FAR WEST TEXAS WATER PLAN

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Prepared by

Far West Texas Water Planning Group

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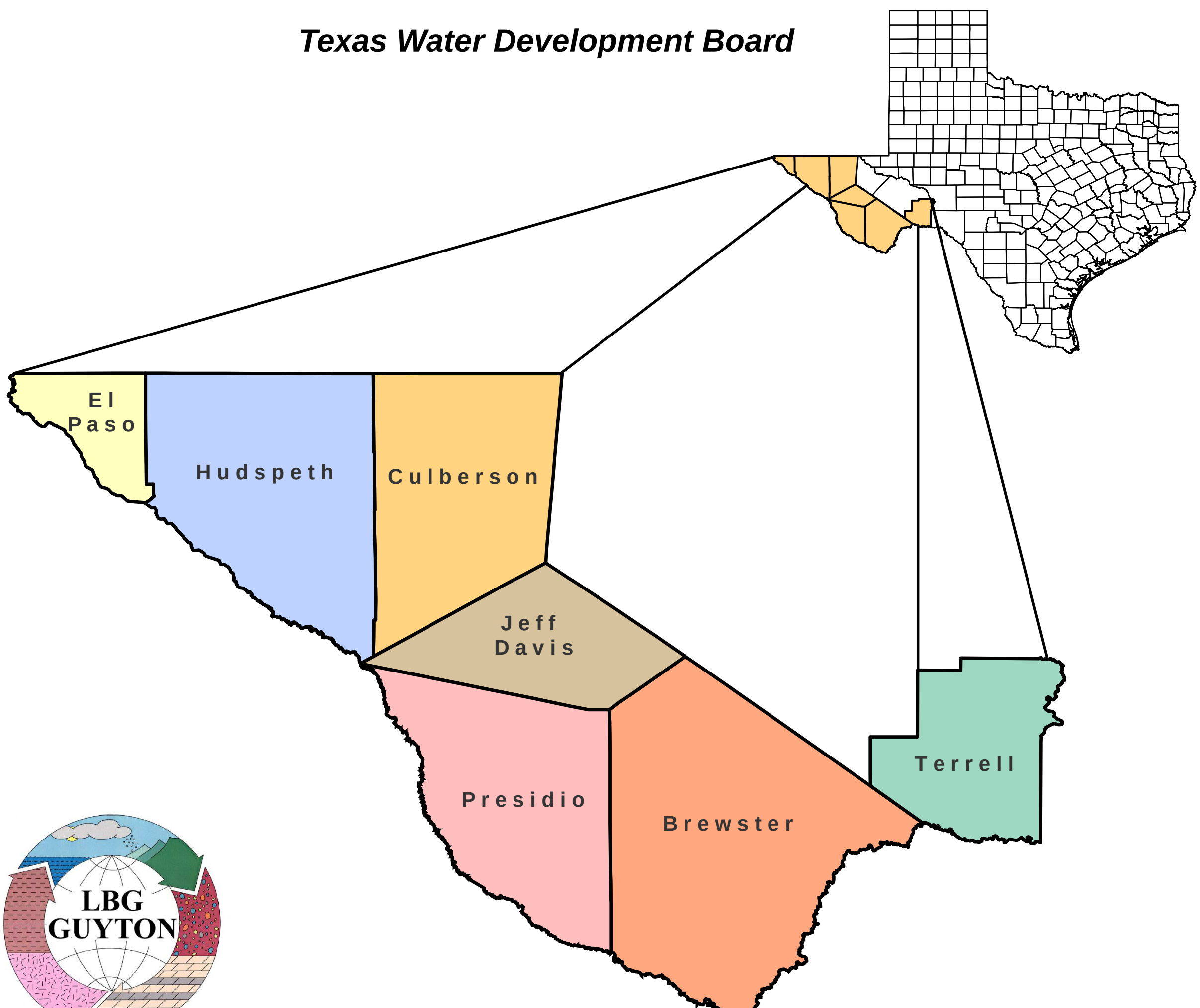

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EXECUTIVE SUMMARY

FAR WEST TEXAS

Far West Texas encompasses the most arid region of the State of Texas. Residents of this expansive desert environment recognize that water is a scarce and valuable resource that must be developed and managed with great care to ensure the area's long-term viability. The Region's economic health and quality of life are dependent on a sustainable water supply that is equitably managed.

Far West Texas is bounded on the north by New Mexico, on the south and west by the Rio Grande, and on the east by the Pecos River and incorporates the counties of Brewster, Culberson, El Paso, Hudspeth, Jeff Davis, Presidio and Terrell, all which lie solely within the Rio Grande River Basin. These counties claim some of the most impressive topography and scenic beauty in Texas. The Region is home to the Guadalupe Mountains National Park, Big Bend National Park, and the contiguous Big Bend Ranch State Park. El Paso, the largest city in the Region, is also the nation's largest city on the U.S.-Mexico border. Ciudad Juarez, with an estimated population of over 1.3 million, is located across the Rio Grande from El Paso, and shares the same water sources with El Paso.

In January of 2001, the first round of regional water planning was concluded with the adoption of the *Far West Texas Regional Water Plan*. It is understood that this plan is not a static plan but rather is intended to be revised as conditions change. For this reason, the current plan put forth in this document by the Far West Texas Water Planning Group (FWTWPG) is not a new plan, but rather an evolutionary modification of the predecessor plan. Only those parts of the original plan that require updating, and there are many, have been revised.

The purpose of the *2006 Far West Texas Water Plan* is to provide a document that water planners and users can reference for long- and short-term water management recommendations. Equally important, this plan serves as an educational tool to inform all citizens of the importance of properly managing and conserving the delicate water resources of this desert community.

The *2006 Far West Texas Water Plan* follows an identical format as the plans prepared by the other 15 water planning regions in the State as mandated by the Texas Legislature and overseen by the Texas Water Development Board. The plan provides an evaluation of current and future water demands for all water-use categories, and water supplies available during drought-of-record conditions to meet those demands. Where future water demands exceed an entity's ability to supply that need, alternative strategies are considered to meet the potential water shortages. Because our understanding of current and future water demand and supply sources is constantly changing, it is intended for this plan to be revised every five years or sooner if deemed necessary. This plan fully recognizes and protects existing water rights, water contracts, and option agreements, and there are no known conflicts between this plan and plans prepared for other regions.

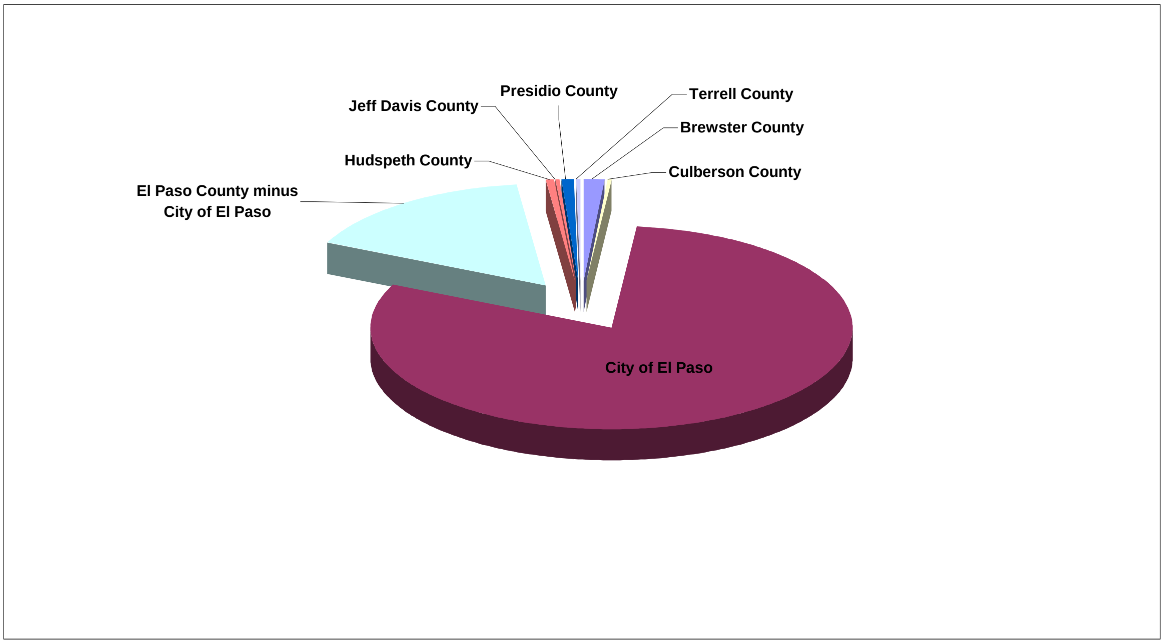
POPULATION AND WATER DEMAND

With the exception of El Paso County, the counties of Far West Texas are among the least populated of the State. In the year 2000, approximately 96 percent (679,622) of the Region's 705,399 residents resided in El Paso County, where the population density is 760 persons per square mile. The population density of the six rural counties is approximately 1.1 persons per square mile. Approximately 75 percent of the residents in the Region are Hispanic or Latinos.

El Paso, one of the fastest growing cities in Texas, is the largest city in the Region, with a year-2000 population of 563,662. This is 83 percent of the total population of El Paso County and 80 percent of the Region's total population. The other communities in El Paso County, as well as outlying areas, had a year-2000 population of 115,960.

