the two new entities may jointly expand water treatment capacity.

The TNRCC's Water Availability Model currently does not account for spring flows from one or more springs in the area that contribute substantial flows to surface waters. Perhaps the City of Kerrville's optimal chance to modify its existing permits lies in petitioning the TNRCC to revise the WAM to reflect these spring flows. Alternatively if the City could show TNRCC permitting staff that using these spring flows would not subtract a like amount of unappropriated water from the model or from physical reality, it could perhaps make a case for modifying its existing water permits to take advantage of the spring flows. The City of Kerrville's need to modify its existing water rights is discussed as Strategy No. 133-1.

The availability of water will become a factor limiting the growth of both Kerrville and Kerr County. Options that the City considers as possible future sources of supply include:

- Obtaining additional water rights or modification to existing permits to provide more surface water during an extended drought, both for ASR storage and for demand.
- Contracting with GBRA for a raw water supply to be delivered to Kerr County.
- Reconsider the potential for storage of raw water in a surface water impoundment to provide additional firm yield of surface water during a prolonged drought.
- Develop remote well fields to provide additional ground-water sources beyond the Lower Trinity in the Kerrville area.

Town of Hunt

The Hunt Community Water Supply Corporation (HWSC) serves the City of Hunt. This system produces water out of a single Middle Trinity well. Two Middle Trinity wells in nearby Camp Lajunta serve as the official backups to the HWSC well, and all three are connected so that the backups can be brought online quickly. The WSC has a 30,000-gallon storage tank and a 3,000-gallon pressure tank that has approximately one day of storage for the community. The HWSC currently serves 42 connections, and uses between 700,000 and 1,200,000 gallons per month. The well has a potential capacity of about 3,000,000 gallons per month.

Because of the layout of the area, only about 10 additional lots can be developed, and therefore this is the only increase in demand that is possible. The system has the capacity to serve these potential additional connections, even without the backup wells being considered. Therefore, the system is considered to be static, and should be for the next 50 years. There are no plans for improvement or expansion of supplies. Only the routine maintenance of the system is planned or expected for next 50 years. All wastewater is disposed of in septic systems, and no there are no plans to change this.

Upper Guadalupe River Authority (UGRA)

A significant amount of the potable water system needs in the approximately 51 unincorporated areas in Kerr County are being supplied by investor-owned utilities (IOU's). Today's trends indicate that growth in unincorporated areas of the county will exceed the expected growth of the City of Kerrville. Currently, water needs outside of Kerrville are met by wellfields in the middle Trinity (Cow Creek) and lower Trinity (Hosston-Sligo) aquifers. One of UGRA's major objectives is to shift the dependency of these areas from ground water to surface water, insofar as permits and surface flow will support this plan.

To meet peak demand and low-flow restrictions, UGRA expects to acquire, either by purchase or long-term lease, the better wells owned by the IOU's. Contract arrangements with the IOU's will promote the best conjunctive use of wells outside of UGRA's direct control by contract limitations. See Strategy No. 133-9 for a discussion of the regional water system created by tying in the IOUs with the UGRA system.

UGRA and the Guadalupe-Blanco River Authority (GBRA) are negotiating additional surface rights – 2,000 acre-feet of water per year from the current pool of Canyon Reservoir and 2,000 to 4,000 acre-feet of water per year out of an additional pool if GBRA receives its permit amendment from TNRCC for subordination of hydropower. Both UGRA and the City of Kerrville plan to obtain more water from the Guadalupe River than they are currently using under their existing water permits, whether via amendment of their existing permits and/or via purchase of water from GBRA. Therefore a thorough hydrologic and water availability study should be performed to determine if the Guadalupe River can, in physical reality, provide the quantities of water desired by both UGRA and the City of Kerrville.

Similarly, since UGRA now intends to fully implement an Aquifer Storage Recovery (ASR) facility by 2030, and since this facility will be located relatively near the City's ASR facility, the City and UGRA will each need to track how much water each entity is entitled to recover. A more thorough understanding of the geology involved and whether any hydrologic connection exists between the two ASR facilities is needed. UGRA's Aquifer Storage Recovery is discussed in detail as Strategy No. 133-11.

UGRA has had some discussion with Kendall County WCID regarding a joint effort to serve southeastern Kerr County and western Kendall County. The Center Point area in Kerr County is especially expected to develop considerably within the next ten or fifteen years. (UGRA would need to obtain Center Point Lake from Kerr County in order to follow through on this plan, as UGRA would want to place a water treatment plant at Center Point Lake. Reference Strategy No. 133-10). Currently Kendall County WCID is making other plans, but a UGRA-Kendall County WCID joint effort is still an option. If UGRA does not proceed with a joint effort with Kendall County WCID and with the associated water treatment plant at Center Point Lake, then UGRA will tie in the Center Point area with a proposed water treatment plant near James Road. This plant would divert from the Guadalupe River and is projected to be online in year 2002.

UGRA plans to obtain Center Point Lake, Flat Rock Lake and Ingram Lake from the county, possibly use Center Point as the location for a new water treatment plant (jointly with Kendall County WCID as discussed above), and use one or more of the lakes as a "buffer" drought contingency lake. Kerr County's current water right authorization for the three lakes is for non-consumptive recreation use. UGRA would need to apply to TNRCC to change the purpose of the impoundments to municipal storage and to allow diversions at Ingram Lake for municipal use. This is termed "reallocation". These lakes date to the 1950s and probably are in need of dam safety inspections. The minimum (drought of record) unappropriated water amount at all three locations is zero. However, the value of this strategy is that it more effectively makes use of existing water sources by providing a drought contingency "buffer" function for UGRA, especially important during the summer months. The reallocation is discussed in detail as Strategy No. 133-10.

It is estimated that UGRA's conjunctive water demands for the year 2050 will exceed 18,000 acre-ft per year. Some of UGRA's strategies deal with making more effective use of the current sources of water (e.g., the ASR facility, the buffer drought contingency lake), but UGRA needs actual sources of water supply in addition to its current source of the Guadalupe River. Alternatively, UGRA needs to obtain a greater portion of the water that is available in the Guadalupe River. One way to accomplish this is to buy existing water rights on the Guadalupe

River or its tributaries. A study to determine the most reliable rights would be needed to guide UGRA in its decisions on selecting the best water rights to purchase. Such a study would involve a methodology, using the Water Availability Model, to identify rights that are both reliable and that have senior priorities.

If UGRA could not purchase existing water rights on the Guadalupe River or its tributaries or cannot obtain adequate water purchase contract(s) of Canyon Reservoir water from GBRA, then UGRA would have no choice but to develop new sources of water supply farther from home. UGRA has considered the feasibility of constructing a new water supply reservoir on Johnson Creek west of the City of Kerrville. UGRA has envisioned this reservoir as a source of supply to meet growing water needs in the Kerrville and Center Point areas. However, unappropriated water on Johnson Creek is very limited. See Strategy No. 133-12.

UGRA has very recently identified the possibility of obtaining water from the Lower Colorado River Authority. This possibility has not been evaluated as a strategy during this planning cycle because the amount of water that UGRA might obtain from the Guadalupe River via contract(s) with GBRA is still pending, and the amount of groundwater available may perhaps make purchase of Colorado River surface water unnecessary. However, this idea is discussed in Chapter 6 as a possibility to be considered during the next planning cycle.

5.5.4 Kinney County

Town of Brackettville

Brackettville's water is supplied by two city-owned wells that produce from the Edwards aquifer. The production from both wells is sufficient to meet projected demand for the next 50 years, and the town does not foresee the need to add another well. The town expects modest short-term population growth associated with the addition of a 500-bed prison to be built within the next two years. The growth expected from the prison will bring an estimated 50 to 100 new residents in addition to the prisoners to the community.

The town's distribution lines are considered to be in good shape, and storage capacity is adequate for the foreseeable future. The city owns one 75,000-gallon elevated storage tank and one 250,000-gallon ground-storage tank. Wastewater is recycled to the Ft. Clark Springs golf course. Brackettville also provides water to the village of Spofford. There are approximately 40 connections in Spofford.

Ft. Clark Springs

The Ft. Clark Municipal Utility District (Ft. Clark MUD) supplies water to approximately 925 connections at Ft. Clark Springs. About 10 to 15 new connections are added each year. The production is from two wells completed in the Edwards aquifer. Each well is capable of producing about 950 gpm, and average daily production ranges from 300,000 to 500,000 mgd. The Ft. Clark MUD does not foresee the need to add new wells to meet projected demand over the 50-year planning horizon required by SB-1.

The transmission lines are in good shape, and the system has sufficient capacity from a 300,000-gallon tank and another 150,000-gallon tank to meet all projected storage requirements. The Ft. Clark MUD has built a new 750,000-gpd sewage treatment plant. The plant is now processing 200,000 gpd to 250,000 gpd. Treated effluent is being used to water the Ft. Clark Springs golf course.

The Ft. Clark MUD will supply approximately 65,000 gpd to a 500-bed prison to be built inside the city limits of Bracketville.

5.5.5 Real County

Town of Camp Wood

The Town of Camp Wood derives all of its municipal water from Kreuger Spring (Camp Wood Spring) that issues from alluvial gravel overlying the Edwards-Trinity (Plateau) aquifer. Discharge from the spring is occasionally insufficient to meet all current needs, and the Town is considering developing an alternate source of supply. Other significant problems with Kreuger Spring are the occurrence of Giardia (in late 1988) and intermittent high turbidity.

Town of Leakey

The Town of Leakey depends on three wells completed in the Frio River Alluvium aquifer and underlying limestones for all of its water supply. The Town provides water to approximately 400 connections within the City Limits and to another 35 connections in outlying areas. A fourth well is planned to give the Town more supply potential. Distribution lines and storage tanks are in good condition. The Town has one 177,000-gallon standpipe and two 75,000-gallon ground storage tanks.

5.5.6 Val Verde County

City of Del Rio

The population and the associated municipal water demand of the City of Del Rio are expected to grow by 46 percent and 30 percent, respectively, over the 50-year planning period from the year 2000 to 2050. To meet future water needs, the City has started a long-term program to develop ground water as a supplemental source of municipal water. The City also plans to replace leaking storage tanks and distribution lines to cut down on the amount of water loss in the system. Also planned for the City is a 16-million gpd filtration plant.

Two former municipal supply wells are being brought back into production, and a third well will be developed on municipal property north of the City. Other wells may be developed as needed. The three wells are expected to provide as much as 4 million gpd of water to the system.

Replacing the Bedell Street tanks with a 4-million-gallon storage tank will eliminate approximately 1-million gallons of water loss per day. Other upgrades to the system over the next 10 to 15 years will also reduce water loss. Total water losses are estimated to be as much as 35 percent of daily production. Approximately 10 percent are attributable to leakage from the old Bedell St. tanks. The remaining 25 percent occur in the City's distribution lines.

The City is also adding a filtration plant to comply with a directive from the TNRCC to ensure that water from San Felipe springs meets the primary drinking water standards for microorganisms. The directive was issued by TNRCC because of concerns raised by elevated levels of turbidity in water discharging from San Felipe springs especially after rainstorm events in the vicinity of Del Rio.

The City will continue to supply water to Laughlin Air Force Base. In recent negotiations, the Base has requested a maximum of 5 million gpd from the City. Peak use at the Base, however, was 3 million gpd in 1996, and the TWDB does not expect demand at the Base to grow over the 50-year planning period. With new sources of supply and improvements to the storage and distribution system, the City should be able to meet all of the Base's water needs.

5.6 NATURAL RESOURCES AND ENVIRONMENTAL ISSUES

Environmental water needs is a generic term applied by many persons with many perspectives and therefore the term might have different meanings within the same conversation, or one person may have a broader understanding of the term than another. Statutorily, two environmental water needs that are specifically recognized within Texas Water Code as beneficial uses of water are 'instream flows' and 'bay and estuary flow needs'. Texas Water Code also institutes responsibilities on TNRCC to assess instream flow needs, and on the TWDB and TP&WD to determine bay and estuary flow needs via hydrologic modeling of the bay and estuary systems. TNRCC as the regulatory agency may impose requirements on water right holders to pass-through flows for instream flows and for bay and estuary flow needs. However, pass-through flows for bay and estuary flow needs are required only for water rights within two hundred river miles of the coast. As such, the Plateau Region is beyond the regulatory range.

The impacts of environmental water demands on existing surface water supplies are non-existent from a legal standpoint. Existing surface water rights are legal documents and if a water right does not require the water right holder to pass through water for environmental purposes, then the water right holder does not need to do so. However, when a water right holder applies for an amendment to his or her existing water right, and that amendment involves a change in the place of use, type of use or an additional amount of water to be used, then that water right will be open for requiring pass-through for instream flows and possibly bay and estuary flow needs. Future water rights are also subject to TNRCC requirements for instream flow and bay and estuary flow needs.

Natural and environmental resources are often overlooked when considering the consequences of prolonged drought. As water supplies diminish during periods of drought, the balance between the needs of humans and environmental water requirements becomes increasingly precarious as competition for water becomes more intense. A goal of this plan is to provide for the health, safety, and welfare of the human community, with as little detrimental impact as possible on the environment. To accomplish this goal, the evaluation of strategies to meet future needs included consideration of the environmental effects of the implementation of each strategy.

While some strategies may contain variable levels of negative impact, other strategies may likely have positive effects. Negative environmental impacts were generally associated with decreased spring flow and decreased discharge of ground water to streams because of lower water levels in the Edwards-Trinity (Plateau) aquifer. Diminished spring and stream flows may affect the habitats of fish and aquatic plants, as well as decrease the number of watering areas for fowl and wildlife.

Of particular concern to the City of Del Rio is the potential impact on San Felipe Springs of ground-water development in watersheds that are the originating areas for the local flow system that supplies most of the spring flow. Aggressive exploitation of ground water in areas upgradient of the springs may threaten the City's source of drinking water. Governing bodies of the City and Val Verde County might consider commissioning a study to determine the volume of ground water that can be produced and the consequential aquifer drawdown under normal conditions and drought-of-record conditions without threatening the City's source of drinking water.

The City of Del Rio's continued reliable source of water supply in San Felipe Springs will be jeopardized if U.S. Fish and Wildlife Service declares the Devil's River Minnow an endangered species. Currently the City of Del Rio, Texas Parks and Wildlife Department, and U.S. Fish and Wildlife Department cooperatively administer a Conservation Agreement with the objective of ensuring the continued existence of the minnow. The City of Del Rio depends heavily on San Felipe Springs for water supply and is currently engaged in rehabilitating old ground-water wells and developing new wells, as well as taking steps to replace a leaking water storage tank. The new ground water and stopping the waste of water from the leaking tank should mitigate the impact to the City should San Felipe Springs no longer be available as a source of water supply. However, the City is confident in the Conservation Agreement and does not expect to lose either the Devil's River Minnow or San Felipe Springs.

5.7 EMERGENCY TRANSFER CONSIDERATIONS

The Texas Legislature has established a statute (Texas Water Code 11.139) by which non-municipal surface-water rights may temporarily be interrupted to make water available for public-supply needs during times of emergencies. The intent of the statute is to reduce the health and safety impact to communities that have run short of water because of unexpected circumstances. The statute was specifically enacted as an emergency process to bring relief to several communities that had been affected by drought conditions that had severely diminished their water-supply sources. The Plateau Regional Planning Group considered the potential for emergency transfer of surface water for communities in the region and chose not to recommend this strategy for this planning period.

5.8 DROUGHT RESPONSE TRIGGERS

Droughts typically develop slowly over a period of months or even years and can have a major impact on the region. Water shortages may also occur over briefer periods as a result of water production and distribution facility failures. Drought contingency plans provide a structured response that is intended to minimize the damaging effects caused by the water shortage conditions. A common feature of drought contingency plans is a structure that allows increasingly stringent drought response measures to be implemented in successive stages as water supply or water demand worsens (TNRCC, 1999). This measured or gradual approach allows for timely and appropriate action as a water shortage develops. The onset and termination of each implementation stage should be defined by specific "triggering" criteria. Triggering criteria are intended to ensure that timely action is taken in response to a developing situation and that the response is appropriate to the level of severity of the situation.

Each water-supply entity is responsible for establishing its own drought or emergency contingency plan that includes appropriate triggering criteria. Depending on the water use category, the plan may ultimately affect the health and welfare of a large population or it may only affect the property of a single owner.

Drought response triggers should be specific to each water supplier and should be based on an assessment of the water user's vulnerability. In some cases it may be more appropriate to establish triggers based on a supply source volumetric indicator such as a lake surface elevation or an aquifer static water level. Similarly, triggers might be based on supply levels remaining in an elevated or ground storage tank within the water distribution system; this is not a recommended approach, as the warning of supply depletion would be only three to four days. Triggers based on demand levels can also be effective, if the demands are very closely and frequently monitored. Whichever method is employed, trigger criteria should be defined on well-established relationships between the benchmark and historical experience. If historical observations have not been made then common sense must prevail until such time that more specific data can be presented.

5.8.1 Surface Water Triggers

The region's surface water occurs primarily in the major watercourses identified in Chapter 3 and listed in Table 3-1. These are the Medina and Sabinal Rivers and Hondo Creek in Bandera County; the West Nueces and Nueces Rivers in Edwards, Kinney and Real Counties; the South Llano and Guadalupe Rivers in Kerr County; the Frio River in Real County; the Pecos and Devils Rivers and San Felipe Springs in Val Verde County.

However, the Plateau Region is replete with numerous smaller streams and springs throughout the Hill Country and Edwards Plateau areas. Examples of these are Indian Creek, San Julian Creek, Bullshead Creek, Nowlin Hollow, Imperialist Creek and many others. Minor streams are listed in Chapter 6 under the section discussing Unique Sites for Reservoir Construction.

Many of the smaller water bodies as well as the major watercourses are exceedingly scenic, pristine and of historical significance. Small communities have been settled, grown and prospered for varying lengths of time on the shores of these streams, and man's activities have altered the hydrologic regime and seasonal patterns of use numerous times over the years. The TNRCC South Texas Watermaster Office provided surface water reported use data for surface water rights of record within the Plateau Region. These data provide opportunity for analysis as to patterns according to use type and seasonality. Municipal users tend to need and divert a fairly consistent amount of water throughout the year. Municipal use increases during the summer due to increased biological need for water, increased lawn watering and other increases associated with hot summer weather. This increase in use tends to be on the order of 20 or 30 percent in the case of large municipal entities, and sometimes up to 50 or 60 percent in the case of individual users or very small communities and systems. This pattern is illustrated in the average monthly reported use amounts shown in Table 5-1 "Seasonal Use of Surface Water" for the Guadalupe and Sabinal Rivers. The principal municipal user on the Guadalupe River is the City of Kerrville, whereas the principal municipal user on the Sabinal River is an individual.

Table 5-1 also shows reported use for irrigation purposes on the Guadalupe, Sabinal, Frio, Medina and Nueces Rivers and Indian Creek and San Julian Creek. Generally the increase in use by irrigators during the summer months is much greater than the increase in use by municipal users during the summer months. This can be seen by irrigation use on the Guadalupe River during July and August (105 and 120 acre-feet per month respectively) versus during February or November (11 and 15 acre-feet per month respectively). However, the table shows an exception to the trend of increased irrigation use during summer months for the Sabinal River. These data show almost no summer use by irrigators from the Sabinal. A possible reason could be the cultivation of small grains in the area; small grains consume no water from June through September.