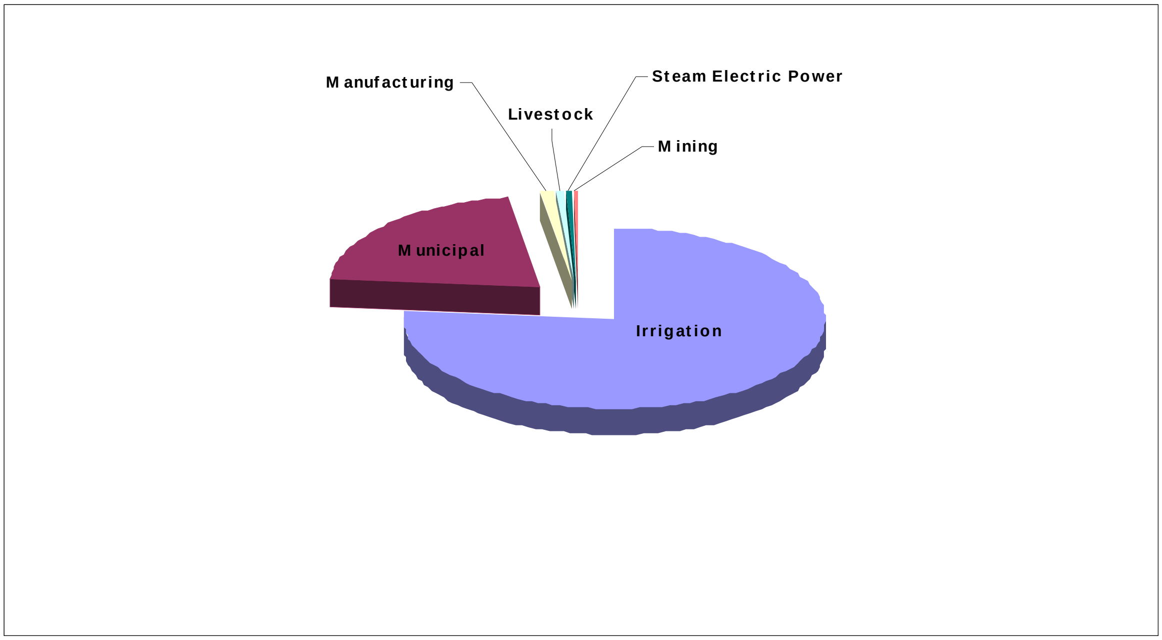
The year-2000 populations of cities in the six rural counties are as follows: Alpine, Brewster County (5,786); Van Horn, Culberson County (2,435); Dell City, Hudspeth County (413); Sierra Blanca, Hudspeth County (533); Fort Davis, Jeff Davis County (1,050); Marfa, Presidio County (2,121); Presidio, Presidio County (4,167); and Sanderson, Terrell County (861). Population of smaller communities such as Fort Hancock, Marathon and Valentine are included in the "County Other" (rural) population of each county. The population of the outlying areas of the rural counties is 8,824, or 34 percent of the total rural population.

The regional population is projected to more than double to 1,527,713 by the year 2060, which is an increase of 822,314 citizens; 80 percent of which will occur in El Paso County.

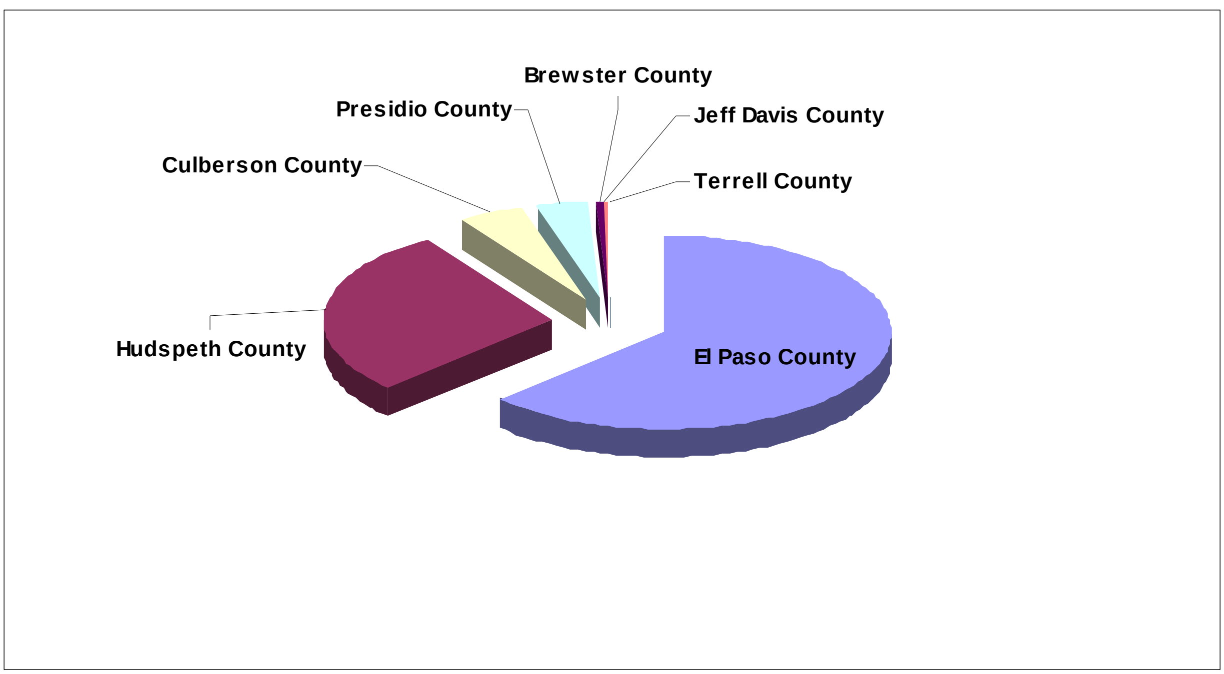


YEAR-2000 POPULATION

Total estimated year-2000 water consumptive use in Far West Texas was 665,793 acre-feet. The largest category of use was irrigation (508,266 acre-feet), followed by municipalities (139,690 acre-feet), manufacturing (7,750 acre-feet), livestock (4,843 acre-feet), steam-electric cooling (2,962 acre-feet), and mining (2,282 acre-feet). Seventy-six percent of water use in the Region is by the agricultural sector in support of irrigation. Twenty-one percent is used by municipalities and the remaining 3 percent supports manufacturing, steam-electric generation, livestock and mining.



YEAR-2000 WATER DEMAND BY WATER USE CATEGORY



YEAR-2000 WATER DEMAND BY COUNTY

The potential role of conservation is an important factor in projecting future water supply requirements. In this 2006 regional plan, conservation is only included in the municipal projections as a measure of expected savings based on requirements of the State plumbing code. All other conservation practices are discussed in terms of water supply strategies and as a component of drought management plans.

Environmental and recreational water use in Far West Texas is recognized as being an important consideration as it relates to the natural community in which the residents of this region share and appreciate. In addition, for rural counties, tourism activities based on natural resources offer perhaps the best hope for modest economic growth to areas that have seen a long decline in traditional economic activities such as agriculture and mining.

Rural communities (outside of El Paso County) are relatively small and are generally reliant on self-provided water supplies. Water demand within these communities is related directly to their population trends and is thus relatively stable or moderately increasing over the next 50 years. Projected water-demand growth for the numerous communities within El Paso County is significantly greater and thus will require a level of coordinated intercommunity planning.

Projected Municipal Water Demand By County (Ac-ft/yr)

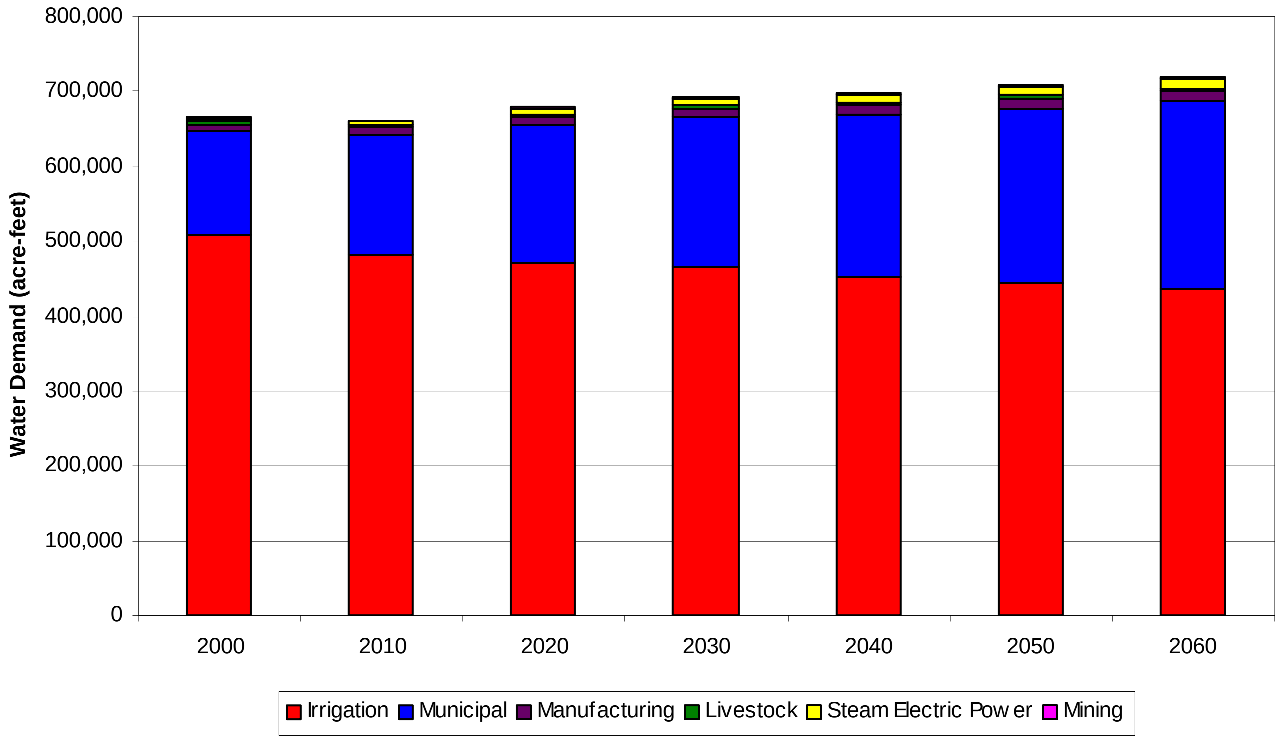
	2000	2010	2020	2030	2040	2050	2060
Brewster	2,127	2,242	2,336	2,358	2,360	2,445	2,466
Culberson	826	913	968	985	982	977	977
El Paso	134,065	155,795	176,736	194,882	209,460	226,764	244,450
Hudspeth	374	410	427	435	420	415	415
Jeff Davis	408	528	557	588	578	575	575
Presidio	1,662	2,006	2,290	2,570	2,733	2,806	2,857
Terrell	228	238	244	239	235	234	234

Statewide, irrigation water demands are expected to decline over time. More efficient canal delivery systems have improved water-use efficiencies of surface water irrigation. More efficient on-farm irrigation systems have also improved the efficiency of groundwater irrigation. Other factors that have contributed to decreased irrigation demands are declining groundwater supplies and the voluntary transfer of water rights historically used for irrigation to municipal uses.