Summer usage by multiple diverters on the same stream can be extensive. The TNRCC protects adequacy of flow in certain streams by placing special restrictions on water right holders, allowing them to divert during the summer months only when stream flows reach a certain level. For example, both the City of Kerrville and the Upper Guadalupe River Authority have within their permits a Special Condition stipulating that during the months October through May, the permittees may divert only when the flow of the Guadalupe River exceeds 40 cfs, and during the months of June through September, the permittees are authorized to divert only when the flow of the Guadalupe River exceeds 30 cfs. These 40-cfs and 30-cfs levels protect the flow and serve as key water supply indicators for the Upper Guadalupe River. Both the City of Kerrville and UGRA use these levels of flow within their respective drought contingency plans as drought triggers.

Sources of surface water are probably among the first reliable indicators of the onset of hydrologic drought, as defined in Section 1.2.2. Diminished spring discharge and stream flow, for example, can be monitored daily by city, county, and state agencies, and also by landowners. Of particular interest, however, are the levels to which spring discharge and stream flow must be reduced before the onset of drought is declared and appropriate response measures are initiated in the region. Cities that rely exclusively on spring flow for municipal water are particularly vulnerable to drought-induced reductions in discharge, especially if alternative sources of supply have not been developed to make up potential shortfalls created by lower discharge. As an operating definition of hydrologic drought, it is recommended that reductions of spring discharge between 25 percent and 33 percent (compared with average discharge and flow) be considered effective hydrologic drought triggers in the Plateau Region.

Two reservoirs that are considered key water supply reservoirs for meeting the region's near- and long-term water-supply future needs are Canyon Reservoir and the Medina/Diversion lake system. Both of these reservoirs have triggers built into the operating programs as administered by the reservoir sponsoring entities; to suggest other triggers would be inappropriate. Canyon Reservoir is an Army Corps of Engineers reservoir, and as such operates under the COE's Reservoir Regulation document (FWDR 1130-2-16), originally issued in 1971. Should TNRCC approve Guadalupe-Blanco River Authority's pending water right amendment application regarding Canyon Reservoir, the COE Reservoir Regulation document will need to be amended to accommodate the deletion of FERC hydroelectric pass-through flows. The Medina/Diversion lake system operation is administered by the major water right holder on the lake, Bexar-Medina-Atascosa WCID 1. Operations are constrained by a Special Condition of BMAWCID1's water right that specifies that emergency firefighting vehicles should have access to impounded water, and further constrained by a Memorandum of Understanding between

BMAWCID1, Bandera County, Springhills Water Management District, and Bexar Metropolitan Water District dated March 19, 1997. The MOU specifies that BMA will restrict diversions for municipal purposes when the level of Medina Lake is at or below 1,035 feet (which level is to be measured based upon the datum plane for the Medina Dam identified as being located at the 1,084 feet msl level). The 1,035-ft level can very well be considered a drought trigger, although the term is not explicitly applied within the MOU.

5.8.2 Ground Water Triggers

Ground-water triggers that indicate the onset of drought are not as easily identified as factors related to surface-water systems. This is attributable to (1) the rapid response of stream discharge and reservoir storage to short-term changes in climatic conditions within a region and within adjoining areas where surface drainage originates, and (2) the typically slower response of ground-water systems to recharge processes. Although climatic conditions over a period of one or two years might have a significant impact on the availability of surface water, aquifers of the same area might not show comparable levels of response for much longer periods of time, depending on the location and size of recharge areas in a basin, the distribution of precipitation over recharge areas, the amount of recharge, and the extent to which aquifers are developed and exploited by major users of ground water.

With the exception of the Trinity aquifer of Bandera and Kerr Counties, all other aquifers in the six rural counties were identified in Chapter 3 as unlikely candidates for dewatering, based on comparisons between projected demand, recharge and storage. In these areas, water levels might be expected to remain constant or relatively constant over the 2000 – 2050 planning period. Observation wells in major recharge areas and in areas adjacent to municipal well fields in the rural counties might provide a sufficient number of points to monitor water levels, provided that water-level measurements are made on a regular basis for long periods of time. Water levels below specified elevations for a pre-determined period of time might be interpreted to be reasonable ground-water indicators of drought conditions in any basin.

Basins that do not receive sufficient recharge to offset natural discharge and pumpage may be depleted of ground water (e.g., mined). This is especially the case with the Trinity aquifer of Bandera and Kerr Counties. The rate and extent of ground-water mining in any area are related to the timeframe and the extent to which withdrawals exceed recharge. In such basins, water levels may fall over long periods of time, eventually reaching a point at which the cost of lifting water to the surface becomes uneconomic. Thus, water levels in such areas may not be a satisfactory drought trigger. Instead, communities might consider the rate at which water levels decline in response to increased demand as a sufficient indicator of drought.

Because of the above described problems with using water levels as drought-condition indicators, most municipal water-supply entities in The Plateau Region that rely on ground water generally establish drought-condition triggers based on levels of demand that exceed a percentage of the systems production capacity. Table 5-4 provides a list of ground-water dependent entities, their supply source, their type of trigger, and their associated responses.

Water levels in observation wells in and adjacent to municipal well fields, especially where wells are completed in aquifers that respond relatively quickly to recharge events, may be established as drought triggers for municipalities in the future providing a sufficient number of measurements are made annually to establish a historical record. Water levels below specified elevations for a pre-determined period of time might be interpreted to be reasonable ground-water indicators of drought conditions. Until such historical water-level trends are established, municipalities will likely continue to depend on demand as a percentage of production capacity as their primary drought trigger.

Water-use categories in the Region other than municipal that are dependent on ground water as their primary or only source of supply must rely on a number of factors to identify drought conditions. In most cases, atmospheric condition (days without measurable rainfall) is the most obvious factor. Various drought indices (Palmer, Standard Precipitation, and Keetch-Byram) are available from State and local sources. Groundwater conservation districts, agricultural agencies, as well as individuals can access these indices for use in determining local drought conditions and appropriate responses.

As discussed earlier in this section, ground-water levels in this part of the State currently have only limited use as drought triggers. Although numerous water-level measurements are available on a number of wells in the Region, most of this data represents only one measurement a year. This does not allow for observation of seasonal fluctuation or response to recharge events. However, the table below provides a selection of wells (one per aquifer) with a history of measurements and a proposed drought trigger level. Most of these wells are measured annually by staff of the TWDB and some may be influenced by local pumping. Wells selected for drought contingency triggers should be re-evaluated for appropriateness during the next planning period. Where possible, drought-trigger wells should be selected or positioned so that local pumping does not influence the water level. Data collection on these and other wells will begin so that appropriate drought levels can be assigned.

SUGGESTED GROUND-WATER LEVEL TRIGGER WELLS BY SOURCE

Aquifer	County	Well Number	Avg. Depth to Water in 1990s
Trinity	Bandera	69-14-604	98
Edwards-Trinity (Plateau)	Edwards	55-63-803	415
Edwards-Trinity (Plateau)	Kerr	56-53-304	181.1
Edwards-Trinity (Plateau)	Val Verde	70-42-205	64.0
Edwards (BFZ)	Kinney	70-45-401	24.6
Austin Chalk	Kinney	70-45-404	unknown
Frio River Alluvium	Real	70-24-601	71.7

* Wells selected for drought triggers should be re-evaluated for appropriateness during next planning period.

** Insufficient water-level history record available to establish trigger depths. Additional data will be collected to establish water-level trends.

Groundwater conservation districts are generally responsible for monitoring conditions within their boundaries and making appropriate public notification. Outside of existing districts, the TWDB should assume responsibility of public notification of drought conditions based on their water-level monitoring network. County Commissioners are expected to designate trigger levels and establish responses. In Val Verde County, the City of Del Rio is responsible for designating trigger levels and establishing responses. Appropriate drought responses are also the responsibility of and at the discretion of private well owners.

5.9 STRATEGIES TO MEET WATER SUPPLY SHORTAGES

Strategies intended to provide solutions to both short-term and long-term drought-contingency water-supply shortages are the major aspect of this regional water management plan. Short-term strategies are those that are needed to meet deficits in the next 30 years. These strategies are identified in sufficient detail to allow state agencies to make financial and regulatory decisions. Long-term strategies are less precise and are intended to meet water needs occurring 30 to 50 years into the future.

The evaluation of each individual water management strategy requires an identification of the legal and regulatory issues that will directly impact the feasibility of the strategy. The 1944 International Treaty below Ft. Quitman governs the primary western surface water resource in the Region, the Rio Grande. The Lower Rio Grande Watermaster administers withdrawals from the Rio Grande on the Texas side of the border. As to the regulatory restraints on the use of ground water, Historically, ground water has not been regulated in Texas except in relatively few areas, but pursuant to Senate Bill 1, ground water districts are now the legislature's preferred method to regulate ground water. Within the Plateau Region there are three underground or groundwater conservation districts, each with statutory rule-making and management authority within their respective jurisdictional boundaries. In summary, no management strategy in the Plateau Region should be pursued without a careful consideration of the legal issues impacted by that strategy.

5.9.1 Strategy Decision Process

Entities and water-use categories with drought-contingency supply shortages (Table 5-2) were identified in Chapter 4. A preliminary list of strategies to meet these shortages was developed and assigned to the consulting team for evaluation. The evaluation process is described in the following section. Following review of the strategy evaluations, the regional planning group selected the specific strategies that are contained in this plan (Table 5-3).

5.9.2 Strategy Evaluation Process

Each strategy evaluation is based on an identical set of criteria. The evaluations represent preliminary overviews and should not be considered as detailed feasibility analyses. Cost analyses in particular are speculative. Each evaluation lists the strategy name, description, portion of strategy intended for implementation during short- and long-term periods, and comparative criteria. Total capitol cost, cost by decade, and available supply by decade were recorded in TWDB Table 11. Following is a description of each of the evaluation criteria. The Regional Planning Group members then equitably compared each evaluation criteria, along with the cost and volume comparison in TWDB Table 11 to determine the feasibility of each strategy in relation to other strategies proposed for each shortage. Where appropriate, the Group specifically considered cost-effective water-management strategies that are environmentally sensitive. The Planning Group chose not to prioritize the strategies but rather to retain all feasible strategies. Strategy evaluations are presented at the end of this chapter.

- Quantity of water expected to be delivered and treated for the end user's requirements.
- Reliability of water supply including its quality suitability and expected life.
- Cost of water treated and delivered for end user requirements, including factors used in calculating infrastructure debt retirement.
- Environmental factors including effects on environmental water needs, wildlife habitat, endangered species, and cultural resources.
- Impact on other water resources including other water management strategies and ground-water surface-water relationships.
- Consideration of threats to agriculture.
- Consideration of threats to natural resources.
- Other factors deemed relevant by the regional planning group including recreation.
- Equitable comparison and consistent application of all strategies.
- Consideration of transport of water outside of its river basin of origin (interbasin transfer).

- Consideration of third party social and economic impacts resulting from voluntary redistribution of water.
- Consideration of existing water rights, water contracts, and option agreements.
- Consideration of effect on navigation.

5.10 SUMMARY

A primary objective of this regional water management plan is to make recommendations for specific water-supply strategies that can be implement during severe droughts. A listing of the preferred strategies to meet projected shortages during drought-of-record conditions is listed in Table 5-2. In the process of identifying strategies to alleviate supply deficits of each entity or water-use category, it became apparent that no single strategy, in many cases, was sufficient by itself to handle the shortage. The implementation of two or more strategies appears to offer the best solution.

A portion of the "County Other" category represents shortages that are the result of projected increases in rural population. Although strategies are shown for this category, the implementation and cost of providing the water supply for future rural residents is recognized as the responsibility of each landowner.

Strategies are developed for livestock and irrigation categories, however, it is important to understand the effects that drought has on these areas of agriculture. In the case of livestock, diminished forage generally occurs before the water supply becomes a problem. Ranchers often compensate for this by reducing sizes of herds. This strategy minimizes the overall impact on the remaining forage and on water supplies.

The impact of drought on irrigated farms depends on the source of the water supply. Irrigated farms that depend on ground water are less susceptible to drought than are farms that rely exclusively on surface water. Ground water in areas north of Brackettville, for example, will continue to be available during drought. On the other hand, prolonged droughts will likely dry up most sources of surface water that are used to support irrigation in years with normal to above-normal precipitation.

The Plateau Regional Planning Group determined that surface water uses that will not have a significant impact on the region's water supply are consistent with the regional water plan even though not specifically recommended in the plan. Also, the Group determined that water supply projects that do not involve the development of or connection to a new water source are consistent with the regional water plan even though not specifically recommended in the plan.

5.11 PLATEAU REGION STRATEGIES

Strategy evaluations begin on page 5-45.

STRATEGY # 10-1

WATER USER NAME:

County: Bandera
River Basin: San Antonio
User Name: County Other

STRATEGY NAME:

Additional system wells developed by Aqua Source Inc.

STRATEGY DESCRIPTION:

Aqua Source currently provides water to four subdivisions from eight wells. The number of additional Trinity aquifer wells needed to meet short-term needs is estimated at 2. A total of 2 additional wells will be needed to meet long-term needs for a total of 4 wells. Fewer wells may be required if this strategy is combined with Strategy #10-2.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): Two new wells.

Long Term (from the year 2030 to the year 2050): An additional 2 wells for a total of 4 wells.

QUANTITY OF WATER:

Each well is anticipated to yield about 100 gpm, which pumped for 12 hours per day would produce about 81 acre-feet per year. At this production rate, 2 wells will produce about 162 acre-feet per year and 4 wells will produce 323 acre-feet per year.

RELIABILITY OF WATER:

Sufficient ground water is available from a combination of the middle and lower Trinity aquifers; however, local water-level declines should be expected. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:

Cost for drilling an initial 12-inch diameter hole to 200-foot depth with 8-inch diameter steel casing pressure cemented then drilled to 600-foot depth with 7-7/8-inch open hole is estimated at $30,000. Cost for a 15-horsepower submersible pump capable of producing 100 gpm with wiring and control box and 300 feet of 3-inch diameter column pipe is estimated at $8,000. With cost for other appurtenances and engineering, the total estimated price is $45,000. The total cost for two and four wells, respectively, is estimated at $90,000 and $180,000. Additional cost for debt retirement was calculated using the TWDB program. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $670,939 from the year 2000 through the year 2050. Annual cost per acre-foot is $108.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:

Local water-level declines may occur which potentially may affect water levels in wells on surrounding properties. Local springs that feed into surface streams should not be affected.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

The drilling of public-supply wells must be in compliance with TNRCC regulations, county ordinances and Springhills Water Management District rules.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact.

IMPACT ON NAVIGATION:

No impact on navigation.

STRATEGY # 10-2

WATER USER NAME:
County: Bandera
River Basin: San Antonio
User Name: County Other

STRATEGY NAME:
Expanded use of existing wells operated by Aqua Source Inc.

STRATEGY DESCRIPTION:
Aqua Source currently provides water to four subdivisions from eight wells. Additional pumping time of each well will generate additional supply from the Trinity aquifer. Increased storage capacity may be required to hold water generated during night (off demand) pumping period. Less well production from each well is necessary if this strategy is combined with Strategy #10-1.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed.
Long Term (from the year 2030 to the year 2050): Phased in as needed.

QUANTITY OF WATER:
An additional 2 hours of pumping time of each of the eight existing wells at an average pumping rate of 100 gpm will generate 108 acre-feet per year.

RELIABILITY OF WATER:
Sufficient ground water is available from a combination of the middle and lower Trinity aquifers; however, local water-level declines should be expected. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:
Only cost is for additional power and some long-term maintenance. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $197,427 from the year 2000 through the year 2050. Annual cost per acre-foot is $108.

ENVIRONMENTAL ISSUES:
No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:
Local water-level declines may occur which potentially may affect water levels in wells on surrounding properties. Local springs that feed into surface streams should not be affected.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

The additional pumping time of each well could potentially affect the amount of local water-level decline.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact.

IMPACT ON NAVIGATION:

No impact.

STRATEGY # 10-3

WATER USER NAME:
County: Bandera
River Basin: Guadalupe
User Name: County Other

STRATEGY NAME:
Additional private domestic wells

STRATEGY DESCRIPTION:
Water supply for rural homes is predominantly produced from private domestic wells. Additional private domestic wells will be drilled to supply water mostly from the Edwards-Trinity aquifer to new rural homes outside of subdivisions with public supply systems.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as population increases. Estimated at 68 domestic wells.
Long Term (from the year 2030 to the year 2050): Phased in as population increases. Estimated at an additional 23 wells for a total of 91 wells.

QUANTITY OF WATER:
Private domestic wells generally yield 5 to 20 gpm and are pumped at a rate necessary to meet household demands, which are estimated at 600 gallons per day per household depending on one well. The quantity of additional water supply generated annually from this strategy is 46 acre-feet by 68 wells and 61 acre-feet by 91 wells.

RELIABILITY OF WATER:
Sufficient ground water is available from a combination of the middle and lower Trinity aquifers and possibly from the Edwards-Trinity (Plateau) aquifer. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:
Typical domestic wells are about 300 to 500 feet deep. Estimated cost to drill a 8-inch diameter hole is $5 per foot for a maximum of $2,500. Most domestic wells in the Hill Country have about 100 feet of 5- or 6-inch PVC casing, which is estimated at about $3.50 per foot for a total of about $350. Bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. Pressure tank prices are estimated at about $500. The estimated total cost for each domestic well is about $7,000. The short term need for 68 wells will cost about $476,000 and the additional 23 wells needed for the long term will cost about $161,000 for a total of about $637,000 for 91 domestic wells.

Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $710,157 from the year 2000 through the year 2050. Annual cost per acre-foot is $270.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:

Local water-level declines may occur which potentially may affect water levels in wells on surrounding properties. Local springs that feed into surface streams should not be affected.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

The drilling of new must be in compliance with Springhills Water Management District rules.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

Depending on density and well spacing dictated by lot size some negative impacts may result from this strategy. As a result of high density and wells spaced too close, interference between nearby wells may cause local water-level declines between neighboring properties possibly diminishing the yield or dropping water levels below pump settings. Local regulations dictating lot size and well spacing should help alleviate this problem.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

No impact to navigation is anticipated.

STRATEGY #10-4

WATER USER NAME:

County: Bandera
River Basin: San Antonio
User Name: County Other

STRATEGY NAME:

Additional private domestic wells

STRATEGY DESCRIPTION:

Water supply for rural homes is predominantly produced from private domestic wells. Additional private domestic wells will be drilled to supply water mostly from the Trinity aquifer to new rural homes outside of subdivisions with public supply systems.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): Phased in as population increases. Estimated at 4,128 domestic wells.

Long Term (from the year 2030 to the year 2050): Phased in as population increases. Estimated at an additional 1,264 wells for a total of 5,392 wells.

QUANTITY OF WATER:

Private domestic wells generally yield 5 to 20 gpm and are pumped at a rate necessary to meet household demands, which are estimated at 600 gallons per day per household depending on one well. The quantity of additional water supply generated annually from this strategy is 2,766 acre-feet by 4,128 wells and 3,613 acre-feet by 5,392 wells.

RELIABILITY OF WATER:

Basin wide, there is sufficient ground water available from this strategy to meet future needs; however, there is likely insufficient quantities available in specific, densely populated areas. In densely populated areas, ground-water depletion may occur at an increasingly rapid rate if all water supplies are derived from individual wells. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells. Ground-water supplies occur from a combination of the middle and lower Trinity aquifers, and possibly from the Edwards-Trinity (Plateau) aquifer in western Bandera County. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:

Typical domestic wells are about 300 to 500 feet deep. Estimated cost to drill a 8-inch diameter hole is $5 per foot for a maximum of $2,500. Most domestic wells in the Hill Country have about 100 feet of 5- or 6-inch PVC casing, which is estimated at about $3.50 per foot for a total of about $350. Bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. Pressure tank prices are estimated at about $500. The estimated total cost for each domestic well is about $7,000. The short term need for 4,128 wells will cost about $28,896,000 and the additional 1,264 wells needed for the long term will cost about $8,848,000 for a total of about $37,744,000 for 5,392 domestic wells. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $42,189,790 from the year 2000 through the year 2050. Annual cost per acre-foot is $272.

ENVIRONMENTAL ISSUES:

If large numbers of wells are concentrated in relatively small areas, declines in ground-water levels may be anticipated. If the wells withdraw water from the shallow subsurface, decreased flow from shallow springs may occur. These springs provide base flow to many of the streams in the Hill Country. Decreased streamflow would have a negative impact on aquatic plants and animals living in those streams.

IMPACT ON OTHER WATER RESOURCES:

Local water-level declines may occur which potentially may affect water levels in wells on surrounding properties. If the wells are completed into the deeper aquifers, local springs that feed into surface streams should not be affected.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

The drilling of new must be in compliance with Springhills Water Management District rules.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

Depending on density and well spacing dictated by lot size some negative impacts may result from this strategy. As a result of high density and wells spaced too close, interference between nearby wells may cause local water-level declines between neighboring properties possibly diminishing the yield or dropping water levels below pump settings. Local regulations dictating lot size and well spacing should help alleviate this problem.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

No impact on navigation is anticipated.

STRATEGY #10-6

WATER USER NAME:
County: Bandera
River Basin: Nueces
User Name: County Other

STRATEGY NAME:
Additional private domestic wells

STRATEGY DESCRIPTION:
Water supply for rural homes is predominantly produced from private domestic wells. Additional private domestic wells will be drilled to supply water mostly from the Trinity aquifer to new rural homes outside of subdivisions with public supply systems.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as population increases. Estimated at 375 domestic wells.

Long Term (from the year 2030 to the year 2050): Phased in as population increases. Estimated at an additional 128 wells for a total of 503 wells.

QUANTITY OF WATER:
Private domestic wells generally yield 5 to 20 gpm and are pumped at a rate necessary to meet household demands, which are estimated at 600 gallons per day per household depending on one well. The quantity of additional water supply generated annually from this strategy is 251 acre-feet by 375 wells and 337 acre-feet by 503 wells.

RELIABILITY OF WATER:
Sufficient ground water is available from a combination of the middle and lower Trinity aquifers, and possibly from the Edwards-Trinity (Plateau) aquifer in the small northern portion of this river basin. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:
Typical domestic wells are about 300 to 500 feet deep. Estimated cost to drill a 8-inch diameter hole is $5 per foot for a maximum of $2,500. Most domestic wells in the Hill Country have about 100 feet of 5- or 6-inch PVC casing, which is estimated at about $3.50 per foot for a total of about $350. Bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. Pressure tank prices is estimated at about $500. The estimated total cost for each domestic well is about $7,000. The short-term need for 375 wells will cost about $2,625,000 and the additional 128 wells needed for the long term will cost about $896,000 for a total of about $3,521,000 for 503 domestic wells.

Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $3,923,810 from the year 2000 through the year 2050. Annual cost per acre-foot is $153.

ENVIRONMENTAL ISSUES:

If large numbers of wells are concentrated in relatively small areas, declines in ground-water levels may be anticipated. If the wells withdraw water from the shallow subsurface, decreased flow from shallow springs may occur. These springs provide base flow to many of the streams in the Hill Country. Decreased streamflow would have a negative impact on aquatic plants and animals living in those streams.

IMPACT ON OTHER WATER RESOURCES:

Local water-level declines may occur which potentially may affect water levels in wells on surrounding properties. If the wells are completed into the deeper aquifers, local springs that feed into surface streams should not be affected.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

The drilling of new must be in compliance with Springhills Water Management District rules.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

Depending on density and well spacing dictated by lot size some negative impacts may result from this strategy. As a result of high density and wells spaced too close, interference between nearby wells may cause local water-level declines between neighboring properties possibly diminishing the yield or dropping water levels below pump settings. Local regulations dictating lot size and well spacing should help alleviate this problem.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

No impact to navigation is anticipated.

STRATEGY # 10-7

WATER USER NAME:

County: Bandera
River Basin: San Antonio
User Name: Mining

STRATEGY NAME:

Additional wells

STRATEGY DESCRIPTION:

Initial shortages can be handled by additional pumping. The construction of one well can yield more than enough water from the Trinity aquifer to supply the projected shortage.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): Add one well as needed.

Long Term (from the year 2030 to the year 2050): No additional wells after the first well construction.

QUANTITY OF WATER:

One well capable of yielding 50 gpm could pump about three hours per day and provide the short-term shortage of 10 acre-feet. If the same well pumps a little longer, then the long-term shortfall of 12 acre-feet can be provided.

RELIABILITY OF WATER:

Sufficient ground water is available from the Trinity aquifer.

COST OF WATER:

Cost of drilling a 10-inch diameter hole to a 200-foot depth with 8-inch diameter steel casing cemented then drilled to 600-foot depth with 7-7/8-inch open hole is estimated at $14,000. Cost for a 5-horsepower submersible pump capable of producing 50 gpm with wiring and control box and 300 feet of 2-inch diameter column pipe is estimated at $4,000. The total estimated price for one well is $18,000. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $38,144. Annual cost per acre-foot is $156.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:

No impact on other water resources is anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:
No negative impact to natural resources is anticipated.

OTHER FACTORS:
No other factors are anticipated.

INTERBASIN TRANSFER:
No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:
No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:
No impact is anticipated.

IMPACT ON NAVIGATION:
No impact on navigation is anticipated.

STRATEGY # 69-1

WATER USER NAME:
County: Edwards
River Basin: Colorado
User Name: Irrigation

STRATEGY NAME:
Additional wells

STRATEGY DESCRIPTION:
The 1994 TWDB irrigation survey identified 133 acre-feet of water produced from the Edwards-Trinity (Plateau) aquifer for irrigation from four wells. The establishment of four additional wells producing at an equivalent rate and time would provide sufficient supply to meet the estimated deficit.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Additional wells would be needed immediately to meet current expected deficits but would only be used when sufficient surface water supplies are unavailable.
Long Term (from the year 2030 to the year 2050): No additional wells needed, but replacement and maintenance may be necessary.

QUANTITY OF WATER:
Four additional wells producing at an equivalent rate and time as the existing wells would provide 133 acre-feet of water per year.

RELIABILITY OF WATER:
Sufficient ground water exists from the Trinity aquifer provided that pumping of ground water continues to be the secondary supply and is used only when sufficient surface water supplies are unavailable. Continued pumping at this rate for several consecutive years would likely result in water-level declines, especially in dry years with minimal recharge.

COST OF WATER:
Cost of drilling a 10-inch diameter hole to a 100-foot depth with 8-inch diameter steel casing cemented then drilled to 600-foot depth with 7-7/8-inch open hole is estimated at $12,000. Cost for a 15-horsepower submersible pump capable of producing 100 gpm with wiring and control box and 300 feet of 3-inch diameter column pipe is estimated at $8,000. The total estimated price for one well is $20,000. The total cost for four wells is estimated at $80,000. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $323,127 from the year 2000 through the year 2050. Annual cost per acre-foot is $115.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:

Water-level declines resulting from increased ground-water withdrawals could potentially diminish spring flow that feeds the upper reaches of the South Llano River, however, during severe drought conditions there is no flow in the river. Therefore, no effect on other water resources is anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No threat to agricultural activities is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No threat to natural resources is anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer is required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

Wells would be drilled and water withdrawn with the consent of the landowner.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 69-2

WATER USER NAME:
County: Edwards
River Basin: Colorado
User Name: Irrigation

STRATEGY NAME:
Expanded use of existing wells

STRATEGY DESCRIPTION:
The 1994 TWDB irrigation survey identified 133 acre-feet of water produced for irrigation from four wells completed in the Edwards-Trinity (Plateau) aquifer.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Increased pumping rate of existing wells would be needed immediately to meet current expected deficits but would only be employed when sufficient surface water supplies are unavailable.
Long Term (from the year 2030 to the year 2050): Employed as needed.

QUANTITY OF WATER:
Calculations assume a 120-day growing season in which the wells would be operated.
Est. current pumping rate = 4wells x 125gpm x 60min x 12hrs x 120days = 133 ac-ft/yr
Est. expanded pumping rate = 4wells x 150gpm x 60min x 12hrs x 120days = 159 ac-ft/yr
Quantity of additional supply generated = 159 – 133 = 26 ac-ft/yr

RELIABILITY OF WATER:
The Edwards-Trinity aquifer is capable of sustaining additional pumping. However, the potential to increase the pumping rate of each well by 25 gpm is marginal. Existing wells are likely to have been originally designed to pump at maximum efficient rates. The period of time in which the wells are pumped is limited to the growing season.

COST OF WATER:
Main expense would be for additional power for longer pumping durations. Unless a larger pump is needed, then there would be additional cost for new pumps. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $47,529 from the year 2000 through the year 2050. Annual cost per acre-foot is $148.

ENVIRONMENTAL ISSUES:
No negative environmental effects are anticipated.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:

Water-level declines resulting from increased ground-water withdrawals could potentially diminish spring flow that feeds the upper reaches of the South Llano River, however, during severe drought conditions there is no flow in the river. Therefore, no effect on other water resources is anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No threats to agricultural activities are anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No threats to natural resources are anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No social or economic impacts anticipated.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

Additional water from wells would be withdrawn with the consent of the landowner.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 69-3

WATER USER NAME:
County: Edwards
River Basin: Colorado
User Name: Irrigation

STRATEGY NAME:
Conservation technology and equipment

STRATEGY DESCRIPTION:
This strategy involves irrigation methodologies and technological advances that could conserve water being used by irrigators, or reduce the demand for water by the irrigators. The irrigation conservation methodologies and technologies conceptualized for this strategy are those conservation methods and equipment that are "above and beyond" the methods and equipment included in the level of conservation built-in to the original demands. The level of conservation built-in to the original demands is the expected level of conservation, Level 2, discussed in the text of Section 5.4.4 of Chapter 5.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): No effect.
Long Term (from the year 2030 to the year 2050): Strategy in place.

QUANTITY OF WATER:
One acre-foot of water in each of the decades 2030, 2040, 2050.

RELIABILITY OF WATER:
This conservation strategy reduces irrigation water use demand and is therefore reliable.

COST OF WATER:
Additional costs for upgrading equipment.

ENVIRONMENTAL ISSUES:
Reduced demand results in less diversion from streams, which benefits wildlife dependent on the water in the stream. There is no anticipated environmental effect if irrigation water is derived from ground-water sources.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
This strategy lessens demand thus preserving source water.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
This strategy is generally employed if there is a positive economic impact.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

This strategy generally results in less diversion and increased flows in streams.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

This strategy generally conserves water in streams and underground thus benefiting other users of the resources.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

There is no impact anticipated

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 69-4

WATER USER NAME:
County: Edwards
River Basin: Nueces
User Name: Livestock

STRATEGY NAME:
Expanded use of existing wells

STRATEGY DESCRIPTION:
Typical wells used exclusively for livestock watering have low yields and are pumped for minimal periods of time. Sufficient water is generally available from the Edwards-Trinity (Plateau) aquifer to meet increased supply needs for existing livestock facilities by increasing the pumping time of existing wells.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed
Long Term (from the year 2030 to the year 2050): No additional supply needed

QUANTITY OF WATER:
An additional two hours of pumping time of each of 21 existing wells at an average pumping rate of 10 gpm will generate 28 acre-feet per year.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) aquifer without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
Only cost is for additional power and some long-term maintenance. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $51,185 from the year 2000 through the year 2050. Annual cost per acre-foot is $274.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
No effects on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No social or economic impacts anticipated.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 69-5

WATER USER NAME:
County: Edwards
River Basin: Nueces
User Name: Livestock

STRATEGY NAME:
Additional wells

STRATEGY DESCRIPTION:
A sufficient number of additional wells will be drilled into the Edwards-Trinity (Plateau) aquifer to supply the water needs. Additional wells will be drilled only if expanded use of existing wells (strategy 69-4) is insufficient to meet the anticipated needs.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed. Estimated at 10 wells total.
Long Term (from the year 2030 to the year 2050): No additional supply needed.

QUANTITY OF WATER:
Ten new wells pumping at a rate of 10 gpm for four hours each day will generate 27 acre-feet per year.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) aquifer for the minimal expanded pumpage without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
Typical livestock wells are about 300 to 500 feet deep. Estimated cost to drill a 8-inch diameter hole is $5 per foot for a maximum of $2,500. The cost of 100 feet of 5- or 6-inch PVC casing is estimated at about $3.50 per foot for a total of about $350. Cost for bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. Pressure tank prices are estimated at about $500. The estimated total cost for each well is about $7,000. The cost for ten wells is estimated at $70,000. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $119,357 from the year 2000 through the year 2050. Annual cost per acre-foot is $270.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
No impacts on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:
No negative impact to natural resources is anticipated.

OTHER FACTORS:
No other factors.

INTERBASIN TRANSFER:
No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:
No social or economic impacts anticipated.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:
No impact is anticipated.

IMPACT ON NAVIGATION:
There is no impact on navigation.

STRATEGY # 133-1

WATER USER NAME:

County: Kerr County
River Basin: Guadalupe
User Name: City of Kerrville

STRATEGY NAME:

Obtain additional or modify existing water rights

STRATEGY DESCRIPTION:

The City of Kerrville's own existing water permits on the Guadalupe River will be supplemented by agreement(s) with Guadalupe-Blanco River Authority that will provide for subordination of GBRA's Canyon Reservoir authorization to the City's permits. The City has also identified the possibility of modifying its own existing water permits.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): To be implemented during this period.
Long Term (from the year 2030 to the year 2050): Additional supplies needed.

QUANTITY OF WATER:

Currently the City's ability to divert under its existing permits is dependent on whether more senior water right holders exercise their rights, and is also affected by the City's Special Conditions written into its permits. If the City had more reliability from the Guadalupe River and more latitude in its ability to divert during certain months of the year, the City could more fully utilize its ASR facility. Up to 3,840 acre-feet is needed by the year 2030 and an additional 1,610 acre-feet by 2050 for a total of 5,450 acre-feet.

RELIABILITY OF WATER:

Currently the City's ability to divert under its existing permits is dependent on whether more senior water right holders exercise their rights, and is also affected by the City's Special Conditions written into its permits. If the City had more reliability from the Guadalupe River and more latitude in its ability to divert during certain months of the year, the City could more fully utilize its ASR facility and thus supply its needs uniformly throughout the year.

COST OF WATER:

The cost to purchase water from GBRA is currently unknown. Modifying the City's existing permits will likely involve a detailed hydrologic/water availability study; such a study may cost $40,000 to $100,000 dependent on objective and scope. See "Other Factors" below. Estimated cost per acre-foot is $500.

ENVIRONMENTAL ISSUES:

The City's Special Conditions were placed in its permits partially to protect instream flows. The TNRCC will study the effect that removal of one or more of these Special Conditions is likely to have on the aquatic environment.

IMPACT ON OTHER WATER RESOURCES:

Both UGRA and the City of Kerrville have within their water permits certain Special Conditions that were placed by TNRCC partially to protect instream flows and partially to protect the level of flow in the Guadalupe River itself. Both entities now plan to obtain more water from the Guadalupe River than they are currently using under their existing water permits (reference UGRA's Strategies 133-9 and 133-11 under "Quantity of Water"). A thorough hydrologic and water availability study should be performed to determine if the Guadalupe River can, in physical reality, provide the quantities of water desired.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No impact foreseen.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No impact foreseen.

OTHER FACTORS:

The TNRCC's Water Availability Model currently does not account spring flows from Stockman Springs (a.k.a. Ellebracht Springs). There may be other springs in the area that contribute substantial flows to surface waters, and which likewise are not incorporated into the Water Availability Model. Perhaps the City of Kerrville's optimal chance to modify its existing permits lies in petitioning the TNRCC to revise the WAM to reflect these spring flows, or in contracting a private firm to do so and getting TNRCC to approve the revised model. Alternatively if the City could show TNRCC permitting staff that using these spring flows would not subtract a like amount of unappropriated water from the model or from physical reality, it could perhaps make a case for modifying its existing water permits to take advantage of the spring flows.

INTERBASIN TRANSFER:

Not applicable.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

As noted, the source of the water is the City's existing permits and/or purchase of Guadalupe River water from GBRA. Also see "Impact on Other Water Resources".

IMPACT ON NAVIGATION:

No impact foreseen.

STRATEGY # 133-2

WATER USER NAME:

County: Kerr County
River Basin: Guadalupe
User Name: City of Kerrville

STRATEGY NAME:

Purchase raw water from UGRA

STRATEGY DESCRIPTION:

The City of Kerrville's existing water permits on the Guadalupe River will be supplemented by agreement(s) with Guadalupe-Blanco River Authority (refer to Strategy #133-1), or by purchase of raw water from UGRA. If the city annexes out to areas UGRA plans to serve, then the city would purchase water from UGRA rather than from GBRA. Presumably the purchase of raw water from UGRA will involve a contractual agreement between the two entities allowing the City to divert more water from the Guadalupe River than it is authorized under its permits - the additional water diverted being accounted for under UGRA's existing permits. This strategy will provide water to supply only those areas to be annexed by the City of Kerrville.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): To be implemented during this period.
Long Term (from the year 2030 to the year 2050): Additional supplies needed.

QUANTITY OF WATER:

No quantity has been specified thus far. The City's objective in obtaining more water from the Guadalupe River (via whatever method mentioned here or in Strategy #133-1), is to have more reliability from the Guadalupe River flows and more latitude in its ability to divert during certain months of the year, thus allowing the City to more fully utilize its ASR facility. Up to 3,840 acre-feet is needed by the year 2030 and an additional 1,610 acre-feet by 2050 for a total of 5,450 acre-feet.

RELIABILITY OF WATER:

The reliability of the water may be perceived as dependent on which entity the City approaches for a water purchase. Actually, the reliability is dependent on the amount of water physically present within the Guadalupe River. UGRA and the City both take from the same source (Guadalupe River). The term "regulated stream flow" is generally synonymous with water that is physically present within a water body. It is noted that the Upper Guadalupe River's minimum regulated stream flow (flow during drought of record), as determined by TNRCC's Water Availability Model Run No. 3, is 6,867 acre-feet of water per year. However, the sum of authorized water rights is 12,128 acre-feet of water per year. This means that during a drought of record, the water present in the Upper Guadalupe River is only half the amount of water authorized for diversion.

COST OF WATER:

The cost to purchase water from UGRA is currently unknown. Estimated cost per acre-foot is $1,000.