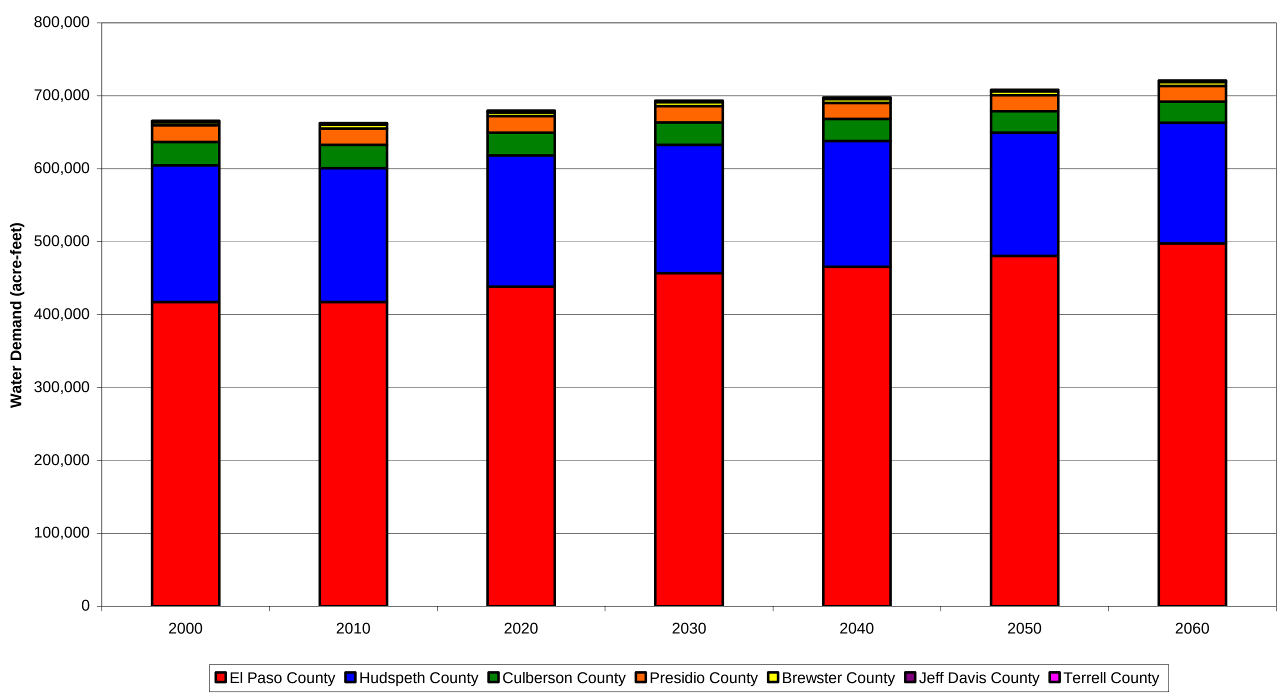
Water used for agricultural irrigation in Far West Texas is significantly greater (76% of total) than all other water-use categories. On a regional basis, water used for the irrigation of crops is projected to decline slightly over the 50-year planning horizon. However, as any irrigator can attest, climate, water availability, and the market play key roles in how much water is actually applied on a year-by-year basis.

Projected Irrigation Water Use By County (Ac-ft/yr)

	2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Brewster	621	1,622	1,613	1,605	1,596	1,588	1,580
Culberson	29,593	28,960	28,340	27,733	27,140	26,559	25,991
El Paso	270,424	247,111	242,798	240,848	232,380	228,579	224,840
Hudspeth	186,494	182,627	178,840	175,132	171,501	167,945	164,463
Jeff Davis	3,184	3,119	3,057	2,995	2,935	2,875	2,816
Presidio	25,678	25,156	24,646	24,145	23,655	23,175	22,705
Terrell	80	78	77	75	73	72	70



PROJECTED WATER DEMAND BY WATER USE CATEGORY



PROJECTED WATER DEMAND BY COUNTY

Ciudad Juarez is located across the Rio Grande from El Paso, and currently is 100 percent dependent on the Hueco Bolson aquifer to satisfy all of its municipal and industrial demands. With a growing population that is currently estimated to be over 1.3 million, Ciudad Juarez recognizes the limitations of the Hueco Bolson to supply future demands. Current planning calls for capping Hueco pumping at about 122,000 acre-ft/yr, and supply increased demands through 2020 from the following "imported" groundwater sources:

- Conejos Medanos (38,000 acre-ft/yr)
- Bismark Mine (26,000 acre-ft/yr)
- Mesilla (26,000 acre-ft/yr)
- Somero (28,000 acre-ft/yr)
- Profundo (31,000 acre-ft/yr)

In addition, plans are also being developed to convert 38,000 acre-ft/yr of surface water from the Rio Grande (Rio Bravo) for municipal supply use. Currently, Mexico's allocation from the Rio Grande Project of 60,000 acre-ft/yr is used for irrigated agriculture. The conversion would involve supplying wastewater effluent to farmers in exchange for surface water. Of these projects, the first phase of the Conejos Medanos is expected to be operational in 2006.

WATER SUPPLY RESOURCES

Whether it flows in rivers and streams or percolates through underground rock formations, water sustains life and thus is our most important natural resource. In the Chihuahuan Desert environment of Far West Texas, water supply availability takes on a more significant meaning than elsewhere in the State. The entire Far West Texas planning region is located within the Rio Grande Basin. With evaporation far exceeding rainfall, planning for the most efficient management of limited water supplies is essential.

Water supply availability from each recognized source is estimated during drought-of record conditions. This allows each entity and water-use category to observe conditions when their supply source is at its most critical availability level. Specific assumptions used in estimating supply availability are listed below:

- With the exception of the controlled flows in the Rio Grande, very little surface water can be considered as a reliable source of supply in Far West Texas, especially in drought-of-record conditions. In this chapter, two primary surface water sources are considered, the Rio Grande and the Pecos River. Other ephemeral creeks and springs are recognized as important livestock supply, wildlife habitat, and recreational resources.
- The availability of water in the Rio Grande and Pecos River to meet existing permits during drought-of-record conditions is determined by using the TCEQ Rio Grande Water Availability Model (WAM) – Run 3.
- The availability of groundwater is based on acceptable levels of water level decline as simulated with Groundwater Availability Models (GAMs) or historical maximum pumpage estimates.
- Reuse of water is calculated for the City of El Paso based on anticipated build-out of their "purple pipe" project.

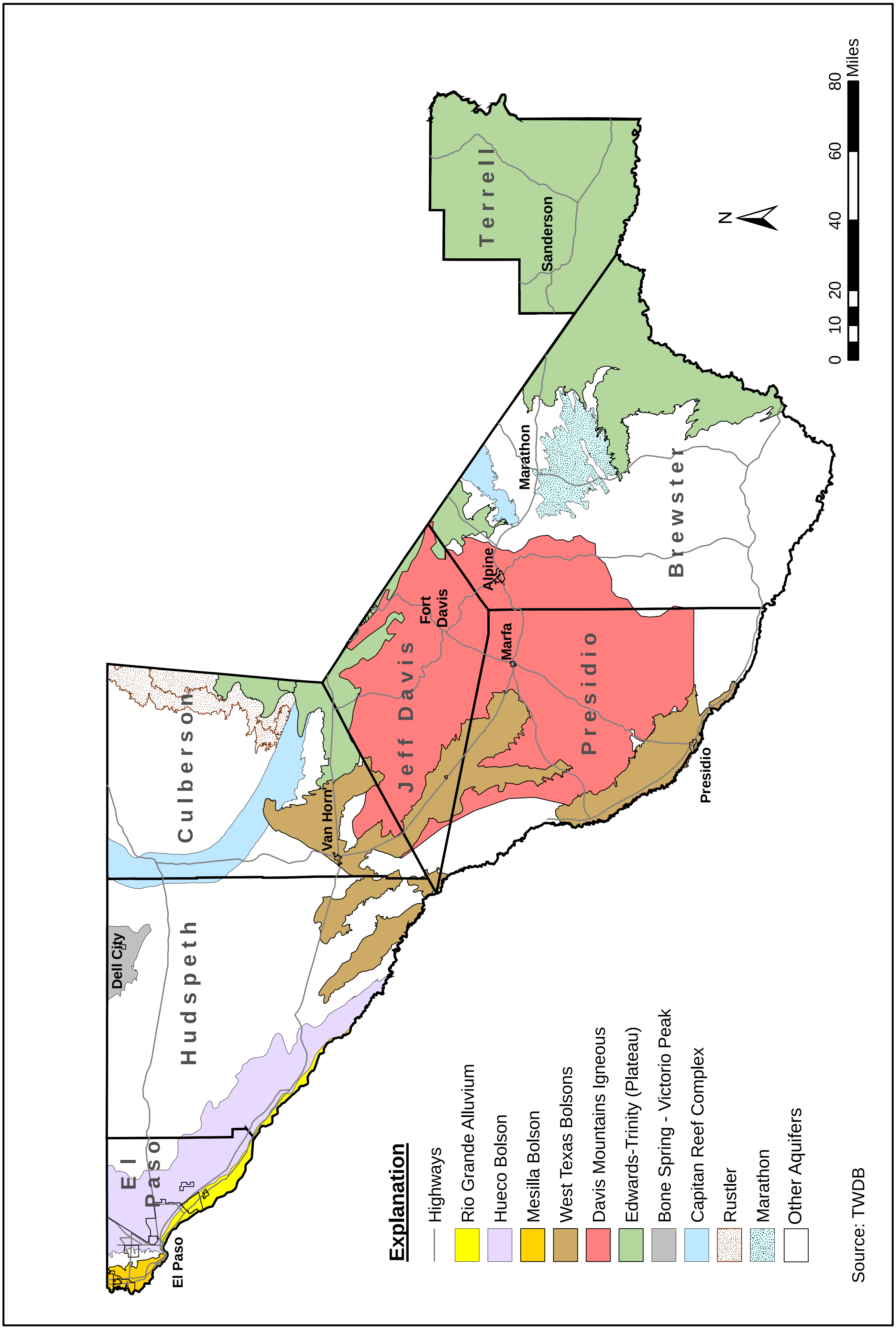
The Rio Grande originates in southwestern Colorado and northern New Mexico, where it derives its headwaters from snowmelt in the Rocky Mountains. The Elephant Butte Dam and Reservoir in New Mexico is approximately 125 miles north of El Paso and can store over two million acre-feet of water. Water in the reservoir is stored to meet irrigation demands in the Rincon, Mesilla, El Paso, and Juarez Valleys and is released in a pattern for power generation. Above El Paso, flow in the River is largely controlled by releases from Caballo Reservoir located below Elephant Butte; while downstream from El Paso to Fort Quitman, flow consists of treated municipal wastewater from El Paso, untreated municipal wastewater from Juarez, and irrigation return flow. Below the El Paso-Hudspeth County line, flow consists mostly of return flow and occasional floodwater and runoff from adjacent areas. Channel losses are significant enough that the Rio Grande is often dry from below Fort Quitman to the confluence with the Mexican river, the Rio Conchos, upstream of Presidio. There are no significant perennial tributaries, other than the Rio Conchos, in the 350 miles between Elephant Butte Reservoir and Presidio.