ENVIRONMENTAL ISSUES:

The existing water permits of both UGRA and the City contain Special Conditions that restrict diversions only when flows of the Guadalupe are above a minimum level. These restrictions help protect instream flows and the aquatic environment, in addition to serving as key water supply indicators. Any water purchase contract will likely have to contain the same or similar stream flow restrictions because TNRCC and TPWD are interested in maintaining minimum flows regardless of where the water is purchased.

IMPACT ON OTHER WATER RESOURCES:

Any impact on the underlying aquifer through ground water and surface water interactions is unknown. Perhaps increased diversions from the Upper Guadalupe River may affect ground-water supplies in Region L's Kendall County.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No impact foreseen.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No impact foreseen.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

Not applicable.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

The source of the water is Guadalupe River water through a purchase contract with UGRA, or a subordination and purchase contract with GBRA. All water purchase contracts must be approved by TNRCC, just as new or amended water rights must be approved by TNRCC. This means that - although TNRCC staff will not conduct a full hydrologic study for a contract - the agency will likely investigate any implications of the proposed contract on the Special Conditions outlined within the City's existing water permit. See "Environmental Issues" above. Bookkeeping within the TNRCC master water rights database would simply show the City's new diversions as a contract keyed to the water right of whichever entity provides the water.

IMPACT ON NAVIGATION:

No impact foreseen.

STRATEGY #133-4

WATER USER NAME:
County: Kerr
River Basin: Guadalupe
User Name: City of Kerrville

STRATEGY NAME:
Additional wells in a remote well field

STRATEGY DESCRIPTION:
Current city wells and many other competing wells are located near the major cities. This causes some problems especially during droughts were a larger number are competing for a limited ground-water resource. If a well field was located in more remote areas either relatively nearby to the south or west or in the very western portion of the county in the Edwards-Trinity (Plateau) aquifer, then less competition for the ground-water resources would occur even during droughts. The most optimal arrangement of wells would be to stagger them along the length of the pipeline, which also means that the diameter of the line could be telescoped with smaller diameter possibly 12-inch diameter to a larger 20-inch diameter pipeline near the destination point.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Partial 25 mile pipeline telescoping with about 20-inch diameter near destination and 6 wells.
Long Term (from the year 2030 to the year 2050): Complete 25 miles and 6 more wells for a total of 12 wells.

QUANTITY OF WATER:
The specific quantity can only be determined after exploration and testing of wells is performed. An estimate of yield of typical wells in the Kerrville area is about 400 to 600 gpm. At 400 gpm each, 6 wells would the capacity of 2,400 gpm. If the wells are run 78 percent of the time then the yield would be about 3,000 ac-ft per year. With a 20-inch diameter pipeline, the total wells could be doubled for the long term, which would also double the quantity of water to 6,000 ac-ft of water per year.

RELIABILITY OF WATER:
If the well field is located in the Edwards-Trinity (Plateau) aquifer away from current pumping centers located near the major cities then the overall reliability is good. Some water-level declines in the well field can be expected during severe drought. Specific details to how much can only be estimated when more specific aquifer parameters are determined.

COST OF WATER:
Cost for drilling an initial 14-inch diameter hole to 200-foot depth with 10-inch diameter steel casing pressure cemented then drilled to 800-foot depth with 10-inch open hole is estimated at

$67,000. Cost for a 50-horsepower submersible pump capable of producing 400 gpm with wiring and control box and 300 feet of 5-inch diameter column pipe is estimated at $28,000. With cost for other appurtenances and engineering, the total estimated price is $120,000. The total cost for the first 6 wells is estimated at $720,000 and another $720,000 for the second six wells. For estimation purposes a 16-inch diameter pipeline is used. The line may actually telescope from 12-inch to 20-inch diameter. Estimated price for a 16-inch pipeline with appurtenances is about $41 per foot length or about $217,000 per mile. If the pipeline is 10 miles then the cost is $2,170,000. If the pipeline is 25 miles, then the cost is $5,412,000. Adding in the cost of the wells, then the cost is $2,890,000 for 6 wells and a 10-mile pipeline or $6,132,000 for wells and a 25-mile pipeline. The total number of wells could be doubled to 12 wells for an additional $720,000. An estimate for right-of-ways is $5 per foot length or $26,400 per mile, which includes some property for locating well sites. Total for 25 miles is $660,000. Total cost for 25-miles of pipeline averaging 16-inch diameter and 12 wells is $7,512,000. Additional cost for debt retirement was calculated using the TWDB program. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $22,561,453 from the year 2000 through the year 2050. Annual cost per acre-foot is $66.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:

Local water-level declines may occur which potentially may affect water levels in wells on surrounding properties. If the well field is located away from other wells and well spacing between wells in the field are optimized, then effects can be minimized. If the deeper aquifer is targeted, then local springs that feed into surface streams should not be affected.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

The drilling of public-supply wells must be in compliance with TNRCC regulations, county ordinances and Headwaters Underground Water Conservation District rules.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No social or economic impacts are anticipated.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 133-5A

WATER USER NAME:
County: Kerr County
River Basin: Guadalupe
User Name: City of Kerrville

STRATEGY NAME:
Increased Water Treatment Plant Capacity

STRATEGY DESCRIPTION:
The City of Kerrville and the UGRA have a Memorandum of Understanding (MOU), under which they have discussed expanding the City of Kerrville's existing water treatment plant. The City cites the scenario whereby UGRA buys treatment capacity from the City.

TIME INTENDED TO IMPLEMENT:
The time line is very aggressive, with the plant envisioned to be operable in year 2002.

QUANTITY OF WATER:
This strategy does not create or provide new water, but more effectively makes use of existing water sources. The City's own existing water permits on the Guadalupe River will be supplemented by agreement(s) with Guadalupe-Blanco River Authority that will provide for subordination of GBRA's Canyon Reservoir authorization to the City's permits. Reference Strategy #133-1.

RELIABILITY OF WATER:
The City's current water treatment capacity limits its utilization of its ASR facility. The City has identified an immediate need for 2 mgd of treatment capacity to take care of peak use, take advantage of periods when higher stream flows occur in the Guadalupe River, and thus fully utilize its ASR.

COST OF WATER:
The cost to purchase water from GBRA is currently unknown. The cost of a 5MGD water treatment plant expansion is approximately $6,000,000 according to the City. The cost for an associated 1 MGD ASR expansion, which goes hand in hand with the WTP expansion, would be approximately $250,000. Total capital cost is 46,250,000 and estimated cost per acre-foot is $500.

ENVIRONMENTAL ISSUES:
No environmental issues are anticipated.

IMPACT ON OTHER WATER RESOURCES:
The impact of the regional water treatment plant itself is not the issue. Both UGRA and the City of Kerrville plan to obtain more water from the Guadalupe River than they are currently

using under their existing water permits (reference Kerrville's Strategy 133-1, and UGRA's Strategies 133-9 and 133-11 under "Quantity of Water"). A thorough hydrologic and water availability study should be performed to determine if the Guadalupe River can, in physical reality, provide the quantities of water desired.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No impact foreseen.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:
No impact foreseen.

OTHER FACTORS:
No other impacts.

INTERBASIN TRANSFER:
Not applicable.

SOCIAL AND ECONOMIC IMPACTS:
No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:
As noted, the source of the water is the City's existing permits and/or purchase of Guadalupe River water from GBRA. Also see "Impact on Other Water Resources".

IMPACT ON NAVIGATION:
No impact foreseen.

STRATEGY # 133-5B

WATER USER NAME:
County: Kerr County
River Basin: Guadalupe
User Name: City of Kerrville

STRATEGY NAME:
Increased Water Treatment Plant and ASR Capacity

STRATEGY DESCRIPTION:
This strategy is similar to Strategy No. 133-5A except that in this strategy the City of Kerrville will expand their existing water treatment plant on their own, without assistance and cooperation of UGRA. Also, the ASR system will be expanded to include the addition of two additional ASR wells,

TIME INTENDED TO IMPLEMENT:
The time line is very aggressive, with the plant envisioned to be operable in year 2002.

QUANTITY OF WATER:
The City's own existing water permits on the Guadalupe River will be supplemented by agreement(s) with Guadalupe-Blanco River Authority that will provide for subordination of GBRA's Canyon Reservoir authorization to the City's permits. Reference Strategy #133-1. Water treatment capacity will be expanded by 5 MGD and the ASR expansion will result in a total ASR capacity of 3MGD. Upon completion, this strategy will generate 5,600 acre-feet per year.

RELIABILITY OF WATER:
The City's current water treatment capacity limits its utilization of its ASR facility. The City has identified the need for 2 mgd of treatment capacity to take care of peak use, take advantage of periods when higher streamflows occur in the Guadalupe River, and thus fully utilize its ASR. The increased storage capacity provided by the expanded ASR operation will make available water supplies more reliable. However, during drought of record conditions, water available from the upper Guadalupe River may be limited or nonexistent.

COST OF WATER:
The cost to purchase water from GBRA is currently unknown. The cost of a 5-MGD water treatment plant expansion is approximately $6,000,000. The expansion of the ASR system includes the conversion of an existing city well (utilizing existing pumping equipment) at a cost of approximately $250,000 and the drilling and completion of a new well at an approximate cost of $400,000. Total cost for this strategy is $6,650,000. estimated cost per acre-foot is $500.

ENVIRONMENTAL ISSUES:
No environmental issues are anticipated.

IMPACT ON OTHER WATER RESOURCES:

The impact of the regional water treatment plant itself is not the issue. Both UGRA and the City of Kerrville plan to obtain more water from the Guadalupe River than they are currently using under their existing water permits (reference Kerrville's Strategy 133-1, and UGRA's Strategies 133-9 and 133-11 under "Quantity of Water"). A thorough hydrologic and water availability study should be performed to determine if the Guadalupe River can, in physical reality, provide the quantities of water desired.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No impact foreseen.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No impact foreseen.

OTHER FACTORS:

No other impacts.

INTERBASIN TRANSFER:

No interbasin transfer is required.

SOCIAL AND ECONOMIC IMPACTS:

This strategy will increase the reliability of water during peak demand periods and, thus, will benefit the public and businesses in the City of Kerrville.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

As noted, the source of the water is the City's existing permits and/or purchase of Guadalupe River water from GBRA. Also see "Impact on Other Water Resources".

IMPACT ON NAVIGATION:

No impact foreseen.

STRATEGY # 133-6

WATER USER NAME:
County: Kerr
River Basin: Guadalupe
User Name: Aqua Source (County Other)

STRATEGY NAME:
Additional system wells

STRATEGY DESCRIPTION:
Aqua Source currently provides water to numerous subdivisions in Kerr County from wells completed in the Trinity aquifer. Additional wells completed in the Trinity aquifer would be required to meet future needs. Fewer wells may be required if this strategy is combined with Strategy #133-7.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Approximately 12 additional Trinity aquifer wells would be required to meet short-term needs.
Long Term (from the year 2030 to the year 2050): An additional 9 wells for a total of 21 wells.

QUANTITY OF WATER:
Each well is anticipated to yield about 200 gpm, which pumped for 12 hours per day would produce about 162 acre-feet per year. At this production rate, 12 wells will produce about 1,944 ac-ft/yr and 9 additional wells will produce an additional 1,458 ac-ft/yr.

RELIABILITY OF WATER:
Sufficient ground water is available from a combination of the middle and lower Trinity aquifers; however, local water-level declines should be expected. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:
Cost for drilling an initial 12-inch diameter hole to 200-foot depth with 8-inch diameter steel casing pressure cemented then drilled to 600-foot depth with 7-7/8-inch open hole is estimated at $30,000. Cost for a 20-horsepower submersible pump capable of producing 200 gpm with wiring and control box and 300 feet of 3-inch diameter column pipe is estimated at $12,000. With cost for other appurtenances and engineering, the total estimated price is $49,000. The total cost for 12 and 9 wells, respectively, is estimated at $588,000 and $441,000. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons for a total of $121,940 for each year with 21 wells.

ENVIRONMENTAL ISSUES:
No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:

Local water-level declines may occur which potentially may affect water levels in wells on surrounding properties. Local springs that feed into surface streams should not be affected.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

The drilling of public-supply wells must be in compliance with TNRCC regulations, county ordinances and Headwaters Underground Water Conservation District rules.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact.

IMPACT ON NAVIGATION:

No impact on navigation.

STRATEGY # 133-7

WATER USER NAME:
County: Kerr
River Basin: Guadalupe
User Name: Aqua Source (County Other)

STRATEGY NAME:
Expanded use of existing wells

STRATEGY DESCRIPTION:
Aqua Source currently provides water from 26 wells in Kerr County. Additional pumping time of each well completed in the Trinity aquifer will generate additional supply. Increased storage capacity may be required to hold water generated during night (off demand) pumping period. Less well production from each well is necessary if this strategy is combined with Strategy # 133-6.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed.
Long Term (from the year 2030 to the year 2050): Phased in as needed.

QUANTITY OF WATER:
An additional 2 hours of pumping time of each of the 26 existing wells at an average pumping rate of 150 gpm will generate 524 acre-feet per year.

RELIABILITY OF WATER:
Sufficient ground water is available from a combination of the middle and lower Trinity aquifers; however, local water-level declines should be expected. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:
Only cost is for additional power and some long-term maintenance. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons for a total of $18,782 for each year.

ENVIRONMENTAL ISSUES:
No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:
Local water-level declines may occur which potentially may affect water levels in wells on surrounding properties. Local springs that feed into surface streams should not be affected.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

The additional pumping time of each well could potentially affect the amount of local water-level decline.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact.

IMPACT ON NAVIGATION:

No impact.

STRATEGY# 133-8

WATER USER NAME:
County: Kerr County
River Basin: Guadalupe
User Name: Aqua Source and county other

STRATEGY NAME:
Purchase Treated Water from UGRA / GBRA

STRATEGY DESCRIPTION:
Aqua Source and other investor owned utilities (IOUs) will purchase treated surface water from UGRA and the water will be distributed regionally in the new regional system created by interconnecting the IOU systems. Note that the water source is the Guadalupe River, whether via UGRA's existing permits or purchase of Guadalupe River water from Guadalupe-Blanco River Authority.

TIME INTENDED TO IMPLEMENT:
UGRA has received a Preliminary Design and associated Engineer's Opinion of Probable Construction Cost from Alan Plummer Associates, made agreements with IOUs, worked on funding issues and met with TNRCC on funding and rate structure issues. The implementation of this strategy is eminent, with the system on-line probably within the next two years.

QUANTITY OF WATER:
This strategy does not create or provide new water, but more effectively makes use of existing water sources. The UGRA's own existing water permits on the Guadalupe River, as well as purchase of Guadalupe River water from Guadalupe-Blanco River Authority, will provide the source of water. Reference Strategy #133-9.

RELIABILITY OF WATER:
The reliability of water from the perspective of some of the IOUs would probably increase, as some of the groundwater wells in the area have been experiencing reliability difficulties. From the perspective of surface water, it is noted that the Upper Guadalupe River's minimum regulated stream flow (i.e., flow during drought of record) as per the TNRCC's Water Availability Model Run No. 3 is 6,867 acre-feet of water per year. However, the sum of authorized water rights is 12, 128 acre-feet of water per year (See Table 3-1 of Chapter 3). In other words, during a drought of record the water present in the Upper Guadalupe River is only half the amount of water authorized for diversion. Aqua Source and UGRA must thoroughly examine whether Guadalupe River flows are adequate for the needs of the regional water system.

COST OF WATER:
The cost to purchase water from UGRA is currently under discussion pending TNRCC approving the rate structure that UGRA is currently developing. The cost of the regional water system itself (pump station, water treatment plant, high service pump station, distribution),

estimated by Alan Plummer Associates at a total construction cost of $8,760,000, is a cost that will be incurred by UGRA. Therefore the cost is shown in Strategy No. 133-9 rather than in this strategy.

ENVIRONMENTAL ISSUES:

Disturbance of wildlife habitat during layout and construction of pipeline should be considered and possibly mitigated.

IMPACT ON OTHER WATER RESOURCES:

The conjunctive use of groundwater and surface water will probably decrease the rate of aquifer depletion. Groundwater will be used only to help supply the system during times of peak usage.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No impact foreseen.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No impact foreseen.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

Not applicable.

SOCIAL AND ECONOMIC IMPACTS:

No social or economic impacts anticipated.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

As noted, the source of the water is UGRA’s existing permits and/or purchase of Guadalupe River water from GBRA. See “Reliability of Water “ above.

IMPACT ON NAVIGATION:

No impact foreseen.

STRATEGY # 133-9

WATER USER NAME:
County: Kerr County
River Basin: Guadalupe
User Name: Upper Guadalupe River Authority (UGRA)

STRATEGY NAME:
Increased Water Treatment Capacity

STRATEGY DESCRIPTION:
UGRA and Alan Plummer Associates met with 32 private investor-owned utilities (IOUs) to get the IOUs' cooperation in interconnecting their systems with each other and with UGRA to form a regional water system. The IOUs will purchase treated surface water from UGRA and the water will be distributed in the new regional system created by interconnecting the IOU systems. Some IOUs are willing to sell their water treatment plants to UGRA while others will lease their plants to UGRA. During peak times, the regional water system as operated by UGRA can utilize groundwater wells and treatment plants currently owned by the IOUs. UGRA's new regional water treatment plant facility will serve this regional water system (Aqua Source and other IOUs) in eastern and southern Kerr County.

TIME INTENDED TO IMPLEMENT:
UGRA has received a Preliminary Design and associated Engineer's Opinion of Probable Construction Cost from Alan Plummer Associates, made agreements with IOUs, worked on funding issues and met with TNRCC on funding and rate structure issues. The implementation of this strategy with the system including a new water treatment plant will probably be on-line within the next two years.

QUANTITY OF WATER:
This strategy does not create or provide new water, but more effectively makes use of existing water sources. The existing UGRA water permits on the Guadalupe River plus the purchase of up to 2,000 acre-feet per year from Guadalupe-Blanco River Authority out of the current pool of Canyon Reservoir will provide the source of water. However, this purchase may not meet UGRA's needs to meet its plans for supplying eastern Kerr County. UGRA may need to purchase existing water rights on the Guadalupe River or its tributaries. A study to determine the most reliable rights would be needed to guide UGRA in its decisions on selecting the best water rights to purchase.

RELIABILITY OF WATER:
The reliability of water from the perspective of some of the IOUs would probably increase as some of the groundwater wells in the area have been experiencing reliability difficulties. From UGRA's perspective, the reliability of the Guadalupe River water (via UGRA's own water permits and its purchase of water from GBRA) must be very carefully and thoroughly examined.

COST OF WATER:

The cost to purchase water from GBRA is currently under discussion. The cost of the regional water system itself (pump station, water treatment plant, high service pump station, distribution) is estimated by Alan Plummer Associates at a total construction cost of $8,760,000. The water treatment plant component of this estimate is $1,805,000. The remaining infrastructure necessary to deliver the water to the IOU systems within the regional system makes up the other major component of this total construction cost.

ENVIRONMENTAL ISSUES:

Disturbance of wildlife habitat during layout and construction of pipeline should be considered and possibly mitigated.

IMPACT ON OTHER WATER RESOURCES:

The conjunctive use of groundwater and surface water will probably decrease the rate of aquifer depletion. Groundwater will help supply the various users on the regional system during peak times. Generally, regionalization will help the users decrease dependency on ground water, which is currently the sole source water supply in the area.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No impact foreseen.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No impact foreseen.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

Not applicable.

SOCIAL AND ECONOMIC IMPACTS:

No social or economic impacts anticipated.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

As noted, the source of the water is UGRA's existing permits and/or purchase of Guadalupe River water from GBRA.

IMPACT ON NAVIGATION:

No impact foreseen.

STRATEGY # 133-10

WATER USER NAME:

County: Kerr County
River Basin: Guadalupe
User Name: Upper Guadalupe River Authority (UGRA)

STRATEGY NAME:

Reallocation of reservoir storage

STRATEGY DESCRIPTION:

This strategy involves UGRA obtaining three small recreational lakes from the County of Kerr and changing the water rights to authorize reallocation of the impoundment volumes to municipal use, and to authorize diversions from the lakes for municipal purposes. The lakes, their current water authorizations, and their authorized impoundment volumes are: Ingram Lake a.k.a. New Lake Ingram (Adjudication Certificate No. 18-1971), 450 acre-feet; Flat Rock Lake a.k.a. Kerrville Lake (Adjudication Certificate No. 18-2004), 720 acre-feet; and Center Point Lake a.k.a. Lions Club Lake (Adjudication Certificate No. 18-2017), 87 acre-feet.

TIME INTENDED TO IMPLEMENT:

UGRA has approached Kerr County about the possibility of purchasing or obtaining these lakes. No agreement currently is in effect, but the time line for implementation is generally represented as being almost eminent.

QUANTITY OF WATER:

The minimum (drought of record) unappropriated water amount is zero. However, the value of this strategy is that it more effectively makes use of existing water sources by providing a drought contingency “buffer” for UGRA, especially important during the summer months. Unappropriated water information at recreation-only lakes is not available from the updated TNRCC Water Availability Model due to differences in coding of the updated models versus the Legacy Models. Unappropriated water data from the Legacy Model Revised Guadalupe-San Antonio Model Run 1 includes water rights issued through June 1982. The amounts from this model should be adjusted for water rights issued since that time. TNRCC Water Rights Master File shows that 235 acre-feet of water per year has been appropriated through issuance of water rights since June 1982; all of these water rights were issued for locations upstream of Ingram Lake. No water rights have been issued downstream of Ingram Lake since June 1982.

For informational purposes, unappropriated water at Ingram Lake on a mean annual basis is 1,504 acre-feet of water per year. Adjusted for water rights granted since June 1992, the amount is 1,269 acre-feet of water per year. Unappropriated water at Flat Rock Lake on a mean annual basis is 7,461 acre-feet of water per year. Adjusted for water rights granted since June 1992, the amount is 7,226 acre-feet of water per year. Unappropriated water at Center Point Lake on a mean annual basis is 11,321 acre-feet of water per year. Adjusted for water rights granted since June 1992, the amount is 11,086 acre-feet of water per year.

RELIABILITY OF WATER:

The unappropriated water amounts from the Legacy Model for the months June through August give an indication of the usefulness of these lakes for buffering effects of drought. At Ingram Lake, unappropriated water ranges from 56 to 93 acre-feet per month during these months. At Flat Rock Lake, unappropriated water ranges from 370 to 599 acre-feet per month during these months, and at Center Point Lake, unappropriated water ranges from 506 to 963 acre-feet per month during these months.

This seems to indicate that the Center Point Lake location - the most downstream of the three locations - is the most valuable in terms of providing municipal diversions during the critical summer months. However, this lake's storage is so small that the usual benefits of a reservoir may virtually be lost. Overall, Flat Rock Lake seems to offer the most in terms of storage (720 acre-feet) and in terms of unappropriated water. Flat Rock Lake's unappropriated water during the months of February through May (the important months in which to accrue water in storage prior to the critical summer months) ranges from 535 to 1,422 acre-feet per month.

COST OF WATER:

The cost of the water lies in the studies and administrative costs of successfully obtaining a permit for reallocation of storage (from recreational to municipal) and for diversion of water for municipal purposes for one or more of the three lakes. The choice of a single lake or combination of two out of the three lakes dictates the cost. At this time, UGRA has not decided if it will use one or more of these lakes as drought contingency buffer lake(s). Also, these dams date from the 1950s and require dam safety inspections, the cost of which may also be calculated into the cost of water.

ENVIRONMENTAL ISSUES:

Since TNRCC's and TPWD's interest is in maintaining minimum flows in the Guadalupe River, an investigation or study on the impact to the Special Conditions of the City of Kerrville's water permit and of UGRA's water permit may be needed.

IMPACT ON OTHER WATER RESOURCES:

No impact foreseen.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No impact foreseen.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

The possibility that migratory fowl currently uses these lakes should be considered.

OTHER FACTORS:

UGRA's drought contingency plan should be amended to take into account the contingency buffer effect of the lake(s). The authorized impoundment volumes of the lakes correspond to the normal storages. In the case of Ingram Lake and Flat Rock Lake, the maximum storage exceeds normal storage by 30 acre-feet and 100 acre-feet respectively; maximum storage is storage above the service spillway. Ingram Lake is a high-hazard dam.

INTERBASIN TRANSFER:

Not applicable.

SOCIAL AND ECONOMIC IMPACTS:

Kerr County residents would lose the current recreational benefits of these lakes.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

The TNRCC will probably study whether using this lake(s) in this manner will affect the ability of downstream users to divert.

IMPACT ON NAVIGATION:

No impact foreseen.

STRATEGY # 133-11

WATER USER NAME:

County: Kerr County
River Basin: Guadalupe
User Name: Upper Guadalupe River Authority (UGRA)

STRATEGY NAME:

Aquifer Storage and Recovery (ASR) Facility for UGRA

STRATEGY DESCRIPTION:

UGRA will divert water from the Guadalupe River, treat it and pipe it upstream to an injection well completed into the Trinity aquifer in the vicinity of Johnson Creek's confluence with the Guadalupe. Recovery of the water will occur somewhere between the injection well and water treatment plant for the City of Kerrville or between the injection well and a proposed joint UGRA/Kerrville water treatment plant.

Water for an ASR must be treated, as per TNRCC Rules for injection wells. Using the proposed reservoir on Johnson Creek (Strategy 133-12) as a water source may be impractical, as this would require constructing an additional treatment plant at the reservoir site.

TIME INTENDED TO IMPLEMENT:

UGRA intends to have a fully implemented ASR facility in operation by year 2020. This schedule requires that planning, feasibility, funding and consideration of permitting issues begin eminently.

QUANTITY OF WATER:

An ASR facility does not create or provide new water, but more effectively uses the existing water sources. The UGRA will supplement its own existing water permits on the Guadalupe River by purchasing up to 4,000 acre-feet of water from Guadalupe-Blanco River Authority (contingent on GBRA's Canyon Reservoir permit amendment). However, this purchase may not actually occur, and even should it occur, UGRA may still need additional water to meet its plans for supplying eastern Kerr County. UGRA may need to purchase existing water rights on the Guadalupe River or its tributaries. A study to determine the most reliable rights would be needed to guide UGRA in its decisions on selecting the best water rights to purchase. In all likelihood, diversion will occur from the same point on the Guadalupe River regardless if the water is UGRA's or is purchased from GBRA, or is purchased from existing water right holders.

RELIABILITY OF WATER:

The reliability of water would increase on a per-month basis, compared to the reliability of the Guadalupe River. The ASR facility would allow usage more uniformly throughout the year at the entity's convenience rather than at the seasonal river flow.

COST OF WATER:

The cost to purchase water from GBRA is currently under discussion. The cost of the ASR facility itself (well construction, wellhead facilities construction, engineering design, ASR testing, permitting) is likely to be the high end of the range estimated for Phase II ASR in 1989 - approximately $765,000.[1] The 1989 high end estimate is reasonable given inflation. However, UGRA spent $986,000 in expert witness testimony to get the Phase I ASR permit. Therefore the $10,000 may be under estimated for the permitting component of the $765,000 estimate given above.

ENVIRONMENTAL ISSUES:

No environmental issues anticipated.

IMPACT ON OTHER WATER RESOURCES:

The City of Kerrville and UGRA will need an accurate and detailed accounting system of amounts of water each entity has injected to the ASR in order to track how much water each entity is then entitled to recover. Also, thorough understanding of the geology involved will ensure that the ASR is indeed a discrete unit unlikely to affect the underlying aquifer's ability to supply other users.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No impact anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No impact anticipated.

OTHER FACTORS:

The potential for plugging the aquifer should be considered. In some situations, supersaturated mineral could precipitate and affect porosity and permeability of the formation. Preliminary testing on Monitor Well PZ-1 indicated that no significant plugging has occurred to date. Allowing a small amount of treated water to flow back into the well to maintain a disinfectant residual, and selecting non-ferrous or coated casing and wellhead materials should help control bacterial plugging. Back-flushing the well at the beginning of injecting and recovery operations should help prevent physical plugging. Also, design alternatives intended to prevent physical plugging due to air entrainment during injecting should be utilized.

INTERBASIN TRANSFER:

Not applicable.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact.

IMPACT ON NAVIGATION: No impact foreseen.

Footnote:
[1] "Aquifer Storage Recovery Feasibility Investigation, Phase IIA Monitoring Well PZ-1, Volume I" prepared for Upper Guadalupe River Authority by CH2mHill, December 1989.

STRATEGY # 133-17

WATER USER NAME:

County: Kerr
River Basin: Guadalupe
User Name: Irrigation

STRATEGY NAME:

Additional wells

STRATEGY DESCRIPTION:

The 1994 TWDB irrigation survey identified 406 acre-feet of water produced for irrigation from 18 Trinity aquifer wells. The establishment of 16 additional wells completed into the Trinity aquifer producing at an equivalent rate and time would provide sufficient supply to meet the estimated deficit. This strategy would be needed only if expanded use of existing wells (strategy 133-F) is impractical.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): The 16 additional wells would be needed immediately to meet current expected deficits but would only be used when sufficient surface water supplies are unavailable and expanded use of existing wells is impractical.

Long Term (from the year 2030 to the year 2050): No additional wells needed, but replacement and maintenance may be necessary.

QUANTITY OF WATER:

Sixteen additional wells producing at an equivalent rate and time as the existing wells would provide 361 ac-ft/yr.

RELIABILITY OF WATER:

Sufficient ground water exists from the Trinity aquifer providing the pumping of ground water continues to be the secondary supply and is used only when sufficient surface water supplies are unavailable. Continued pumping at this rate for several consecutive years would likely result in water-level declines, especially in dry years with minimal recharge.

COST OF WATER:

Cost of drilling a 10-inch diameter hole to a 100-foot depth with 8-inch diameter steel casing cemented then drilled to 600-foot depth with 7-7/8-inch open hole is estimated at $12,000. Cost for a 15-horsepower submersible pump capable of producing 100 gpm with wiring and control box and 300 feet of 3-inch diameter column pipe is estimated at $8,000. The total estimated price for one well is $20,000. The total cost for 16 wells is estimated at $320,000. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $979,917 from the year 2000 through the year 2050. Annual cost per acre-foot is $170.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:

No effect on other water resources is anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No threat to agricultural activities is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No threat to natural resources is anticipated.

OTHER FACTORS:

The drilling of new wells must be in compliance with Headwaters Underground Water Conservation District rules.

INTERBASIN TRANSFER:

No interbasin transfer is required.

SOCIAL AND ECONOMIC IMPACTS:

No social or economic impacts are anticipated.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 133-18

WATER USER NAME:

County: Kerr
River Basin: Guadalupe
User Name: Irrigation

STRATEGY NAME:

Expanded use of existing wells

STRATEGY DESCRIPTION:

The 1994 TWDB irrigation survey identified 406 acre-feet of water produced for irrigation from 18 Trinity aquifer wells. Extended pumping time on these existing wells will provide additional water supply from the Trinity aquifer.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): Increased pumping time of existing wells would be needed immediately to meet current expected deficits but would only be employed when sufficient surface water supplies are unavailable.

Long Term (from the year 2030 to the year 2050): Employed as needed.

QUANTITY OF WATER:

Calculations assume a 180-day growing season in which the wells would be operated.
Est. current pumping rate = 18 wells x 57gpm x 60min x 12hrs x 180days = 408 ac-ft/yr
Est. extended pumping time = 18 wells x 57gpm x 60min x 16hrs x 180days = 544 ac-ft/yr
Quantity of additional supply generated = 544 – 408 = 136 ac-ft/yr

RELIABILITY OF WATER:

The Trinity aquifer is capable of supplying the needed water. However, the potential of increasing the pumping time of each well by 2 hours is marginal. Significant water-level declines likely exist with current pumping patters. Existing wells are likely to have been originally designed to pump at maximum efficient rates, therefore, increasing pumping rate is also probably impractical.

COST OF WATER:

Additional cost is associated with additional power needed for expanded operating time. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $24,861 from the year 2000 through the year 2050. Annual cost per acre-foot is $381.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:

No effect on other water resources is anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No threats to agricultural activities are anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No threats to natural resources are anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No social or economic impacts are anticipated.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 133-19

WATER USER NAME:
County: Kerr
River Basin: Guadalupe
User Name: Irrigation

STRATEGY NAME:
Conservation technology and equipment

STRATEGY DESCRIPTION:
This strategy involves irrigation methodologies and technological advances that could conserve water being used by irrigators, or reduce the demand for water by the irrigators. The irrigation conservation methodologies and technologies conceptualized for this strategy are those conservation methods and equipment that are "above and beyond" the methods and equipment included in the level of conservation built-in to the original demands. The level of conservation built-in to the original demands is the expected level of conservation, Level 2, discussed in the text of Section 5.4.4 of Chapter 5.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Effect begins in year 2010.
Long Term (from the year 2030 to the year 2050): Strategy yields two or more acre-feet of water in 2030 and beyond.

QUANTITY OF WATER:
One acre-foot of water in each of the decades 2000 through 2030; two acre-feet of water in 2030 and 2040; three acre-feet in 2050.

RELIABILITY OF WATER:
This conservation strategy reduces irrigation water use demand and is therefore reliable.

COST OF WATER:
Additional cost for new improved equipment.

ENVIRONMENTAL ISSUES:
Reduced demand results in less diversion from streams, which benefits wildlife dependent on the water in the stream. There is no anticipated environmental effect if irrigation water is derived from ground-water sources.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
This strategy lessens demand thus preserving source water.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
This strategy is generally employed if there is a positive economic impact.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

This strategy generally results in less diversion and increased flows in streams.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

This strategy generally conserves water in streams and underground thus benefiting other users of the resources.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

There is no impact anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 133-20

WATER USER NAME:
County: Kerr
River Basin: Colorado
User Name: Livestock

STRATEGY NAME:
Expanded use of existing wells

STRATEGY DESCRIPTION:
Typical wells used exclusively for livestock watering have low yields and are pumped for minimal periods of time. Sufficient water is generally available from the Edwards-Trinity (Plateau) aquifer to meet increased supply needs for existing livestock facilities by increasing the pumping time of existing wells.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed
Long Term (from the year 2030 to the year 2050): No additional supply needed

QUANTITY OF WATER:
An additional two hours of pumping time of each of an estimated 24 existing wells at an average pumping rate of 20 gpm will generate 65 ac-ft/yr.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) aquifer without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
Only cost is for additional power and some long-term maintenance. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $118,822 from the year 2000 through the year 2050. Annual cost per acre-foot is $135.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
No effects on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 133-21

WATER USER NAME:
County: Kerr
River Basin: Colorado
User Name: Livestock

STRATEGY NAME:
Additional wells

STRATEGY DESCRIPTION:
A sufficient number of additional wells will be drilled into the Edwards-Trinity (Plateau) aquifer to supply the water needs. Additional wells will be drilled only if expanded use of existing wells (strategy 69-4) is insufficient to meet the anticipated needs.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed.
Long Term (from the year 2030 to the year 2050): No additional supply needed.

QUANTITY OF WATER:
Thirty-two new wells pumping at a rate of 10 gpm for four hours each day will generate 62 acre-feet per year.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) aquifer for the minimal expanded pumpage without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
Estimated cost to drill an 8-inch diameter hole is $5 per foot for a maximum of $2,500. The well might have about 100 feet of 5- or 6-inch PVC casing, which is estimated at about $3.50 per foot for a total of about $350. Bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. The estimated total cost for each stock well is about $6,000, which calculates to $192,000 for 32 wells. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $305,337 from the year 2000 through the year 2050. Annual cost per acre-foot is $377.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:

No impacts on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

The drilling of new wells must be in compliance with Headwaters Underground Water Conservation District rules.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 133-22

WATER USER NAME:
County: Kerr
River Basin: San Antonio
User Name: Livestock

STRATEGY NAME:
Expanded use of existing wells

STRATEGY DESCRIPTION:
Typical wells used exclusively for livestock watering have low yields and are pumped for minimal periods of time. Sufficient water is generally available from the Edwards-Trinity (Plateau) and Trinity aquifers to meet increased supply needs for existing livestock facilities by increasing the pumping time of existing wells.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed
Long Term (from the year 2030 to the year 2050): No additional supply needed

QUANTITY OF WATER:
An additional two hours of pumping time of each of an estimated 10 existing wells at an average pumping rate of 20 gpm will generate 27 ac-ft/yr.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) and the Trinity aquifers without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
Only cost is for additional power and some long-term maintenance. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $49,357 from the year 2000 through the year 2050. Annual cost per acre-foot is $135.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
No effects on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 133-23

WATER USER NAME:
County: Kerr
River Basin: San Antonio
User Name: Livestock

STRATEGY NAME:
Additional wells

STRATEGY DESCRIPTION:
A sufficient number of additional wells will be drilled into the Edwards-Trinity (Plateau) and Trinity aquifers to supply the water needs. Additional wells will be drilled only if expanded use of existing wells (Strategy #133-22) is insufficient to meet the anticipated needs.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed.
Long Term (from the year 2030 to the year 2050): No additional supply needed.

QUANTITY OF WATER:
Ten new wells pumping at a rate of 10 gpm for four hours each day will generate 27 ac-ft/yr.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) and Trinity aquifers for the minimal expanded pumpage without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
Estimated cost to drill an 8-inch diameter hole is $5 per foot for a maximum of $2,500. The well might have about 100 feet of 5- or 6-inch PVC casing, which is estimated at about $3.50 per foot for a total of about $350. Bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. The estimated total cost for each stock well is about $6,000, which calculates to $60,000 for 10 wells. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $109,357 from the year 2000 through the year 2050. Annual cost per acre-foot is $270.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
No impacts on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:
No negative impact to natural resources is anticipated.

OTHER FACTORS:
The drilling of new wells must be in compliance with Headwaters Underground Water Conservation District rules.

INTERBASIN TRANSFER:
No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:
No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:
No impact is anticipated.

IMPACT ON NAVIGATION:
There is no impact on navigation.

STRATEGY # 133-24

WATER USER NAME:

County: Kerr
River Basin: Colorado
User Name: Mining

STRATEGY NAME:

Additional wells

STRATEGY DESCRIPTION:

Initial shortages can be handled by additional pumping. The construction of one well can yield more than enough water from the Edwards-Trinity (Plateau) aquifer to supply the projected shortage.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): Add one well as needed.

Long Term (from the year 2030 to the year 2050): No additional wells after the first well construction.

QUANTITY OF WATER:

One well capable of yielding 50 gpm could pump a little less than four hours per day and provide the short-term shortage of 12 acre-feet.

RELIABILITY OF WATER:

Sufficient ground water is available from the Edwards-Trinity (Plateau) aquifer.