The Rio Grande is unique in its complexity of distribution management. Because the waters of the River must be shared between three U.S. states and the nation of Mexico, a system of federal, state and local programs has been developed to oversee the equitable distribution of water. Compacts, treaties and projects currently provide the River's management framework.

The Pecos River is the largest Texas river basin that flows into the Rio Grande. Originating in New Mexico, the Pecos flows southerly into Texas, and discharges into the channel of the Rio Grande near Langtry in Val Verde County. The River forms the easternmost border of Far West Texas along the northeast corner of Terrell County. Flows of the Pecos River are controlled by releases from the Red Bluff Reservoir near the Texas – New Mexico state line. Storage in the reservoir is affected by the delivery of water from New Mexico. According to data of the IBWC, the Pecos River contributes an average of 11 percent of the annual streamflow into the Rio Grande near Amistad Reservoir. The Pecos also contributes more than 29 percent of the annual salt loading into the reservoir.

Other than irrigation use and a portion of City of El Paso municipal use from the Rio Grande, almost all other water use in Far West Texas is supplied from groundwater sources. Although not as large in areal extent as some aquifers in the State, individual aquifers in Far West Texas are more numerous (14) than in any of the other planning regions.

Aquifers in the Region can be categorized into two basic types, bedrock and bolson. Bedrock aquifers are those where groundwater flows through permeable fractures in hard-rock formations (limestone, dolomite, volcanic basalt, etc.). Aquifers of this type include the Bone Spring-Victorio Peak, Capitan Reef, Edwards-Trinity (Plateau), Rustler, Marathon, and Davis Mountains Igneous. Bolson aquifers occur in thick silt, sand, and gravel deposits that fill valleys between the numerous mountain ranges. Bolson aquifers in the Region include the Hueco, Mesilla, and the various individual aquifers that comprise the West Texas Bolson aquifer group.



MAJOR AND MINOR AQUIFERS OF FAR WEST TEXAS

El Paso has nearly 40 miles of reclaimed water lines (purple pipeline) in place in all areas of the City. Reclaimed water serves the landscape irrigation demand of golf courses, parks, schools, and cemeteries, and also provides water supplies for steam electric plants and industries within the City. The supply from the direct reuse program is expected to increase from 5,000 acre-ft per year in 2000 to over 23,000 acre-ft per year by 2060.

Springs and seeps are found in all seven of the Far West Texas counties and have played an important role in the development of the Region. Springs were important sources of water for Native Americans, as indicated by the artifacts and petroglyphs found in the vicinity of many of the springs. In the 18th and 19th centuries, locations of transportation routes including supply and stage coach lines, military outposts, and early settlements and ranches were largely determined by the occurrence of springs that issued from locations in the mountains and along mountain fronts.

Springs contribute to the esthetic and recreational value of private land and parkland in Far West Texas - especially in the Big Bend area, where a number of thermal springs discharge along the banks of the Rio Grande. Springs are significant sources of water for both aquatic and terrestrial wildlife as they form small wetlands that attract migratory birds and other fowl that inhabit the region throughout the year. As documented by the Texas Parks and Wildlife Department, springs also provide habitat for threatened and endangered species of fish (such as the Pecos and Big Bend Gambusia).

The FWTWPG recognizes the importance of all springs in this desert community for their contribution as a water supply source and as a natural habitat. However, the FWTWPG chooses to respect the privacy of private lands and therefore specifically identifies “Major Springs” occurring only on state, federal, or privately owned conservation managed lands.

WATER MANAGEMENT STRATEGIES

Projected water supply deficits in Far West Texas during the next 50 years are identified where anticipated water demands exceed available supplies. Available supplies represents the largest amount of water that can be diverted or pumped from a given source without violating the most restrictive physical, regulatory, or policy condition limiting use, under drought-of-record conditions. Water supply deficits are identified for a number of municipalities, manufacturing use, and steam power electric generation in El Paso County, and for irrigation supply use in El Paso, Hudspeth, and Presidio Counties.

Water supply strategy recommendations intended to meet the deficits are made for those water use groups that have projected water supply shortages. In the development of water management strategies, existing water rights, water contracts, and option agreements are recognized and fully protected.

A strategy evaluation procedure was designed to provide a side-by-side comparison such that all the strategies could be assessed based on the same factors. Specific factors considered were:

- Quantity of water supply generated
- Water quality considerations
- Reliability
- Cost (total capital cost, annual cost, and cost per acre-foot)
- Environmental impacts
- Impacts to agricultural resources
- Impact to natural resources
- Recreational impacts

To adequately consider the unique challenges faced by municipal and industrial water users in El Paso County, an integrated approach was used to establish a feasible strategy capable of identifying sufficient future supplies to meet the needs of El Paso Water Utilities, the largest wholesale water provider in the county. Six separate approaches were considered that combined various potential surface water and groundwater sources at variable supply rates and times of implementation. The FWTWPG compared the six integrated strategies and selected the strategy termed the *"Balanced Approach with Moderate Increase in Surface Water"*, which is composed of the following elements:

- Increased conservation
- Increased reclaimed water use
- Increased use from the Rio Grande (developed conjunctively with local groundwater)

- Importation of groundwater from the Capitan Reef aquifer (Culberson and Hudspeth Counties)
- Importation of groundwater from the Bone Spring-Victorio Peak aquifer in the Dell City area (Hudspeth County)

The importation of groundwater from the West Texas Bolson aquifers in the vicinity of Van Horn and Valentine (Culberson, Jeff Davis and Presidio Counties) was evaluated under other integrated strategies, but it is not part of the preferred strategy.

Recommended strategies for other entities in El Paso County include purchasing need supplies from El Paso Water Utilities or developing needed self-supplied groundwater by drilling additional wells.

Irrigation shortages in El Paso, Hudspeth, and Presidio Counties are the direct result of insufficient water in the Rio Grande during drought-of-record periods to meet anticipated needs. The quantity of water needed to meet the full demands cannot be realistically achieved and farmers in these areas have generally approached this situation by reducing irrigated acreage, changing types of crops planted, or possibly not planting crops until water becomes available during the following season.

In some cases, farmers may benefit from Best Management Practices (BMPs) for agricultural water users, which are a mixture of site-specific management, educational, and physical procedures that have proven to be effective and are cost-effective for conserving water. A number of BMPs under the following categories are selected for their suitability to the irrigation practices occurring in Far West Texas.

- Agricultural Irrigation Water Use Management
- Land Management Systems
- On-Farm Water Delivery Systems
- Water District Delivery Systems
- Miscellaneous Systems

The total estimated capital cost to develop the recommended strategies is $688,858,000.

WATER QUALITY

Water quality plays an important role in determining the availability of water supplies to meet current and future water needs in the Region. The quality of groundwater and surface water was evaluated to help determine the suitability of each source for use and the potential impacts on these sources that might result from the implementation of recommended water management strategies. Primary and secondary safe drinking water standards are the key parameters of water quality identified by the FWTWPG as important to the use of the water resource.

A groundwater quality database using water quality analyses from the TWDB groundwater database was established to characterize the primary aquifers in the Region. Groundwater quality issues in the Region are generally related to naturally high concentrations of total dissolved solids (TDS) or to the occurrence of elevated concentrations of individual dissolved constituents. High concentrations of TDS are primarily the result of the lack of sufficient recharge and restricted circulation. Together, these retard the flushing action of fresh water moving through the aquifers.

Some aquifers, however, have a low TDS but may contain individual constituent levels that exceed safe drinking-water standards. For example, some wells in the Davis Mountains Igneous aquifer have exceptionally low TDS but contain unsatisfactory levels of fluoride. Also fresh-water wells in the Study Butte-Terlingua- Lajitas area have elevated levels of radioactivity.

Groundwater quality changes are often the result of man's activities. In agricultural areas, aquifers such as the Bone Spring-Victorio Peak have increased in TDS. Irrigation water applied on the fields percolates back to the aquifer carrying salts leached from the soil. Beneath El Paso and Ciudad Juarez, the average concentration of dissolved solids in the Hueco Bolson aquifer has increased as the fresher water in the aquifer is being consumed. Although local instances of groundwater quality degradation have occurred in the Region, there are no major trends that suggest a widespread water-quality problem due to the downward percolation of surface contaminants.

The Rio Grande and the Pecos River are the principal surface water sources in Far West Texas. Unlike groundwater, surface water quality can vary significantly depending on the amount of flow in the streambed and the rate and source of runoff from adjacent lands. Surface water is also more susceptible to biological and petrochemical contamination. Treatment cost to prepare surface water for municipal distribution is generally much greater than cost for groundwater sources, although desalination of brackish groundwater may be similar.

Salinity is an issue associated with the Rio Grande, especially during drought conditions. River flows arriving at El Paso contain a substantial salinity contribution from irrigation return flow and municipal wastewater return in New Mexico. Under current conditions, approximately 25% of the applied irrigation water is needed to move through the project in El Paso County to keep the salt loading at reasonable and manageable levels given average surface flow rates. Studies have shown that salinities in the Rio Grande can increase to over 1,000 mg/l during May and September, depending on actual irrigation demands and releases from reservoirs. Prolonged low flow increase salt storage in riverbanks and riparian zones, which can then be flushed out during high flows.

Downstream from El Paso, most of the flow consists of irrigation return flow, and small amounts of treated and untreated municipal wastewater. Heavy metals and pesticides have been identified along this segment of the Rio Grande. Flow is intermittent downstream to Presidio, where the Rio Conchos augments flow. Fresh water springs contribute to the Rio Grande flow in the Big Bend and enhance the overall quality of the River through this reach.