COST OF WATER:

Cost of drilling a 10-inch diameter hole to a 200-foot depth with 8-inch diameter steel casing cemented then drilled to 600-foot depth with 7-7/8-inch open hole is estimated at $14,000. Cost for a 5-horsepower submersible pump capable of producing 50 gpm with wiring and control box and 300 feet of 2-inch diameter column pipe is estimated at $4,000. The total estimated price for one well is $18,000. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $22,301 from the year 2000 through the year 2050. Annual cost per acre-foot is $347.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:

No impact on other water resources is anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

No impact on navigation is anticipated.

STRATEGY # 136-1

WATER USER NAME:
County: Kinney
River Basin: Nueces
User Name: County Other

STRATEGY NAME:
Additional private domestic wells

STRATEGY DESCRIPTION:
Additional private domestic wells will be drilled mostly in the Edwards (BFZ) to supply water to new rural homes.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as population increases. Initial needs are estimated at 42 domestic wells to meet current demand of 28 acre-feet.

Long Term (from the year 2030 to the year 2050): Phased in as population increases. Estimated at an additional 60 wells for a total of 102 wells.

QUANTITY OF WATER:
Private domestic wells generally yield 5 to 20 gpm and are pumped at a rate necessary to meet household demands, which are estimated at 600 gallons per day per household depending on one well. The quantity of additional water supply generated annually from this strategy is 28 acre-feet by 42 wells and 68 acre-feet by 102 wells.

RELIABILITY OF WATER:
Sufficient ground water is available from Edwards-Trinity (Plateau), Edwards (BFZ) and Austin Chalk aquifers. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:
Typical domestic wells are about 300 to 500 feet deep. Estimated cost to drill a 8-inch diameter hole is $5 per foot for a maximum of $2,500. Most domestic wells in the Hill Country have about 100 feet of 5- or 6-inch PVC casing, which is estimated at about $3.50 per foot for a total of about $350. Bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. Pressure tank prices are estimated at about $500. The estimated total cost for each domestic well is about $7,000. The immediate need for 42 wells will cost about $294,000 and the additional 60 wells needed for the

long term will cost about $420,000 for a total of about $714,000 for 102 domestic wells. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $763,034 from the year 2000 through the year 2050. Annual cost per acre-foot is $548.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:

No impacts on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

Depending on density and well spacing dictated by lot size some negative impacts may result from this strategy. As a result of high density and wells spaced too close, interference between nearby wells may cause local water-level declines between neighboring properties possibly diminishing the yield or dropping water levels below pump settings. Local regulations dictating lot size and well spacing should help alleviate this problem.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 136-2

WATER USER NAME:

County: Kinney
River Basin: Rio Grande
User Name: County Other

STRATEGY NAME:

Additional private wells

STRATEGY DESCRIPTION:

Additional private domestic wells will be drilled into the Edwards-Trinity (Plateau) aquifer to supply most water to new rural homes.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): Phased in as population increases. Initial needs are estimated at 77 domestic wells to meet current demand of 52 acre-feet.

Long Term (from the year 2030 to the year 2050): Phased in as population increases. Estimated at an additional 108 wells for a total of 185 wells.

QUANTITY OF WATER:

Private domestic wells generally yield 5 to 20 gpm and are pumped at a rate necessary to meet household demands, which are estimated at 600 gallons per day per household depending on one well. The quantity of additional water supply generated annually from this strategy is 52 acre-feet by 77 wells and 124 acre-feet by 185 wells.

RELIABILITY OF WATER:

Sufficient ground water is available from Edwards-Trinity (Plateau) and Austin Chalk aquifers. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:

Typical domestic wells are about 300 to 500 feet deep. Estimated cost to drill a 8-inch diameter hole is $5 per foot for a maximum of $2,500. Most domestic wells in the Hill Country have about 100 feet of 5- or 6-inch PVC casing, which is estimated at about $3.50 per foot for a total of about $350. Bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. Pressure tank prices are estimated at about $500. The estimated total cost for each domestic well is about $7,000. The immediate need for 77 wells will cost about $539,000 and the additional 47 wells needed for the long term will cost about $329,000 for a total of about $868,000 for 124 domestic wells. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $958,111 from the year 2000 through the year 2050. Annual cost per acre-foot is $270.

ENVIRONMENTAL ISSUES:

If large numbers of wells are concentrated in relatively small areas, declines in ground-water levels may be anticipated, which if close to springs, correlates to deceased springflow. These springs provide base flow to the streams. Decreased streamflow would have a negative impact on aquatic plants and animals living in those streams.

IMPACT ON OTHER WATER RESOURCES:

Local water-level declines may occur which potentially may affect water levels in wells on surrounding properties. If the wells are completed sufficiently far from the springs, the effects to the springs that feed into surface streams should be small.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

Depending on density and well spacing dictated by lot size some negative impacts may result from this strategy. As a result of high density and wells spaced too close, interference between nearby wells may cause local water-level declines between neighboring properties possibly diminishing the yield or dropping water levels below pump settings. Local regulations dictating lot size and well spacing should help alleviate this problem.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

There is no impact on navigation.

STRATEGY # 136-3

WATER USER NAME:
County: Kinney
River Basin: Rio Grande
User Name: Livestock

STRATEGY NAME:
Expanded use of existing wells

STRATEGY DESCRIPTION:
Typical wells used exclusively for livestock watering have low yields and are pumped for minimal periods of time. Sufficient water is generally available from the Edwards-Trinity (Plateau) aquifer to meet increased supply needs for existing livestock facilities by increasing the pumping time of existing wells.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed
Long Term (from the year 2030 to the year 2050): No additional supply needed

QUANTITY OF WATER:
An additional two hours of pumping time of each of an estimated 30 existing wells at an average pumping rate of 20 gpm will generate 81 acre-feet per year.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) and Austin Chalk aquifers without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
If a windmill is not used, then only additional cost is for power. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $148,070 from the year 2000 through the year 2050. Annual cost per acre-foot is $135.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
No effects on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:
No negative impact to natural resources is anticipated.

OTHER FACTORS:
No other factors.

INTERBASIN TRANSFER:
No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:
No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:
No impact is anticipated.

IMPACT ON NAVIGATION:
There is no impact on navigation.

STRATEGY # 136-4

WATER USER NAME:
County: Kinney
River Basin: Rio Grande
User Name: Livestock

STRATEGY NAME:
Additional wells

STRATEGY DESCRIPTION:
A sufficient number of additional wells will be drilled to supply the water needs. Additional wells will be drilled into mostly the Edwards-Trinity (Plateau) aquifer only if expanded use of existing wells (strategy 136-3) is insufficient to meet the anticipated needs.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed.
Long Term (from the year 2030 to the year 2050): No additional supply needed.

QUANTITY OF WATER:
Sixty-one new wells pumping at a rate of 10gpm for four hours each day will generate 163 acre-feet per year.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) and Austin Chalk aquifers without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
Estimated cost to drill a 8-inch diameter hole is $5 per foot for a maximum of $2,500. The well might have about 100 feet of 5- or 6-inch PVC casing, which is estimated at about $3.50 per foot for a total of about $350. Bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. The estimated total cost for each stock well is about $6,000, which calculates to $366,000 for 61wells. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $663,968 from the year 2000 through the year 2050. Annual cost per acre-foot is $273.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
No impacts on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:
No negative impact to natural resources is anticipated.

OTHER FACTORS:
No other factors.

INTERBASIN TRANSFER:
No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:
Depending on density and well spacing some negative impacts may result from this strategy. As a result of high density and wells spaced too close, interference between nearby wells may cause local water-level declines between neighboring properties possibly diminishing the yield or dropping water levels below pump settings. Local regulations dictating well spacing should help alleviate this problem.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:
No impact is anticipated.

IMPACT ON NAVIGATION:
There is no impact on navigation.

STRATEGY # 193-1

WATER USER NAME:

County: Real
River Basin: Nueces
User Name: City of Leakey

STRATEGY NAME:

Additional system wells

STRATEGY DESCRIPTION:

The City of Leakey currently provides water from three wells completed into the Frio River Alluvium. One additional well would likely be sufficient to meet short-term needs and one additional well for long-term needs.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): One new well.
Long Term (from the year 2030 to the year 2050): One additional well.

QUANTITY OF WATER:

Two new wells producing 50 gpm each for 10 hours a day will provide 67 ac-ft/yr.

RELIABILITY OF WATER:

Sufficient ground water is available from the Frio River Alluvium aquifer; however, local water-level declines might occur. Chemical quality of the water should remain acceptable providing wells are properly constructed.

COST OF WATER:

Cost for drilling an initial 12-inch diameter hole to 100-foot depth with 8-inch diameter steel casing pressure cemented then drilled to 200-foot depth with 7-7/8-inch open hole is estimated at $15,000. Cost for a 15-horsepower submersible pump capable of producing 50 gpm with wiring and control box and 200 feet of 3-inch diameter column pipe is estimated at $8,000. With cost for other appurtenances and engineering, the total estimated price is $23,000. The total cost for two wells is estimated at $46,000. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $84,245 from the year 2000 through the year 2050. Annual cost per acre-foot is $436.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:

Local water-level declines in the near vicinity of the public supply wells may occur which potentially may affect water levels in wells on surrounding properties. Local springs that feed into surface streams should not be affected. Depending on location of the wells, water-level declines could affect flow in the Frio River.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:

No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

Drilling of public-water supply wells must meet TNRCC guidelines and standards.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

No impact on navigation is anticipated.

STRATEGY # 193-5

WATER USER NAME:
County: Real
River Basin: Colorado
User Name: Mining

STRATEGY NAME:
Additional wells

STRATEGY DESCRIPTION:
Initial shortages can be handled by additional pumping. The construction of one well can yield more than enough water from the Edwards-Trinity (Plateau) aquifer to supply the projected shortage.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Add one well as needed.
Long Term (from the year 2030 to the year 2050): No additional wells after the first well construction.

QUANTITY OF WATER:
One well capable of yielding 50 gpm could pump a little less than four hours per day and provide the short-term shortage of 12 acre-feet.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) aquifer.

COST OF WATER:
Cost of drilling a 10-inch diameter hole to a 200-foot depth with 8-inch diameter steel casing cemented then drilled to 600-foot depth with 7-7/8-inch open hole is estimated at $14,000. Cost for a 5-horsepower submersible pump capable of producing 50 gpm with wiring and control box and 300 feet of 2-inch diameter column pipe is estimated at $4,000. The total estimated price for one well is $18,000. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $22,301 from the year 2000 through the year 2050. Annual cost per acre-foot is $347.

ENVIRONMENTAL ISSUES:
No negative environmental effects are anticipated.

IMPACT ON OTHER WATER RESOURCES:
No impact on other water resources is anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:

No negative impact to natural resources is anticipated.

OTHER FACTORS:

No other factors.

INTERBASIN TRANSFER:

No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:

No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:

No impact is anticipated.

IMPACT ON NAVIGATION:

No impact on navigation is anticipated.

STRATEGY # 233-1

WATER USER NAME:
County: Val Verde
River Basin: Rio Grande
User Name: Livestock

STRATEGY NAME:
Expanded use of existing wells

STRATEGY DESCRIPTION:
Typical wells used exclusively for livestock watering have low yields and are pumped for minimal periods of time. Sufficient water is generally available from the Edwards-Trinity (Plateau) aquifer to meet increased supply needs for existing livestock facilities by increasing the pumping time of existing wells.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed
Long Term (from the year 2030 to the year 2050): No additional supply needed

QUANTITY OF WATER:
An additional two hours of pumping time of each of an estimated 24 existing wells at an average pumping rate of 20 gpm will generate 65 acre-feet per year.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) aquifer without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
If the well is not a windmill, then the only additional cost is for power and long-term maintenance. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $118,822 from the year 2000 through the year 2050. Annual cost per acre-foot is $135.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
No effects on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:
No negative impact to natural resources is anticipated.

OTHER FACTORS:
No other factors.

INTERBASIN TRANSFER:
No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:
No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:
No impact is anticipated.

IMPACT ON NAVIGATION:
There is no impact on navigation.

STRATEGY # 233-2

WATER USER NAME:
County: Val Verde
River Basin: Rio Grande
User Name: Livestock

STRATEGY NAME:
Additional wells

STRATEGY DESCRIPTION:
A sufficient number of additional wells will be drilled into the Edwards-Trinity (Plateau) aquifer to supply the water needs. Additional wells will be drilled only if expanded use of existing wells (strategy 233-1) is insufficient to meet the anticipated needs.

TIME INTENDED TO IMPLEMENT:
Short Term (prior to the year 2030): Phased in as needed.
Long Term (from the year 2030 to the year 2050): No additional supply needed.

QUANTITY OF WATER:
Twenty-four new wells pumping at a rate of 10 gpm for four hours each day will generate 64 acre-feet per year.

RELIABILITY OF WATER:
Sufficient ground water is available from the Edwards-Trinity (Plateau) aquifer without causing excessive water-level declines. Temporary water shortages may occur during drought periods, which may require the lowering of pumps or deepening of wells.

COST OF WATER:
Estimated cost to drill an 8-inch diameter hole is $5 per foot for a maximum of $2,500. The well might have about 100 feet of 5- or 6-inch PVC casing, which is estimated at about $3.50 per foot for a total of about $350. Bentonite cementing the casing is estimated at about $1,000. Typical pump might be a 1.5-horsepower submersible capable of delivering about 10 gpm at 350-foot pumping level. Estimated cost for pump with wiring and drop pipe is $2,500. The estimated total cost for each stock well is about $6,000, which calculates to $144,000 for 24 wells. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $260,994 from the year 2000 through the year 2050. Annual cost per acre-foot is $274.

ENVIRONMENTAL ISSUES:
In addition to livestock, local and migratory wildlife often depend on livestock watering facilities. Maintaining water in these facilities is thus a crucial aspect of wildlife habitat.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:
No impacts on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:
No negative impact to natural resources is anticipated.

OTHER FACTORS:
No other factors.

INTERBASIN TRANSFER:
No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:
No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:
No impact is anticipated.

IMPACT ON NAVIGATION:
There is no impact on navigation.

STRATEGY # 233-3

WATER USER NAME:
County: Val Verde
River Basin: Rio Grande
User Name: Mining

STRATEGY NAME:
Additional Wells

STRATEGY DESCRIPTION:

Initial shortages can be handled by additional pumping. The construction of one well can yield more than enough water from the Edwards-Trinity (Plateau) aquifer to supply the projected shortage.

TIME INTENDED TO IMPLEMENT:

Short Term (prior to the year 2030): Add one well as needed.

Long Term (from the year 2030 to the year 2050): No additional wells after the first well construction.

QUANTITY OF WATER:

One well capable of yielding 100 gpm could pump a little more than eight hours and provide the short-term shortage of 56 acre-feet. If the same well pumps a little less than 14 hours, then the long-term shortfall of 92 acre-feet can be provided.

RELIABILITY OF WATER:

The Edwards-Trinity (Plateau) aquifer is more than capable of supplying additional water needed by the mining industry.

COST OF WATER:

Cost of drilling a 10-inch diameter hole to a 100-foot depth with 8-inch diameter steel casing cemented then drilled to 600-foot depth with 7-7/8-inch open hole is estimated at $12,000. Cost for a 15-horsepower submersible pump capable of producing 100 gpm with wiring and control box and 300 feet of 3-inch diameter column pipe is estimated at $8,000. The total estimated price for one well is $20,000. Operation and maintenance is estimated on the basis of $0.11 per 1,000 gallons. This gives a total capital expense of $136,563 from the year 2000 through the year 2050. Annual cost per acre-foot is $28.

ENVIRONMENTAL ISSUES:

No negative environmental effects are anticipated.

IMPACT OF STRATEGY ON OTHER WATER RESOURCES:

No impacts on other water resources are anticipated.

IMPACT OF STRATEGY TO THREATS TO AGRICULTURE:
No negative impact to agriculture is anticipated.

IMPACT OF STRATEGY TO THREATS TO NATURAL RESOURCES:
No negative impact to natural resources is anticipated.

OTHER FACTORS:
No other factors.

INTERBASIN TRANSFER:
No interbasin transfer required.

SOCIAL AND ECONOMIC IMPACTS:
No negative social and economic impacts are anticipated from this strategy.

IMPACT ON WATER RIGHTS, CONTRACTS, AND OPTION AGREEMENTS:
No impact is anticipated.

IMPACT ON NAVIGATION:
There is no impact on navigation.

CHAPTER 6

ADDITIONAL RECOMMENDATIONS

6.1 INTRODUCTION

Senate Bill 1 offers an opportunity to make recommendations to develop and manage the ground-water and surface-water resources of the State of Texas. This chapter contains specific suggestions and decisions made by the Plateau Regional Water Planning Group (RWPG). Water planning specified by SB-1 is a new process for the State of Texas. Because of the complex nature of this undertaking, many ideas and approaches to the problems of water-resource management are either refined or changed significantly as all participants in the planning process learn more about the region and about what is required to produce a plan that will benefit all areas of the Plateau region. The Plateau RWPG supports the continuation of the SB-1 process with certain modifications intended to strengthen its effectiveness.

The following recommendations by the Plateau RWPG are derived from careful consideration of many issues covered during the course of the planning exercise. This includes legislative, administrative, regulatory, planning, and funding, along with data needs and suggestions for additional studies. Issues concerning ecologically unique river and stream segments and sites for the construction of reservoirs are covered. The recommendations in the following sections are designed to present new and/or modified approaches to key technical, administrative, institutional, and policy matters that will help to streamline the planning process, and to offer guidance to future planners with regard to specific issues of concern within the region.

6.2 LEGISLATIVE

These are recommendations that would require a formal statute passed during a legislative session of the Texas State Legislature.

6.2.1 Establish One State Water Agency

The overlapping responsibilities and authorities of two State water agencies are confusing to most people. Overlapping areas of responsibility can lead to inefficient development and management of water resources. Because of issues such as aquifer storage and recovery, springflow enhancement, and pollution of ground-water and surface-water resources, the responsibilities of State agencies will overlap more in the future. The administration, planning and permitting of water rights and water production will be increasingly difficult if more than one agency is involved, especially if water becomes a commodity to be traded or sold. The close interrelationship between surface water and ground water makes a single State water agency an attractive alternative to the present two-agency system. A single agency should bear all of the responsibility for investigating, planning, rulemaking, permitting, enforcement and funding of water-resource issues.

6.2.2 Require State Agencies Involved with the RWPG Process to Participate

Representatives of State agencies involved in the regional planning process could effectively derail a regional plan at the end of the planning period - without attending as much as one meeting. The Plateau RWPG recommends that nonvoting members of State agencies be required to attend and provide input at every RWPG meeting. If an agency's nonvoting representative does not contribute or fails to attend meetings, then that agency should not be permitted to object to or alter the RWPGs management plan or project.

6.2.3 Amend the Open Meetings Act

All meetings and official actions of RWPGs are conducted under rules of the open-meeting format. However, requiring subgroups or committees appointed by a RWPG to meet under rules of the Open Meetings Act creates a severe burden. This should be modified.

6.2.4 Legislation to Address Definitions of "Beneficial Use" and "Waste"

Both the definitions of "Beneficial Use" and "Waste" should be addressed in Chapter 36 of the Texas Water Code to prevent uses other than those originally intended, such as the pumping of ground water to fill large ornamental ponds and small reservoirs.

The term “beneficial use” is currently defined in Texas Water Code 11.002 (the definitions section) thus:

> (4) "Beneficial use" means use of the amount of water which is economically necessary for a purpose authorized by this chapter, when reasonable intelligence and reasonable diligence are used in applying the water to that purpose and shall include conserved water.

6.2.5 Transport of Water Out of a Ground-Water District

The direct economic and sociological impact caused in a county due to depletion of the ground-water supply should be considered in the permitting and transportation of ground water from a district. Local groundwater conservation districts should not be limited in their efforts to meet their mandated responsibilities as directed under Texas Water Code §36.0015. Groundwater conservation districts should not be limited in their scope, but allowed to manage the resource through fees or pumping limitations - the magnitude of which should be determined at the local level to allow for the preservation and conservation of ground water within the district. Either of these methods of management for a conservation district would allow for a true free market system.

6.2.6 Establish Uniform Aquifer-Wide Rules

Establish uniform well rules in all of the Trinity aquifer counties and enforce the rules in an equitable and fair manner. This should not only include provisions for setback distances but also should limit variances.

6.3 STATE FUNDING

The following items are suggestions for additional funding supplied by the State.

6.3.1 Eliminate the Unfunded Mandate

The provision that requires regional water planning groups to raise money to fund 100 percent of the administrative cost of developing the plan should be eliminated. Requiring volunteers to develop the plan, sell the plan, and be fundraisers to support the plan is not only unwise but burdensome, as well. The State should provide funding for the State-mandated plans.

Regional water planning group members who are not employed by entities are especially hard-pressed, as they donate time and monies out of their own personal resources. Such individuals could be discouraged from serving on a regional water planning group simply because their personal resources may not be adequate to cover the time and expense involved.

6.3.2 Reasonable Expenses Incurred by the Planning Group

The time commitment of RWPG members is excessive. That RWPG members should be expected to incur the cost of travel to meetings is neither fair nor reasonable. This will likely deter other interested persons from serving on RWPGs.

Under the current process there is great disparity and inequity in RWPG member compensation or expense reimbursement. Some members are compensated for their time and expenses as part of jobs, such as employees of river authorities, water districts and utilities. However, other members such as public, small business and agriculture representatives must pay their own way and take a significant amount of time away from their permanent occupation. This disparity results in an unequal amount of influence on the RWPG because the "compensated" members and entities tend to have more time and funds to devote to the planning effort and this in turn gives such members and entities a disproportionate amount of influence in the planning process.

6.3.3 Training for New RWPG Members

A training structure for new members of the RWPG should be developed and funded by the State. There is no formal plan to educate new RWPG members on the complexities of the planning process and associated technical information. The old members do not want or need to spend time rehashing details with their replacements. It is vitally important that new members have access to all of the information that previous members helped to develop. A planned reading and instruction schedule should be formulated to educate new members. This should be funded by the State.

6.3.4 New Studies and Data

The required format and content of each regional report are a nonproductive use of the consultant's expertise. All of the tables could be generated by the TWDB, the TNRCC, the TPWD or the TDA with input and review by the RWPG. The consultants should be employed to do more interpretive work.

The State should fund or conduct specific studies that will shed more information on specific water-resource issues. The questions unanswered by current sources of information are critical to future RWPG decisions. Examples include: (1) test wells to monitor aquifer changes, and (2) aquifer models to predict the reactions of aquifers to different input variables. Additional study and monitoring of the Trinity aquifer are needed. This should include refinement of the Trinity model, and modeling of the Lower Trinity aquifer. A good monitoring system for the Trinity aquifer should be established. The network should include a system of permanent monitoring wells drilled by the TWDB. Information from these wells should be used to identify triggers for drought management.

6.3.5 Best Management Practices

The State should draft legislation to provide funding to landowners for Best Management Practices (BMPs) that conserve water resources, such as brush management, land use management and recharge structures. Ground-water recharge structures should be strongly emphasized in areas where they are likely to be useful. Brush management and recharge structures are low-tech methods of increasing recharge and reducing erosion without water loss to excessive evaporation, evapotranspiration, or interception.

Brush management is a strategy of great interest in the Plateau Region as well as surrounding planning regions. The legislature should dedicate funds for studies to estimate the cost of brush removal and of the recharge benefit, not only in the Plateau region, but also in all brush-infested parts of the state. The projects should consider test sites of a minimum of 100 acres. The end product quantifies the short-term and the long-term costs of an acre-foot of water resulting from the removal of vegetation or the installation of a groundwater recharge structure. A program should also be developed for cedar clearing and maintenance through a system of grants or tax incentives.

Currently Texas Parks and Wildlife Department (TPWD) has a program specifically directed at BMPs for landowners dealing with brush management in areas possibly containing endangered species, but additional funding for landowners desiring to practice BMPs in general should be put in place. The voluntary partnership of landowners and TPWD staff is important to the ultimate success of many BMPs, as the landowner may benefit from the technical expertise of TPWD staff.

Great interest in aquifer recharge structures also exists in the Plateau Region and should be encouraged. Increased recharge from such structures benefits underlying aquifers and often contributes to increased discharge of ground water to streams. Programs and funding should be made available to identify appropriate locations for recharge structures and assistance provided for their construction and maintenance.

6.3.6 Municipalities

The State should establish grants and state funding to modernize water and wastewater systems. The State should also develop an education program to inform cities of the need to upgrade or to improve systems and to apprise cities of the availability of funds.

6.3.7 Conjunctive Water Use

State funding should be provided to encourage conjunctive use of surface water and ground water for landowners that claim riparian rights. This could be accomplished though grants or tax relief.

6.3.8 Alternative Sources of Water

Programs such as weather modification and rainwater harvesting should be funded by the State. Rainwater harvesting is one way to meet rural domestic demand, as well as some irrigation and livestock demand. This should be encouraged with some funds made available to individual homeowners, farmers and ranchers.

6.3.9 Preliminary Unique Reservoir Site Studies

The Legislature should dedicate funds for the TWDB to conduct a preliminary study to identify unique sites in the region for dams. A second study should be funded to evaluate the properties of the most promising sites that are likely to affect each site's selection as a potential surface-water reservoir.

6.4 PLANNING

The following recommendations are categorized as those that would help with planning.

6.4.1 Strengthen County Water-Planning Capabilities

Counties and ground-water management districts should be encouraged and enabled to establish lot sizes and well-spacing regulations that are compatible with aquifer recharge and management. Rules should include both individual lots that are not required to be platted, as well as platted subdivisions.

6.4.2 Peak-Use Management

Drought management plans need to be developed based on peak use demand instead of annual production capabilities. The current plan is based on drought of record conditions on an annual basis. While this is a good starting point in the planning process, it would be beneficial to also plan based on peak demand for all regions. For example under the current plan it is possible for the water management plan to address water needs on an annual basis; however, it may not address water needs during the peak use period of the summer months. During the summer, in many areas of the state, severe water problems may exist that are not apparent based on an annual water management plan. This results in a plan that indicates water supply needs are satisfied for a region when in reality such needs are not satisfied throughout the year. This presents a significant problem in the current planning process.

6.4.3 Simplify Required TWDB Tables

Although TWDB data have been very helpful in the development of the regional plan, it would be useful and less time-consuming for the data to be better formatted and easier to locate. Having the required TWDB tables uniformly developed by all regions is recognizably important in establishing a statewide database that will be used in the development of the full State plan. However, the multiple columns containing codes is of no importance to the regions and is quite time-consuming for the consultants. The TWDB should establish a single code for each water user that will automatically refer to the necessary codes in the TWDB database. This would allow the consultants to develop a single table that will serve the purpose for both the printed regional plan and the required TWDB table.

6.4.4 Define the Length of the Drought-Planning Process

The length of drought-of-record conditions during the planning period should be better defined. Does the drought-of-record condition exist continuously for the entire 50-year period, or only during the decade year represented in the tables? Supply estimates over the entire time period are significantly affected by the length of dry and wet periods. It seems reasonable to assume that average conditions prevail throughout most of the 50-year period and are interrupted by droughts in the key decade evaluation year. This becomes a key factor in estimating ground-water availability based on how much and when recharge occurs.

6.4.5 Standardize Ground-Water Evaluations Statewide

Ground-water supply evaluation methodology should be standardized statewide. The different methodologies that have been employed by the 16 regions do not allow the TWDB to develop a comprehensive accounting of available ground water in the state. A standardized methodology should include an analysis for total water by quality range in the aquifer, recoverability of the water, and estimate of recharge. With such data, each region can better evaluate safe-yield and mining strategies.

6.4.6 Allow Later Changes to Demand Numbers

Modification of demand numbers should be allowed further into the planning process. Demand errors may not be discovered until the supply-demand analysis is performed. Some entities or water-use categories may have been overlooked early in the process and their demands need to be added later for the supply-demand analyses to match.

6.4.7 Review of New Census Data

The revision of population or demand estimates should be discussed by RWPGs and put before the public for several months, and then be presented to the RWPGs for consideration and adoption. This will allow more time for water users within the region to hear about the planning effort and to have input to the revisions of population, water demand, and water supply.

6.4.8 More Input and Control of Rules Governing RWPGs

The TWDB should spell out in its rules a region's control of the selection of voting RWPG members. The RWPGs should, in conjunction with the TWDB, be able to designate voting entities for a region. The voting members should represent not only the entity designated by the TWDB but should be nominated by the people in their areas. Another concern is the TWDB's ability to change the rules during a planning process. Rule changes should come from the RWPGs. The RWPGs should be able to amend the rules, through a rule amendment process, to meet the dynamics of their respective regions.

6.4.9 Development of Educational Programs by the State for RWPGs

There is a need for the development of educational programs by State agencies to assist RWPGs in educating both the public and private sectors.

Examples of the educational programs include the following:

- Encourage development and construction of recharge structures.
- Encourage rainfall harvesting to supplement or replace aquifer pumping.
- Educate and encourage municipalities to manage water systems to maximize their preparedness for drought conditions.
- Encourage the public to conserve water through low-flow appliances and fixtures, low-water landscaping and elimination of waste.

6.4.10 Conservation and Drought Planning

Because portions of the region are particularly susceptible to water-supply shortages during periods of drought conditions, these areas are especially encouraged to develop conservation oriented management plans. Likewise, water-user entities within these areas should become actively involved in the regional water planning activities associated with this plan.

6.5 NEEDED STUDIES AND DATA

The following are recommendations for specific studies and data acquisition that is not currently being performed and which the Regional Water Planning Group believes should be performed in the near future.

6.5.1 Trinity Aquifer

The Trinity aquifer is the principal source of water supply in Bandera and Kerr Counties, and it is of vital importance during drought conditions when minimal flows occur in the Guadalupe and Medina Rivers. A reliable system of observation wells for the Trinity aquifer should be developed by the State. A network of water-level monitoring wells capable of recording seasonal water-level trends in the Trinity aquifer should be established to better understand aquifer conditions. Recent seasonal monitoring of water levels has occurred during a drier-than-normal period; therefore, it is essential that seasonal monitoring be extended to a time that incorporates wetter conditions. Drought-management triggers should be developed. Further studies and monitoring of the Trinity aquifer are needed.

A study of the lower Trinity aquifer is underway in Bandera and Kerr Counties. The lower Trinity study should be expanded into surrounding counties to develop a better understanding of the regional nature of this hydrostratigraphic unit. Lower Trinity aquifer test holes should be drilled and completed as observation wells to monitor the long-term effects of pumpage in the City of Bandera and in the City of Kerrville areas. The TWDB recently completed a model of the Upper and Middle Trinity aquifer. The lower Trinity aquifer should be incorporated into this model.

As part of the lower Trinity study, testing for tritium was performed at several lower Trinity wells in Bandera and Kerr Counties, and was found to be absent. Stating that modern recharge does not occur in the lower Trinity as a result of these analyses is premature and inappropriate at this time. However, the implication of this preliminary finding at these wells is potentially enormous. The City of Kerrville, UGRA and individual ground water users currently use and/or plan to use extensive amounts of ground water in this area, and the area is expected to have water shortages in the future. The users in the area need to know if ground-water supply is indeed being replenished, or if continued ground-water usage will deplete the aquifer. Therefore a more extensive study involving several monitor wells and testing for tritium at these wells is needed.

6.5.2 Trinity Aquifer Model

Because of concerns of inaccuracies, the Trinity aquifer model may create a sense of crisis in some areas and complacency in others. There are some concerns about the readiness and reliability of the model among members of the Regional Planning Group. These concerns include the following.

- Data recently collected from a number of new monitor wells have not been incorporated into the model. Only older data, 1997 and earlier, have been used. The older data are sparse and not distributed through out the aquifer.
- Model projections of future aquifer declines are neither reasonable nor logical in some areas.
- The coefficients of transmissivity and storativity might be questionable.

- One-mile grid spacing may not be appropriate for the modeled area.
- Evenly distributing domestic pumpage throughout the aquifer is not realistic.
- The methodology of establishing derivative values on a square-mile grid has created a pessimistic forecast for sparsely populated areas situated between population centers such as San Antonio and Kerrville, etc.
- Data should be collected over a wider area and over a longer period of time. These data need to be collected during periods of greater-than-normal and lower-than-normal precipitation, so that more accurate estimates of recharge can be developed.

Regional Water Planning Groups J, K and L, in whose regions the Trinity aquifer lies, should jointly evaluate and determine in what context the model should be used in current and future planning efforts.

6.5.3 Austin Chalk

The Austin Chalk is a source of ground water for irrigation in southern Kinney County. A ground-water characterization and delineation study is needed to estimate the availability from this aquifer, especially insofar as pumpage may affect water levels in adjacent counties.

6.5.4 Ground Water - Surface Water Interrelationship Study Needs

The interrelationship between groundwater and surface water should be studied to determine the potential effects of ground-water consumption on springflow. An example in the Plateau region is the need for data to understand discharge to the Devils River, San Felipe, Las Moras and Sycamore Creeks and ground-water data needs for the Edwards-Trinity (Plateau) aquifer.

The City of Del Rio, Texas Parks and Wildlife Department, and the U.S. Fish and Wildlife Service have entered into a Conservation Agreement to expedite measures to ensure the continued existence of, and facilitate recovery of, the Devils River minnow, *Dionda diaboli*. The purpose of this agreement is to conserve the aquatic habitat in Devils River, San Felipe Creek, Las Moras Creek and Sycamore Creek that is deemed to be unique for the Devils River minnow.

One objective of the agreement is to obtain and analyze changes in stream discharge for these watercourses. Suggestions were made requesting studies from the Texas Water Development Board and/or the Texas Natural Resource Conservation Commission that result in better stream gaging and data collection. One objective is to determine the relation between discharge rates for San Felipe Springs and species population. The agreement states that a more thorough assessment of ground-water geology and recharge area will be performed if correlations between discharge and species population are demonstrated for this area.

Another issue is the recent interest that some landowners have expressed in selling and exporting water to other interested areas of the State. This has raised a question regarding the impact on springflow and how this is likely to affect the Conservation Agreement of the City of Del Rio. The RWPG recommends studies that link water-level fluctuations in the Edwards-Trinity (Plateau) aquifer to changes in spring discharge and to the abundance of the Devils River minnow. These studies should identify the most sensitive recharge areas of the aquifer with regard to springflow.

6.5.5 Riparian Water

A significant amount of unpermitted riparian water is withdrawn from rivers and their tributaries in the region. This water use is unaccounted for in the Water Availability Models that are developed for these waterways. State water agencies should devise a survey method to establish a reasonable estimate of these diversions.

6.5.6 Medina Lake System

The Medina Lake diversion system should be incorporated into TNRCC's Water Availability Model. The existing Water Availability Models funded and supported by the Texas Natural Resource Conservation Commission are Runs 1 through 8, with Run 3 identified by the agency as the model to be used for purposes of permitting new surface- water rights. These models incorporate HDR's Trans-Texas method of calculating recharge (water which leaves the lake system and goes to an aquifer or aquifers below). A new USGS study, "Assessment of Hydrogeology, Hydrologic Budget, and Water Chemistry of the Medina Lake Area, Medina and

Bandera Counties, Texas," Water-Resources Investigations Report 98, challenges this method as well as an earlier USGS method. The new USGS study asserts that both earlier methods overestimate recharge because they do not account for that portion of water returning to the Medina River as surface water (i.e., both earlier methods assume that the unaccounted-for water goes to recharge). The new USGS study, which is based on measured values from October 1995 through September 1996, correlates to actual measured elevations of the Quihi well. This recommendation consists of four parts:

- The first part is to fund another USGS study similar to the study cited above. The new study should involve measured values over a longer time period. This study will be valuable if started immediately.
- The second part is to replace HDR's Trans-Texas method of estimating recharge with the new USGS method of estimating recharge in the Water Availability Modeling.
- The third part is to incorporate into the Water Availability Modeling any changes in the Medina/Diversion system that will occur eminently (such as BMA and Bexar Met plans to replace leaking dam gates with new or rehabilitated gates).
- Finally, the fourth part is to investigate and correct errors in the current modeling of the system regarding releases that Medina Lake makes to Diversion Lake. These errors may involve the use of target storage for Diversion Lake of 1,818 acre-feet and/or errors within the source code of the Water Availability Model's MEDINA subroutine.

6.5.7 Emphasis on Basic TWDB Water Evaluation Studies

In the past, the TWDB has provided significant knowledge concerning the ground-water resources in the state in the form of basic data and reports. The Board's current emphasis on ground-water modeling with its intended use as a water management planning tool, is recognized as an important advancement in providing planning. However, the Board should not abandon its more important basic data gathering and evaluation responsibility. The Board should emphasize more realistic and useful ground-water studies that include the extensive field data collection necessary for such studies. TWDB staff effort and funding should go to these more realistic and focused studies.

6.5.8 Current Studies Which Should Be Incorporated into the Next Planning Cycle

6.5.8.1 State Irrigation Survey

Since 1958, the Natural Resource Conservation Service of the U. S. Department of Agriculture (NRCS), the Texas State Soil and Water Conservation Department (TSWCD), and the Texas Water Development Board (TWDB) have jointly performed irrigation surveys approximately every five years. Each survey is presented in Report 347 published by the TWDB. For the most recent effort, the associated agencies did not develop detailed 1999 irrigation use estimates; rather the TWDB will have estimates for 1999 but will not have maps. In February 2000, the TWDB approved $140,000 funding for the NRCS to perform a full five-year detailed irrigation survey that would have been expected for 1999 but instead will be performed for 2000. The water use by county and individual crops will come from the NRCS in the same reporting format as in the past. Total acreage of irrigated crops data will come predominantly from the Texas Agricultural Statistics Service, as well as a breakdown of acreage per crop. The general location of the irrigated crops is generally the same as shown in the last detailed survey. The location of wells and surface water diversion points also do not change.

The scope of work for some of the various agencies involved in the new survey has been modified. The detailed year 2000 irrigation survey will include NRCS' ability to contract with other entities in data collection efforts in the field. The NRCS will also deal with surface water irrigation districts and with groundwater districts. The districts' suggestions and data will probably result in greater accuracy of the data. The TWDB is to provide guidance, staff support and computer support.