The Pecos River is not a source of drinking water for communities in Far West Texas; however, it is the most prominent tributary to the Rio Grande on the Texas side of the River above Amistad Reservoir. According to IBWC data, the Pecos River contributes an average of 11 percent of the annual stream flow in the Rio Grande above the Reservoir and 29 percent of the annual salt load. Independence Creek's contribution in Terrell County increases the Pecos River water volume by 42 percent at the confluence and reduces the total suspended solids by 50 percent, thus improving both water quantity and quality.

Within Far West Texas, specific water quality issues include the presence of arsenic and alpha radiation in some groundwater supplies, water quality deterioration in the Bone Spring-Victorio Peak aquifer, general salinity problems, and the positive impact of brackish groundwater use as a drinking water source. The implementation of recommended water management strategies is not expected to impact the natural water quality of water sources beyond current conditions.

AGRICULTURAL IMPACTS

The El Paso County Integrated Water Management Strategy involves the conversion of water and some properties previously used for agricultural purposes to municipal use. An additional 20,000 acre-feet per year from the Rio Grande would be obtained after the retirement of about 5,000 acres of land from irrigation. This represents a reduction of agricultural activities in El Paso County. This conversion is primarily the result of urbanization, not the implementation of this water management strategy. Conversion would be voluntary by lease, sale, or forbearance agreements.

The integrated strategy would also utilize the water rights for 24,000 acres of land in Hudspeth County, which would reduce irrigation activities near Dell City. The transfer to El Paso County is near 80% of the maximum limit. Conversion of water rights to transfer water to El Paso County would be voluntary. El Paso Water Utilities owns the land above the Capitan Reef aquifer. Therefore, the conversion of use from agricultural to municipal will have no impact on agricultural ownership in that area.

WATER CONSERVATION AND DROUGHT CONTINGENCY

Water conservation are those practices, techniques, programs, and technologies that will protect water resources, reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling or reuse of water so that a water supply is made available for future or alternative uses. Water conservation and drought contingency planning implemented by municipalities, water providers, and other water users supersede recommendations in this plan are considered consistent with this plan.

Texas Water Code §11.1271 requires water conservation plans for all municipal and industrial water users with surface water rights of 1,000 acre-feet per year or more and irrigation water users with surface water rights of 10,000 acre-feet per year or more. Water conservation plans of three entities in Far West Texas that meet this criteria are included in this *Plan*. These entities include the El Paso Water Utilities, the El Paso County Water Improvement District No.1, and the Hudspeth County Conservation and Reclamation District No.1.

El Paso Water Utilities is the largest supplier of municipal water in Far West Texas, supplying approximately 95 percent of all municipal needs in 2000. The City of El Paso through the El Paso Water Utilities has been implementing an aggressive water conservation program for the past 13 years and has reduced the per capita demand from 200 gpcd in 1990 to 139 gpcd in 2004. The low consumption in recent years occurred because the area was under drought restrictions in 2003 and 2004. The conservation goal for El Paso is 140 gpcd, which would be the lowest large city per capita use in Texas. The continuation of the conservation effort is a key component of the El Paso Integrated Water Management Strategy.

Drought is a frequent and inevitable factor in the climate of Texas. Therefore, it is vital to plan for the effect that droughts will have on the use, allocation and conservation of water in the state. Far West Texas is perennially under drought or near-drought conditions compared with more humid areas of the State. Although residents of the Region are generally accustomed to these conditions, the low rainfall and the accompanying high levels of evaporation underscore the necessity of developing plans that respond to potential disruptions in the supply of groundwater and surface water caused by drought conditions.

In the consideration of regional conservation and drought management issues, the FWTWPG reviewed active water conservation management and drought contingency plans provided to the planning group by 22 public water suppliers and two irrigation districts.

The Texas Legislature has established a process for local management of groundwater resources through groundwater conservation districts. The districts are charged with managing groundwater by providing for the conservation, preservation, protection, recharging and prevention of waste of groundwater within their jurisdictions. Five districts are currently in operation within Far West Texas.

- Brewster County Groundwater Conservation District
- Culberson County Groundwater Conservation District
- Hudspeth County Underground Water Conservation District No.1
- Jeff Davis County Underground Water Conservation District
- Presidio County Underground Water Conservation District

PROTECTION OF WATER, AGRICULTURAL, AND NATURAL RESOURCES

The long-term protection of the Region's water resources, agricultural resources, and natural resources is an important component of this *2006 Far West Texas Water Plan*. The first step in achieving long-term water resources protection was in the process of estimating each source's availability. Surface water estimates were developed through a water availability model process (WAM) and are based on the quantity of surface water available to meet existing water rights during a drought-of-record. Groundwater availability estimates were based on acceptable levels of water-level decline or historical maximum pumping estimates. Where available, groundwater availability models (GAMs) were used as a tool to view various withdrawal rates in terms of water-level impacts. Establishing conservative levels of water source availability thus results in less potential of over exploiting the supply.

The next step in establishing the long-term protection of water resources occurs in the water management strategies to meet potential water supply shortages. Each strategy was evaluated for potential threats to water resources in terms of source depletion (reliability), quality degradation, and impact to environmental habitat.

Water conservation strategies are also recommended for each entity with a supply deficit. When enacted, the conservation practices will diminish water demand, the drought management practices will extend supplies over the stress period, and the land management practices will potentially increase aquifer recharge.

Agriculture in Far West Texas includes the raising of crops and livestock, as well as a multitude of businesses that support this industry. Water is an absolute necessity to maintaining this industry and its use represents over three-fourths of all the water used in the Region. Many of the communities in the Region depend on various forms of the agricultural industry for a significant portion of their economy. It is thus important to the economic health and way of life in these communities to protect water resources that have historically been used in the support of agricultural activities.

All non-agricultural recommended water management strategies include an analysis of potential impact to agricultural interests. Any strategy that necessitates the conversion of water use from agricultural practices is voluntary at the current landowner's discretion.

The *2006 Far West Texas Water Plan* provides irrigation strategy recommendations that address water conservation best management practices. If implemented, these practices will result in reduced water application per acre irrigated.

The FWTWPG has adopted a stance toward the protection of natural resources. The protection is closely linked with the protection of water resources as discussed above. Where possible, the methodology used to assess groundwater source availability is based on not significantly lowering water levels to a point where spring flows might be impacted. Thus, the intention to protect surface flows is directly related to those natural resources that are dependent on surface water sources or spring flows for their existence.

Environmental impacts were evaluated in the consideration of strategies to meet water-supply deficits. Of prime consideration was whether a strategy potentially could diminish the quantity of water currently existing in the natural environment and if a strategy could impact water quality to a level that would be detrimental to animals and plants that naturally inhabit the area under consideration.

The FWTWPG recommends as "Ecologically Unique River and Stream Segments" three streams that lie within the boundaries of State-managed properties, three within National Park boundaries, and specified streams managed by the Texas Nature Conservancy.

RECOMMENDATIONS

An important aspect of the regional water planning process is the opportunity to provide recommendations for the improvement of future water management planning in Texas. The recommendations 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. The FWTWPG approves of the legislative intent of the regional water planning process and supports the continuance of water planning at the regional level. However, the FWTWPG suggests that the Legislature and TWDB consider the following changes to the regional water planning process.

- Allow for more planning initiatives
- Provide for reimbursements of reasonable expenses incurred by planning group members
- Provide for the ability of the planning group to contract for needed services or information
- Eliminate the unfunded mandate
- Provide training for planning group members
- Allow for modification of water demand numbers further into the planning process
- Provide funding for data collection in rural areas
- Make an "Open Records" exception for private water data
- Insure that plan implementation is the responsibility of local governments, entities, and individuals
- Require that Groundwater Management Area Councils coordinate their efforts with regional planning groups
- Avoid overlapping regional planning cycles with legislative sessions
- Use consistent economic principles when evaluating water management strategy costs
- Codify in-stream flows to better manage surface water availability

- Support Salt Cedar eradication in the Rio Grande watershed
- Provide for the acquisition of identified data and research needs

As a part of the planning process, each regional planning group may include recommendations for the designation of ecologically unique river and stream segments in their adopted regional water plan. The Texas Legislature may designate a river or stream segment of unique ecological value following the recommendations of a regional water planning group. As per §16.051(f) of the Texas Water Code, this designation solely means that a state agency or political subdivision of the State may not finance the actual construction of a reservoir in a specific river or stream segment designated by the legislature under this subsection.

The FWTWPG chooses to respect the privacy of private lands and therefore recommends as "Ecologically Unique River and Stream Segments" the following three streams that lie within the boundaries of state-managed properties, three within National Park boundaries, and specified streams managed by the Texas Nature Conservancy.

- Rio Grande Wild and Scenic River (Big Bend National Park)
- McKittrick Canyon and Choza Creek (Guadalupe Mountains National Park)
- Cienega Creek (Chinati Mountains State Natural Area)
- Alamito and Cienega Creeks (Big Bend Ranch State Park)
- Independence Creek (Texas Nature Conservancy – Independence Creek Preserve)
- Madera Creek, Canyon Headwaters of Limpia Creek, Little Aguja Creek, and Upper Cherry Creek (Texas Nature Conservancy – Davis Mountains Preserve)

The firm yield for any reservoirs constructed on even the most reliable Far West Texas watercourses is not likely to exceed 2,000 acre-feet per year. For this reason, the *2006 Far West Texas Water Plan* does not recommend any watercourse for designation as "unique sites for reservoir construction."

WATER INFRASTRUCTURE FUNDING

A critical part of the water planning process is the recognition of how entities with projected water supply shortages will finance the needed water infrastructure that is recommended in their respective strategies. Total capital cost for all of the Far West Texas strategies is $688,858,000. Three wholesale water providers, representing 10 water user groups, were surveyed to determine their proposed method(s) for financing the estimated capital costs involved in implementing the water supply strategies recommended in the regional plan. Entities responding to the surveys were El Paso Water Utilities, Horizon Regional MUD, and the El Paso County Tornillo WID.

Of the 3 entities with needs that were surveyed, only Horizon Regional MUD indicated that it could pay the entire $1,000,000 cost of its strategy of drilling additional wells. The capital costs will be met through a bond issue, which has already been approved. El Paso Water Utilities indicated that it plans to pay for 25% ($168,798,000) of its expected total of $675,192,000 in capital improvements through the use of cash reserves. And additional 72% ($486,138,240) will be financed through bond sales, with the final 3% ($20,255,760) expected to come from federal government programs. El Paso County Tornillo WID projects that it can afford to pay approximately 30% ($150,000) of its expected cost of $500,000 for drilling one additional well. It will apply to the state Office of Rural and Community Affairs (ORCA) for the additional $350,000 in projected infrastructure costs. These three political subdivisions indicated that they could afford to pay a total of $656,116,240 of their strategy costs using cash reserves or by issuing bonds. Of the three, only El Paso County Tornillo WID intends to access state financial programs, preferably grants, or low-interest loans if grants are not available. El Paso County-Other is also expected to incur capital costs totaling $12,166,000 to finance additional wells to meet the supply deficit projected in the regional plan; however, much of this cost will be borne by the private sector.

Three county aggregate irrigation water user groups in the planning region were projected to face a water supply deficit for which the recommended strategy includes a capital cost. Strategies to meet those needs were developed by an irrigation subcommittee of the FWTWPG, working from the Water Conservation Best Management Practices Guide (TWDB Report 362). Best Management Practices (BMPs), which were considered suitable for application to Far West Texas irrigation practices were selected and endorsed by the entire FWTWPG.

It is clear from the survey results that there will be a significant need to access both state and federal funding sources to pay for the cost of water infrastructure identified in the *2006 Far West Texas Water Plan.* Regional political subdivisions indicated that they will be unable to pay for approximately $27.4 million in projected water infrastructure costs. These figures do not include the costs associated with El Paso County Irrigation, Hudspeth County Irrigation, and Presidio County Irrigation. Where the costs of the recommended best management practice strategies will be the responsibility of irrigation districts, those districts have indicated that they would access state programs such as the water conservation fund, if such funding is available.

The increased role of the state in funding water infrastructure projects identified in the *2006 Far West Texas Water Plan* will require dedicated funding sources to support both grant and loan programs. The FWTWPG recommends that the following dedicated funding sources be considered to enhance the state's ability to assist local governments in implementing the recommended strategies to meet projected future water supply needs:

(a) general revenue;
(b) statewide bond issue;
(c) percentage of Texas Lottery proceeds;
(d) percentage of the fines imposed and collected from water-related violations of state environmental law;
(e) a bottled water fee; and
(f) expanded tax exemption for water conservation fixtures and equipment.

The FWTWPG also considered other potential financing options, which it did not endorse. These include a per capita tax and a statewide sales tax on water and wastewater services. Both of these approaches were considered to be regressive taxes, which would place an unfair financial burden on economically disadvantaged residents.

The FWTWPG recommends that more effort be made on the state level to attract federal money for needed water infrastructure projects, suggesting that the TWDB take a lead role in this effort. The Group commented that less funding is being made available from federal sources at the same time that there are more regulations and duties being imposed on water suppliers, such as the new arsenic standards. They also recommend that efforts should be made by TWDB staff to assist smaller entities in identifying all available funding sources and putting together a "package" of complementary programs to cover the cost of needed infrastructure improvements. TWDB and other state agency programs that can be used to fund water infrastructure should be combined, their procedures simplified or streamlined, and their rules made more flexible. Many of the small communities that need to access state funds have limited staff for project proposals and management, and often feel lost in a maze of confusing program-specific rules and regulations.

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FAR WEST TEXAS DESCRIPTION

1.1 INTRODUCTION

Far West Texas encompasses the most arid region of the State of Texas. Residents of this expansive desert environment recognize that water is a scarce and valuable resource that must be developed and managed with great care to ensure the area's long-term viability. The Region's economic health and quality of life are dependent on a sustainable water supply that is equitably managed.

In January of 2001, the first round of regional water planning was concluded with the adoption of the *Far West Texas Regional Water Plan*. It is understood that this plan is not a static plan but rather is intended to be revised as conditions change. For this reason, the current plan put forth in this document is not a new plan, but rather an evolutionary modification of the predecessor plan. Only those parts of the original plan that require updating, and there are many, have been revised.

The purpose of the *2006 Far West Texas Water Plan* is to provide a document that water planners and users can reference for long- and short-term water management recommendations. Equally important, this plan serves as an educational tool to inform all citizens of the importance of properly managing and conserving the delicate water resources of this desert community.

Chapter 1 presents a broad descriptive overview of Far West Texas including currently existing water management planning facilities and international water issues. This chapter also summarizes specific planning components that are presented in more detail elsewhere in this plan, such as projected population and water demand and available water-supply sources to meet these anticipated demands. Also provided in this chapter is a listing of State and Federal agencies, universities, and private organizations that are involved in various aspects of water supply.

1.2 PLANNING PROCESS

The *Far West Texas Water Plan* follows an identical format as the plans prepared by the other 15 water planning regions in the State as mandated by the Texas Legislature and overseen by the Texas Water Development Board. The plan provides an evaluation of current and future water demands for all water-use categories, and water supplies available during drought-of-record conditions to meet those demands. Where future water demands exceed an entity's ability to supply that need, alternative strategies are considered to meet the potential water shortages. Because our understanding of current and future water demand and supply sources is constantly changing, it is intended for this plan to be revised every five years or sooner if deemed necessary. This plan fully recognizes and protects existing water rights, water contracts, and option agreements. There are no known conflicts between this plan and plans prepared for other regions.

Water supply availability under drought-of-record conditions is considered in the planning process to insure that water demands can be met under the worst of circumstances. For surface water supplies, drought-of-record conditions relate to the quantity of water available to meet existing permits from the Rio Grande and the Pecos River as estimated by the TCEQ Rio Grande Water Availability Model (WAM). This plan has no impact on navigation on these surface-water courses.

The availability of groundwater during drought-of-record conditions is based on an annual quantity of water that can be withdrawn from each aquifer that results in no more than an acceptable level of water-level decline over the 50-year planning period. Chapter 3 contains a detailed analysis of water supply availability in the Region.

Since the completion of the *2001 Far West Texas Regional Water Plan*, a number of advances in water planning have been made available. The year-2000 census provided a more accurate estimate of current population and municipal/rural water demand. Groundwater and surface water availability models (GAMs and WAMs) have been developed as resource tools for use in evaluating water-supply source availability. These computer simulation models were used in the current planning process and provided a more realistic analysis of possible water supply source conditions.

A recent re-evaluation of groundwater availability in the Hueco Bolson aquifer has a major influence on total supply source availability for entities in El Paso County. In the previous regional water plan, fresh water in the aquifer was anticipated to be depleted by the year 2030, which resulted in an unmet supply need following 2030 for eight communities, including the City of El Paso. Through the use of the model, El Paso Water Utilities was able to develop a conjunctive use management plan that utilizes groundwater from the Hueco Bolson aquifer in a sustainable manner.

Also new to this planning period was the availability, through the Texas Parks & Wildlife Department, the National Parks Service, and the Texas Nature Conservancy, of environmental data on the more prominent watercourses in the Region. This data was useful in the assessment and consideration of environmental flow needs, springs, and ecologically unique stream segments.

A number of feasibility studies have been performed in areas where groundwater exportation is being considered. These reports were used when considering supply availability and resource impacts. Feasibility and construction design reports for the El Paso-Fort Bliss Joint Desalination Project were also used in the development of this Water Plan. Also of informational importance to the Water Planning Group were the monthly *"Drought Watch on the Rio Grande"* updates furnished by the Texas Agricultural Experiment Station and the U.S. Bureau of Reclamation.

The Far West Texas Water Planning Group (FWTWPG) strongly encouraged all entities to participate in the planning process so that their specific concerns could be recognized and addressed. The Group also encouraged the participation of groundwater conservation districts and recognized their management plans and rules. District management plans were specifically respected when establishing groundwater availability estimates.

Water quality is recognized as an important component in this 50-year water plan. Water supplies can be diminished or made more costly to prepare for distribution if water quality is compromised. To insure that this plan fully considers water quality, the Federal Clean Water Act and the State Clean Rivers Program were reviewed and considered when developing water-supply availability estimates (Chapter 3), water deficit strategies (Chapter 4), water quality impacts (Chapter 5), and recommendations (Chapter 8).

1.2.1 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.

Acre-Foot - The volume of water required to cover one acre to a depth of one foot; 325,851 gallons.

Alluvial / Alluvium - 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 groundwater 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.”

Bolson/Basin - A term used, especially in the southwestern U.S., to describe flat, saucer-shaped, alluvium-floored basins that are surrounded by mountains and in which drainage is internal. Bolson aquifer or basin aquifer implies the water-saturated portion of the sediments filling the bolson or basin.

Demand - The total volume of water required to meet the needs of a water-use category.

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.

Ephemeral - Describes 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.

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

Forbearance contract - A contract in which a landowner agrees to forego delivery of Rio Grande Project Water.

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 mappability 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.

Hydraulic interconnection - The degree to which groundwater 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.

Hydrostratigraphy - The identification of formations that have considerable

lateral extent and that also form a geologic framework for a reasonably distinct hydrogeologic system.

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 that results in an acceptable impact on the water source and its primary users.

1.2.2 Acronyms

BMP - Best Management Practice

EBID - Elephant Butte Irrigation District

EDAP - Economically Distressed Area Program

EPA - United States Environmental Protection Agency

EPCWCID - El Paso County Water Conservation and Improvement District

EPCWID - El Paso County Water Improvement District

EPWU - El Paso Water Utilities

FDWSC - Fort Davis Water Supply Corporation

FWSD - Fresh Water Supply District

FWTWPG – Far West Texas Water Planning Group

gpm - Gallons Per Minute

GAM - Groundwater Availability Model

GIS - Geographic Information System

HB - House Bill

HCUWCD - Hudspeth County Underground Water Conservation District

IBWC - International Boundary and Water Commission

LVWD - Lower Valley Water District

MCL - Maximum Contaminant Levels

mg/l - Milligrams Per Liter

MGD - Million Gallons Per Day

M & I - Municipal and Irrigation

MUD - Municipal Utility District

NRCS - Natural Resource Conservation Service

OSSF - On Site Septic Facility

PGMA - Priority Groundwater Management Area

RGP - Rio Grande Project

RWPG - Regional Water Planning Group

SB - Senate Bill

SOAH - State Office of Administrative Hearings

TAC - Texas Administrative Code

TCEQ - Texas Commission on Environmental Quality

TDA - Texas Department of Agriculture

TDHCA - Texas Department of Housing and Community Affairs

TNRCC - Texas Natural Resource Conservation Commission

TPWD - Texas Parks and Wildlife Department

TSSWCB - Texas State Soil and Water Conservation Board

TWC - Texas Water Commission

TWDB - Texas Water Development Board

TDS - Total Dissolved Solids

USBR - United States Bureau of Reclamation

USFWS - United States Fish and Wildlife Service

USGS - United States Geological Survey

WAM - Water Availability Model

WCS - Water Supply Corporation

WCID - Water Conservation and Improvement District

WERC - Originally the Waste-management, Education and Research Consortium, now - A Consortium for Environmental Education and Technology Development

WUG - Water User Group

1.3 REGIONAL GEOGRAPHIC SETTING

1.3.1 Far West Texas

Far West Texas is bounded on the north by New Mexico, on the south and west by the Rio Grande, and on the east by the Pecos River and incorporates the counties of Brewster, Culberson, El Paso, Hudspeth, Jeff Davis, Presidio and Terrell (Figure 1-1). These counties claim some of the most impressive topography and scenic beauty in Texas. The Region is home to the Guadalupe Mountains National Park, Big Bend National Park, and the contiguous Big Bend Ranch State Park. El Paso, the largest city in the Region, is also the nation's largest city on the U.S.-Mexico border. Ciudad Juarez, with an estimated population of over 1.3 million, is located across the Rio Grande from El Paso, and shares the same water sources with El Paso.