An important aspect of this latest funded effort is the pilot project, whereby, for five selected counties of Texas, TWDB will use Digital Orthography Mapping, photographic base mapping and remote sensing mapping to differentiate between crops from aerial data rather from field data. The TWDB's Conservation Section will coordinate with TWDB TNRIS StratMapping personnel on this highly technological mapping and data analysis effort. The data collected from the field, with its crop delineations hand-drawn on county maps, will be compared to the data collected through technological mapping. If the "technological" method compares favorably with the "old-fashioned" method, then the TWDB will take over future irrigation surveys and perform the data collection and analysis - with the new technology - for the entire state.

The Senate Bill 1 Regional Water Planning Groups could well benefit from these new irrigation use data as they become available – especially as irrigation data and irrigation water use data is often cited as an area for which good data does not exist. In particular, ground water used for irrigation purposes is sometimes termed a "data hole." Whereas, surface-water right holders are required to report their water use amounts to the TNRCC, no such reporting requirement exists for ground-water users.

6.5.8.2 Source Water Assessment Program

Under the Safe Drinking Water Act Amendments of 1996, the TNRCC is required to submit a Source Water Assessment and Protection Program (SWAP) to the Environmental Protection Agency (EPA) within 18 months after the EPA guidance document is issued. This submission is then reviewed and approved by EPA. TNRCC currently is working on development and implementation of the Source Water Assessment and Protection (SWAP) program. EPA's Source Water Assessment and Protection Guidance Document (EPA 826-R-97-009) assists states in complying with federal mandates by identifying the areas that are sources of public drinking water, by assessing water suppliers' susceptibility to contamination, and by informing the public of the results.

The state's SWAP program document will include a description of methods to be used for delineating boundaries of source water assessment areas and identifying the origins of regulated and certain unregulated contaminants in the delineated areas to produce a susceptibility analysis for the public water systems. TNRCC has elected to encumber $2.5 million of the FY 1997 funds to perform SWAP activities. The vast majority of these resources will be spent under a joint funding agreement with the U.S. Geological Survey (USGS). The USGS will provide technical assistance to the TNRCC's Public Drinking Water (PDW) Program in the joint formulation of a multi-year, summary work plan. TNRCC may link these data within a graphical user interface (GUI) for ease of use and maintenance by the TNRCC PDW Section.

TNRCC envisions that the susceptibility assessment tool could be used to aid TNRCC, water system operators, and the public in siting and planning new water supply intakes and well locations. These data and the associated assessment tool could conceivably be a powerful and convenient aid to Senate Bill 1 regional water planning.

6.5.9 UGRA Surface-Water Purchase from LCRA Feasibility Study

Several strategies for the City of Kerrville and UGRA in Kerr County have been considered. Both of these entities take water from the Guadalupe River, both need more water, and both have considered the possibility of purchasing surface water from GBRA. Both UGRA and Kerrville have considered the building of reservoirs, however, these strategies are only future considerations. Since water is scarce within the Guadalupe River and ground water cannot fully meet the future demands of the population within the City of Kerrville and UGRA's service areas, good planning indicates that entities in Kerr County cannot depend on current water resources within the Guadalupe River basin. Therefore UGRA may also consider purchasing Colorado River surface water from the Lower Colorado River Authority.

6.5.10 Development or Purchase of Desalinated Water

Consideration is being given to the potential for the desalination of local brackish ground-water resources or the purchase of desalinated water from the coast. Desalination is rapidly becoming a technology that is much less expensive than in the past, primarily due to recent improvements in membrane effectiveness and longevity. This is another option that might expand the inventory of possible sources of water supply; however, a feasibility analysis is needed to evaluate its viability.

6.5.11 Bandera County Aquifer Storage and Recovery

In order to provide additional water supply for rural areas of Bandera County, the Springhills Water Management District is considering the purchase of Medina River water from Bexar-Medina-Atascosa WCID. Springhills would divert and treat this surface water, and inject it into the Trinity Aquifer in an Aquifer Storage and Recovery (ASR) facility for later retrieval and use. The original quantity of water discussed is 2,000 acre-feet per year with the recent negotiations for a total of 5,000 acre-feet per year. An evaluation is needed to assess the ability of the aquifer to receive and release injected water at potential sites.

6.6 CONSIDERATION OF ECOLOGICALLY UNIQUE RIVER AND STREAM SEGMENTS

Water needed to maintain ecological habitats was an important consideration in the preparation of this regional water-management plan. In the process, many ecological databases and reports prepared by universities and government agencies were reviewed. Unique ecological stream segments identified by the Texas Parks and Wildlife Department were also reviewed. Consideration was given to the impact that each water-supply strategy might have on local environmental water needs.

SB-1 allows for the voluntary designation of "ecologically unique river and stream segments" in a regional water plan. However, the effects of designating a stream segment on future uses are not clear. The bill does not outline potential restrictions of uses or development along designated watercourses, and, therefore, the activities that will be allowed or disallowed under an "ecologically unique stream segment" designation are unclear. The Plateau Regional Water Planning Group recognizes that streams within the region are already protected under existing state and federal law. Therefore, State and Federal regulatory protection of surface water is deemed to be adequate until the State Legislature clarifies the actions associated with the designation.

In the Federal Water Pollution Control Action Amendments of 1972 (FWPCA), Congress gave the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency authority to regulate water pollution in the waters of the U.S. The Army Corps of Engineers is responsible for that portion of law called "Section 404", which deals with permitting of discharge of dredged or fill material into navigable waters. The Courts expanded regulatory authority to wetlands. The Clean Water Act renamed and expanded the FWPCA - for instance, including within Section 404 general permit provisions, exceptions, and delegation of some authority to the states.

In June of 2000, federal rules implementing Section 404 activities were further modified - the U.S. Army Corps of Engineers New and Modified Nationwide Permit Program (NWP program) makes waters officially designated by a State as having particular environmental or ecological significance into federally defined "Designated Critical Resource Waters". This means that activities formerly eligible for authorization by the NWP program will instead require individual permits or regional permits. The activities affected are outfall and utility structures, bridges, hydropower projects, single- family housing, maintenance of existing flood control projects, all developments (residential, commercial, institutional), agricultural activities, recreational facilities, stormwater management facilities and mining activities.

Clearly, if the Texas Legislature designates a stream as an ecologically unique stream segment, the Legislature's action in doing so would automatically, by the new federal regulations, make that stream a federal "Designated Critical Resource Water" subject to the new federal regulations limiting activities on that stream.

6.7 CONSIDERATION OF UNIQUE SITES FOR RESERVOIR CONSTRUCTION

Texas Administrative Code Section 357.9 states that a Regional Water Planning Group may recommend sites of unique value for construction of reservoirs. Criteria used to determine if a site is unique for reservoir construction are listed in this section of TAC, but these criteria are not prioritized. One criterion is whether the site-specific reservoir development is recommended as a specific water-management strategy or in an alternative long-term scenario in an adopted regional water plan. Other criteria listed are "the location, hydrologic, geologic, topographic, water availability, water quality, environmental, cultural, and current development characteristics, or other pertinent factors which make the site uniquely suited for (A) reservoir development to provide water supply for the current planning period; or (B) where it might reasonably be needed to meet needs beyond the 50-year planning period."

The 1997 Consensus State Water Plan identified Recommended Major Water Supply Projects and Alternative Water Supply Development Sites. The Plan did not identify any Recommended Major Water Supply Projects for the Plateau Region, but did identify two alternative sites. These are Smith Reservoir on the South Fork of the Guadalupe River 18 miles west of Kerrville and Bear North Reservoir on the North Fork Guadalupe River 18.5 miles west of Kerrville. These streams are obvious possible candidates for consideration as unique sites for reservoir construction, although it is observed that the original studies are quite outdated, and also that Camp LaJunta, Camp Arrowhead, and Camp Mystic could possibly be inundated by a reservoir on South Fork Guadalupe if the reservoir were large enough. Similarly, Camp Stewart on North Fork could possibly be inundated by a reservoir. One potential reservoir construction site, that was specifically evaluated, is Johnson Creek in western Kerr County.

A detailed explanation of the process used to evaluate the numerous streams for their potential as unique reservoir construction sites is located in the Appendices. Table 6A-1 contained in the explanation is a matrix with assigned rating points for each watercourse. Many of the watercourses, both major and minor, drop from consideration in early steps of the process explained under the criterion discussions in the methodology explanation contained within the Appendices. The matrix adds the rating points (some rating points are negative, while others are positive), and the overall rating score for each watercourse is shown in the column "Overall Rating". Higher "Overall Rating" numbers indicate greater degrees of favorability.

Based on the results of the ratings for these potential reservoir sites, the Plateau Regional Water Planning Group is not recommending that any sites be designated as Unique Reservoir Construction Sites at this time. This issue may be revisited during the next planning cycle. The Planning Group has also made a recommendation regarding further studies on this issue (see Chapter 6, Additional Recommendations, Section 6.3.9).

CHAPTER 7

PLAN ADOPTION

7.1 INTRODUCTION

Chapter 7, the final chapter of the plan, contains an overview of the Plateau Regional Water Planning Group representation and planning process, and the specific activities that insured that the public was informed and involved in the planning process and the implementation of the plan.

7.2 REGIONAL WATER PLANNING GROUP

The TWDB appointed an initial coordinating body or regional water planning group (RWPG) for the original Region J based on names submitted by the public for consideration. The RWPG then voted to change its name to Plateau and expanded its membership based on the their knowledge of additional persons who could appropriately represent a water user group. Senate Bill 1 provisions mandate that one or more representatives of the following water user groups be seated on each RWPG: agriculture, counties, electric generating utilities, environment, industries, municipalities, river authorities, public, small business, water districts, and water utilities. An electric generating utility does not exist within the Plateau Region and is therefore not represented. In addition to the other 10 categories, the Plateau RWPG chose to appoint a member to represent the tourism industry because of its prevalence in the region. Also, to insure adequate geographic representation, the RWPG made sure that at least one member was selected from each of the six counties. Staff persons from both the Texas Parks and Wildlife Department and the Texas Department of Agriculture were also appointed as non-voting members. The Plateau RWPG members themselves are unpaid and voluntarily devote considerable amounts of their time to the planning process.

PLATEAU WATER PLANNING GROUP MEMBERS

Water-use Category	Name	Entity	County
Agriculture	Zach Davis	Rancher	Kinney
Counties	Nick Gallegos	Edwards County	Edwards
Counties	W.B. Sansom	Real County	Real
Counties	Kenneth Shackleford *	County Commissioner	Real
Counties	Judge Nevile Smart *	County Judge	Edwards
Environment	Tully Shahan		Kinney
Environment	Herb Senne *	Soil Conservation Service, Retired	Kinney
Industries	Ronnie Pace, *Secretary*	Diversified Fabricators	Kerr
Municipalities	Otila Gonzalez	City of Del Rio	Val Verde
Municipalities	Bill McCrea	City of Kerrville	Kerr
Municipalities	John Wendele *	City of Kerrville	Kerr
River Authorities	Jim Brown	Upper Guadalupe River Authority	Kerr
Public	Alejandro Garcia	City of Del Rio Public Works	Val Verde
Public	Art Tuttlebee, Jr.*		Val Verde
Public	Gerald Prather *	Retired military	Val Verde
Public	Daniel S. Burr *	Retired	Val Verde
Small Businesses	Jonathan Letz, *Chair*	Landscape Consultant / Rancher	Kerr
Tourism	John Junker, *Treasurer*	Flying L Guest Ranch	Bandera
Water Districts	Cameron Cornett	Headwaters Underground Water Conservation Dist.	Kerr
Water Utilities	O.J. Erlund	Utility Consultant	Kerr
Other	John Mohar	City of Bandera	Bandera
Other	Jerry Simpton, *Vice Chair*	Del Rio National Bank	Val Verde

* Former or resigned members of the Plateau Regional Water Planning Group.

7.3 PLANNING PROCESS AND PROJECT MANAGEMENT

The Plateau RWPG adopted bylaws and submitted a scope of work and associated budget to the TWDB. With SB1 funds administered through TWDB, the RWPG then hired consultants to perform the work of preparing the regional plan. Work required to complete the plan followed well-defined guidelines intended to meet the mandated language of SB1 and to establish a degree of format uniformity between all 16 regional plans. The Plateau RWPG operates its administrative function through the Upper Guadalupe River Authority (UGRA); all billing of expenses goes to TWDB through UGRA. All meetings of the Plateau RWPG are open to the public and meet Open Meetings Act requirements.

To insure a spread of responsibility the RWPG members were assigned to one or more committees; executive, financial, technical, environmental, or public awareness. Of these committees, the technical committee spent a significant amount of time reviewing the technical aspects of the plan. Once these members were confident in the material being presented, an approval recommendation was made before the entire RWPG.

Members of the environmental committee were charged with the responsibility of providing guidance and assistance on all work related to environmental and natural resource water needs issues. The committee also reviewed environmental and natural resource impact evaluations of the supply-shortage strategies. Staff of the Texas Parks and Wildlife Department stationed in Kerr (Mr. Richard Luebke) and Val Verde Counties worked with the environmental committee and provided their expertise.

7.4 PRE-PLANNING SURVEY

Prior to the development of a scope of work, a public survey was conducted to assist the RWPG members in identifying a common long-range vision for a successful regional water plan. The survey asked for opinions on the following issues and gave the stated responses:

- <u>Adequacy of current water supply</u>
  Most thought current supply was adequate but were concerned about future increased pumping.
- <u>Problems with water supply</u>
  Quality of water supply.
- <u>Accuracy of population and water demand projections</u>
  Most were unaware of projections in the 1997 water plan.
- <u>Environmental water needs</u>
  Most were concerned but unaware of specific need requirements.

- Drought contingency plans

  Most were unaware of drought contingency plans by the communities in which they reside.

- Exportation of water

  All were emphatically against exportation from this water-short area.

- Water conservation policies

  Most acknowledged the importance of conservation.

- Enforcement of water conservation policies

  Split between need for stronger state enforcement and local enforcement.

- Reuse of water

  All considered reuse as important where practical.

- Regional supply and wastewater facilities

  Most felt that the region was too rural for regional solutions.

- Stricter well construction requirements

  Most want stricter compliance and enforcement of well construction requirements.

- Concerns outside of the region

  Concerned about possible exportation of water out of the region.

- Ranking of water planning factors
  - Make sure the supply is sufficient and reliable.
  - Keep the quality of water high.
  - Keep the cost of water low.

7.5 PUBLIC PRESENTATIONS

Several presentations were given to civic and special interest groups. The presentations listed below were intended to increase the awareness of the planning process and to engage public input where possible.

- Public meetings sponsored by the Plateau RWPG:
  Del Rio 3-1-99
  Bandera 3-18-99
  Bracketville 5-10-99
- Meeting of county and municipal officials – Kerrville 3-2-99
- Riverside and Landowners Protection Coalition – Kerrville 9-11-99
- League of Women Voters – Kerrville 10-18-99
- Coalition of Concerned Citizens – Kerrville 3-9-00
- Methodist Church – Kerrville 10-3-00

7.6 PLANNING GROUP MEETINGS AND PUBLIC HEARINGS

All meetings of the Plateau Regional Water Planning Group, including committee meetings, were open to the public where visitors were afforded the opportunity and encouraged to voice their opinions, concerns, or suggestions. Meeting locations were rotated evenly between all six counties so that all citizens within the region would have an equal opportunity to attend. In accordance with the Federal Open Meetings Act, meeting notices were posted in the following county newspapers:

- Kerrville Daily Times
- Kerrville Mountain Sun
- Bandera Bulletin
- Bandera Review
- Tri-County Echo (Leakey)
- Real American (Leakey)
- Bracket News (Bracketville)
- Del Rio News Herald

The first regional public hearing was held in Rocksprings on June 25,1998. The primary intent of the hearing was to explain the planning process, introduce the planning group members, and receive comments and recommendations as to what should be included in the Scope of Work. Fourteen individuals signed the attendance sheet and six individuals made a verbal statement. Written comments were also received.

Two final public hearings were held to receive comments on the initially prepared plan, one in Del Rio on September 28, 2000, and the other in Kerrville on September 29,2000. In addition to the newspapers noted above, notice of the Public Hearings was also run in the San Antonio Express News. Also, 1,650 public notices were sent to down-river water rights holders. Hard copies of the initially prepared plan were placed in the courthouse and library of each of the six counties listed below, and the public was given a full month to review the document. The plan was also made available on the Lower Guadalupe River Authority web site (ugraadmin@ugra.org).

- Bandera County Library
- Butt-Holdsworth Library (Kerr County)
- Edwards County Library
- Kinney County Library
- Real County Library
- Val Verde County Library

Draft plans were also sent to the mayors of Kerrville, Ingram, and Del Rio, and to the Chairs of Regions E, F, K, L, and M.

Prior to the official comment period a question and answer session was held so that the public attendees would have an opportunity to gain a better understanding of how the draft plan was formulated. Approximately 45 people attended the Del Rio hearing and approximately 120 attended the Kerrville hearing. Four individuals offered official comments in Del Rio and eleven in Kerrville.

7.7 COORDINATION WITH OTHER REGIONS

The Plateau RWPG held coordination meetings and established joint agreements with the Rio Grande (M) Region and the South Central Texas (L) Region. At a joint meeting held in Laredo on January 7, 1999, Plateau and Rio Grande RWPG members agreed that the two regions would cooperate on matters of common interest and would share data and information on the following topics:

- Water supply availability from the Rio Grande
- Potential future water needs of Del Rio
- Groundwater supplies within the Plateau Region especially in Kinney County
- Ecologically unique stream segments
- Brush control
- Coordination between project consultants

A similar coordination meeting between the Plateau Region and the South Central Texas Region was held in San Antonio on January 11, 2000. The prime topic of the meeting concerned how to handle shared water resources in the planning process. Water resources of specific interest included the Guadalupe River and Canyon Lake, the Medina River and Medina Lake, and the Trinity aquifer.

Issues concerning reservoirs of common interest between the Plateau Region and Regions L and M were initially coordinated through liaisons. Due to the unavailability of water rights, Amistad Reservoir has a very limited relevance to the Plateau Region and, therefore, little coordination was necessary. Canyon Reservoir and Medina Lake have more relevance to the Plateau Region and Region L. Extensive coordination was conducted with the consultants for Region L regarding these reservoirs.

7.8 COORDINATION WITH FEDERAL AND INTERNATIONAL AGENCIES

Communication was maintained with the IBWC specifically for the purpose of obtaining and coordinating aquifer water-level data in the Del Rio area. This information is provided in the report titled “Ground-Water Resources of the Edwards Aquifer in the Del Rio Area, Texas”.

Because there is very limited Rio Grande water rights by individuals or entities in the Plateau Region, no water-deficit strategies were developed that involved water from the river. This negated the need to coordinate strategies with international agencies. The U.S. Fish and Wildlife Service provided comments to the initially prepared plan.

7.9 PLAN IMPLEMENTATION

Following final adoption of the Plateau Regional Water Plan, copies of the plan will be provided to each municipality and county commissioner's court in the region. Early in the next planning cycle visits will be made to each city for the purpose of reviewing the plan and obtaining recommendations on needed improvements. Each community will be asked to consider their specific short-range and long-range goals with those presented in the regional plan. Based on the results of these meetings, the Plateau RWPG members may consider plan revisions prior to the conclusion of the next 5-year planning period.

Of specific concern is the lack of confidence in future projected population growth trends and their impact on projected water demands as shown in this current regional water plan. An effort will be initiated immediately to begin a process to develop appropriate revisions.

And finally, an educational outreach program task will be established in the next planning cycle with the goal of reaching and involving a larger percentage of the public in the planning process.