All seven counties that comprise the planning region lie solely within the Rio Grande River Basin. The Rio Grande not only forms the border between the United States and Mexico but is also a vital water-supply source for communities, industries, and agricultural activities adjacent to the River. Above Fort Quitman, use of water from the Rio Grande is controlled primarily by the operations of the Rio Grande Project, which was developed to supply agricultural water in southern New Mexico and West Texas. Other than along the Rio Grande corridor, the Region is dependent on groundwater resources derived from several aquifer systems.

The counties of Far West Texas are among the largest in the State, occupying 24,069 square miles (mi^2), or 9 percent of the total State area. Ranked by total area, the counties that make up the Region are Brewster (6,193 mi^2), Hudspeth (4,572 mi^2), Presidio (3,856 mi^2), Culberson (3,813 mi^2), Terrell (2,358mi^2), Jeff Davis (2,264 mi^2), and El Paso (1,013 mi^2).

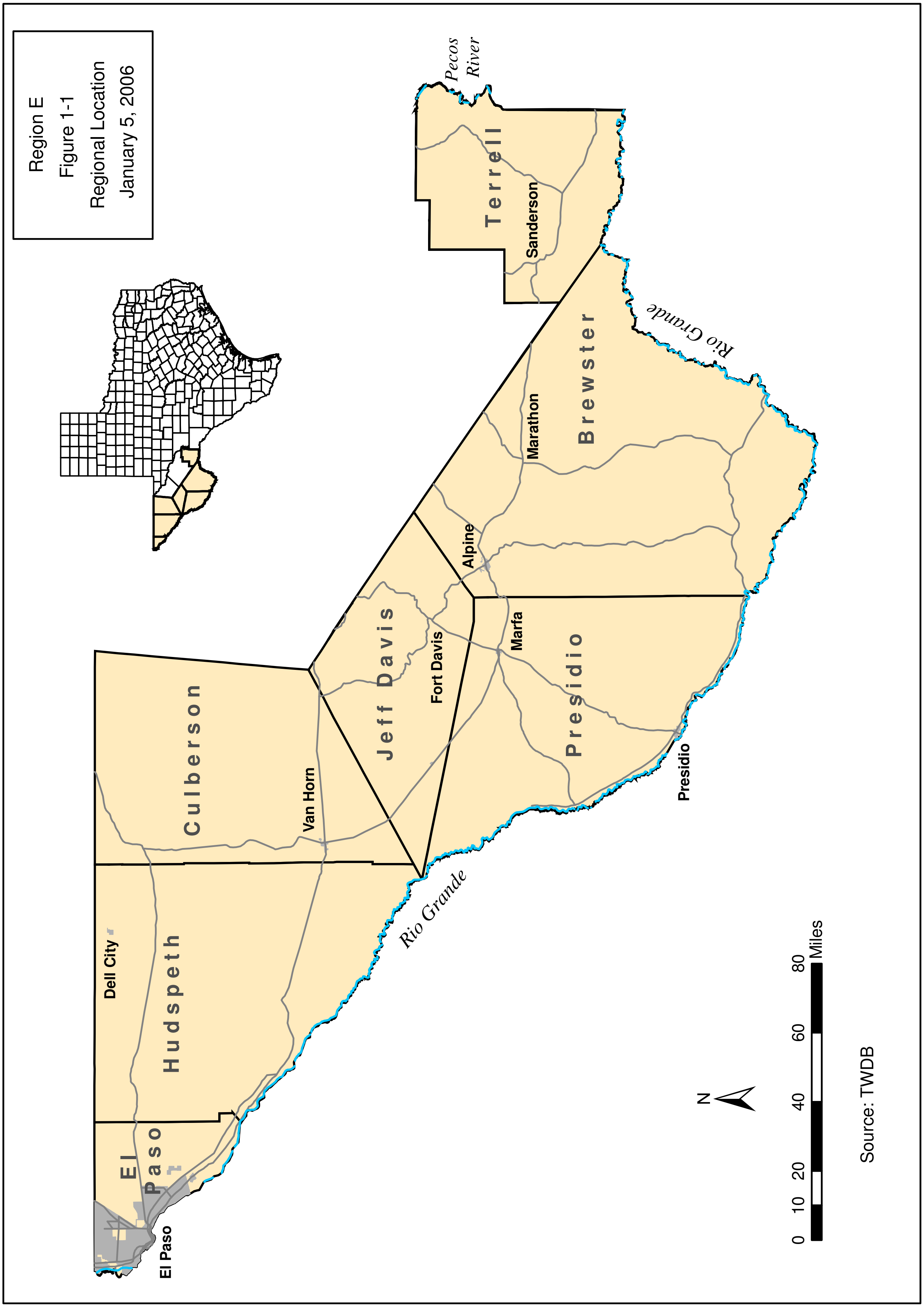

FIGURE 1-1. LOCATION OF FAR WEST TEXAS PLANNING REGION

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1.3.2 Physiography

Far West Texas is located in a topographically distinct area of North America known as the Basin and Range Physiographic Province and is characterized by higher elevations and greater local relief than is observed anywhere else in the State. Traversed from north to south by an eastern range of the Rocky Mountains, the Region contains all of Texas' true mountains (Figure 1-2). Widely spaced mountain ranges rise from 1,000 to more than 3,000 feet above the intervening basin lowlands.

Although most of Texas is generally flat and less than 2,500 feet above mean sea level, the floors of most of the basins in West Texas are at elevations greater than 3,000 feet. The basins (or bolsons) are filled with sediments eroded from the surrounding mountains. At the deepest points of the basins, deposits of basin-fill range in thickness from less than 1,000 feet to more than 9,000 feet. With the exception of the Rio Grande and its tributaries, the Rio Conchos (Chihuahua, Mexico) and the Pecos River (Texas), all surface water in the Region drains toward the lowest elevation within each basin. "Salt Flats" occur in northeastern Hudspeth and northwestern Culberson Counties where water, upwelling from shallow aquifers and collecting from rainfall runoff, rapidly evaporates leaving behind accumulations of mineral deposits. These lakes are dry during periods of low rainfall, exposing bottoms of solid salt. For years, this area was a source of commercial salt extraction.

Highest of the mountain ranges is the Guadalupe Range, which straddles the Texas-New Mexico state line. The range comes to an abrupt end about 20 miles south of the Texas-New Mexico border, where Guadalupe Peak (the highest surface elevation in Texas at 8,751 feet) and El Capitan overlook the Salt Basin to the west and south. Lying west of the Salt Basin and extending to the Hueco Mountains a short distance east of El Paso is the Diablo Plateau.

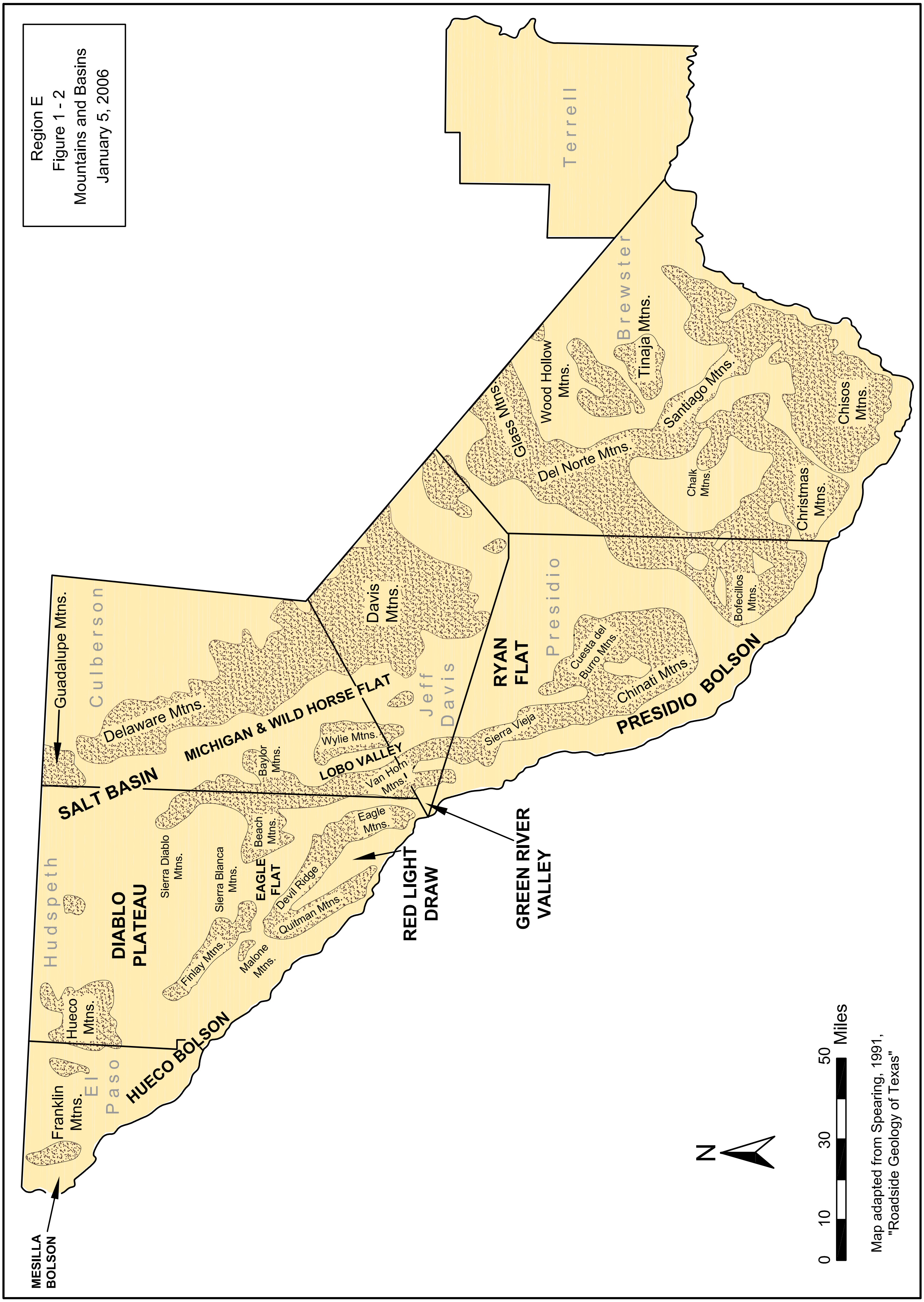

FIGURE 1-2. MOUNTAINS AND BASINS

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Other mountain ranges, including the Eagle, Quitman, Carrizo, Delaware, and Sierra Vieja Mountains, are located south and east of the Diablo Plateau in Culberson, Hudspeth, Jeff Davis, and Presidio Counties. These mountains overlook several intermontane basins from which there is no external drainage (e.g., Eagle Flat, Ryan Flat, Michigan Flat, Wild Horse Flat). Two other basins, Red Light Draw and Green River Valley, are dissected by and drain to the Rio Grande.

The Davis Mountains are principally in Jeff Davis County; however, igneous rocks originating from the volcanic vents that formed the Davis Mountains extend into Brewster and Presidio Counties. The Davis Mountains contain a number of peaks with elevations greater than 7,000 feet, including Mount Livermore, which at 8,206 feet is one of the highest peaks in Texas. Mount Locke at 6,809 feet is home to the University of Texas McDonald Observatory. These mountains intercept moisture-bearing winds and receive more precipitation than other locations in West Texas. The Davis Mountains are greener than other mountains of the Region with the growth of grass and forest trees.

The Big Bend country, which lies southeast of the Davis Mountains, is bounded on three sides by a great eastward swing of the Rio Grande. It is a sparsely populated mountainous country with scant rainfall. Its principal mountains, the Chisos, rise to an elevation of 7,825 feet. Along the Rio Grande are the Santa Elena, Mariscal, and Boquillas Canyons, with rim elevations of 3,500 feet to 3,775 feet. Because of its remarkable topography and plant and animal life, the southern part of this region along the Rio Grande is home to Big Bend National Park and Big Bend Ranch State Park.

The Franklin Mountains, which rise 3,000 feet above the valley floor to an elevation of 7,192 feet, separate the "Upper and Lower Valleys" of the Rio Grande in El Paso County into narrow strips of irrigated land. The historic towns and missions of Ysleta, Socorro and San Elizario are located along the Lower Valley.

1.3.3 Population and Regional Economy

With the exception of El Paso County, the counties of Far West Texas are among the least populated of the State (Figure 1-3). In the year 2000, approximately 96 percent (679,622) of the Region's 705,399 residents resided in El Paso County, where the population density is 760 persons per square mile. The population density of the six rural counties is approximately 1.1 persons per square mile. Approximately 75 percent of the residents in the Region are Hispanic or Latinos.

El Paso, one of the fastest growing cities in Texas, is the largest city in the Region, with a year-2000 population of 563,662. This is 83 percent of the total population of El Paso County and 80 percent of the Region's total population. The other communities in El Paso County, as well as outlying areas, had a year-2000 population of 115,960.

The year-2000 populations of cities in the six rural counties are as follows: Alpine, Brewster County (5,786); Van Horn, Culberson County (2,435); Dell City, Hudspeth County (413); Sierra Blanca, Hudspeth County (533); Fort Davis, Jeff Davis County (1,050); Marfa, Presidio County (2,121); Presidio, Presidio County (4,167); Sanderson, Terrell County (861). Population of other smaller communities such as Fort Hancock, Marathon and Valentine are included in the "County Other" (rural) population of each county. The population of the outlying areas of the rural counties is 8,824, or 34 percent of the total rural population. The current and projected population growth in Far West Texas is further discussed in Chapter 2.

The regional economy is predominantly comprised of agriculture, agribusiness, manufacturing, tourism, wholesale and retail trade, government, and military. According to TWDB's socio-economic analysis (provided in Appendix 4A), in the year 2000, economic output in the Region totaled $29,741 million. This generated $14,866 million worth of income and supported approximately 347,897 jobs. Business and industry also contributed $1,209 million in taxes for state, local and federal governments.

Farming and ranching have been mainstays of the economy for more than 100 years. TWDB's socio-economic analysis reports that in 2000 irrigation farmers in the Region produced about $124 million worth of crops that generated $38 million in regional income. The livestock industry contributed $33 million in wages, salaries, and profits and supported an estimated 1,684 jobs. In recent years, tourism and outdoor recreation have become more significant components of the economies of the rural counties. El Paso County has developed an economy that is driven largely by manufacturing, international trade, military training, wholesale and retail trade, and educational services.

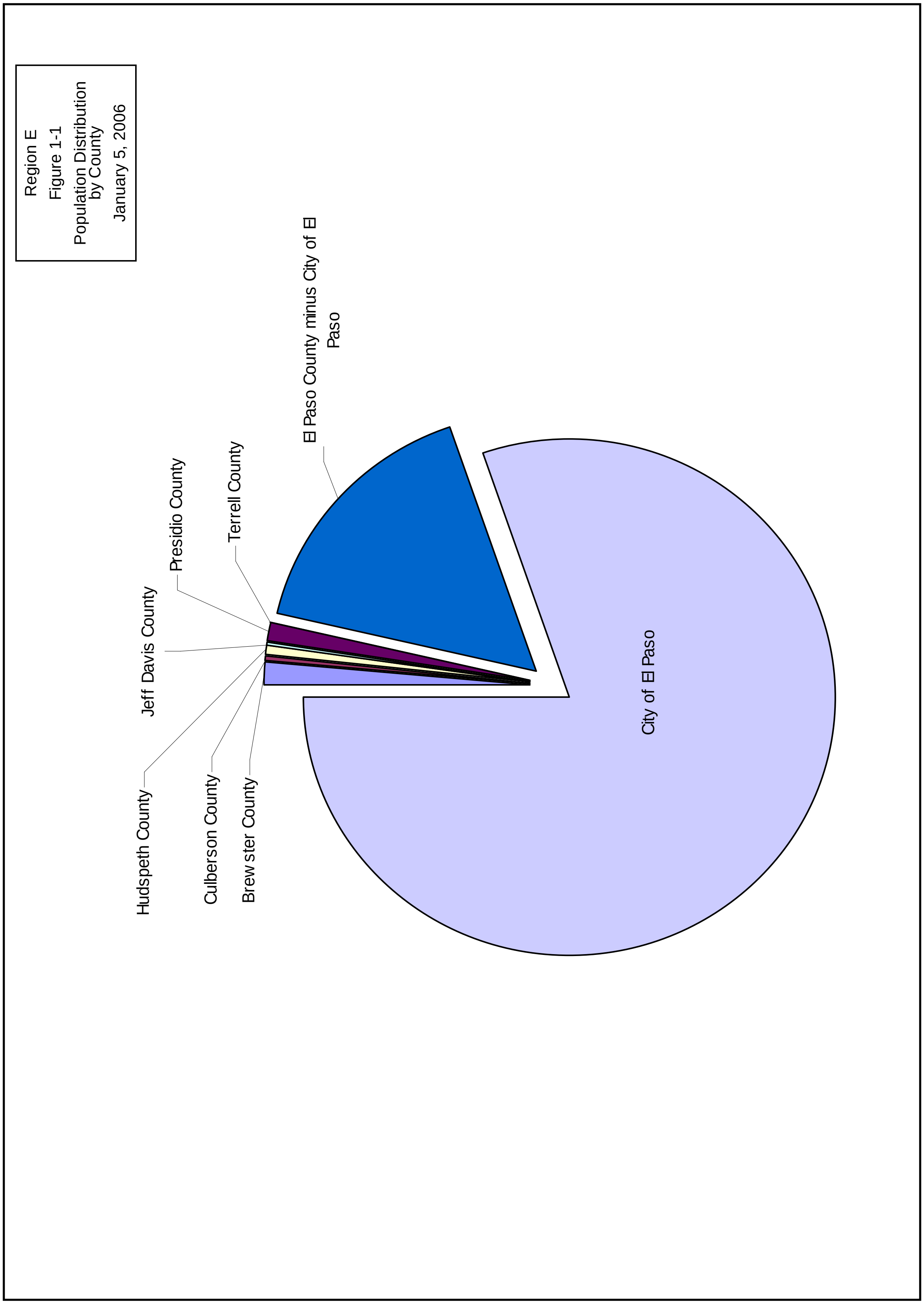

FIGURE 1-3. YEAR 2000 POPULATION DISTRIBUTION BY COUNTY

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1.3.4 Land Use

Land use in the seven-county Region, as illustrated in Figure 1-4, is described in terms of seven categories:

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

Urban lands make up less than one percent of the total land area in Far West Texas. The largest concentration of urban land is in El Paso County, where 96 percent of the Region's residents live. Cultivated agricultural lands are identified as areas that support the cultivation of crops and occupy less than one percent of the total land area of the Region. These lands generally require access to high volumes of groundwater or surface water. Together, urban and agricultural lands comprise the two most significant areas of water consumption.

Rangeland 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, rangeland accounts for one of the smallest sources of water demand. Forestland is limited to areas where topography and climate support the growth of native trees. These are limited to highlands, such as the Davis, Guadalupe and Chisos Mountains. Forestlands rely exclusively on rainfall as a source of moisture.

Areas designated as either water or wetlands are associated with the Rio Grande and the Pecos River and their tributaries. The Rio Grande is also a major source of irrigation water for agricultural lands in El Paso, Hudspeth and Presidio Counties. Most all other streams in the region are ephemeral. In addition to the two rivers, wetlands formed by desert springs (cienegas) provide critical wildlife habitat. Finally, barren lands are defined as undeveloped areas with little potential for use as agricultural land, rangeland, or forestland.

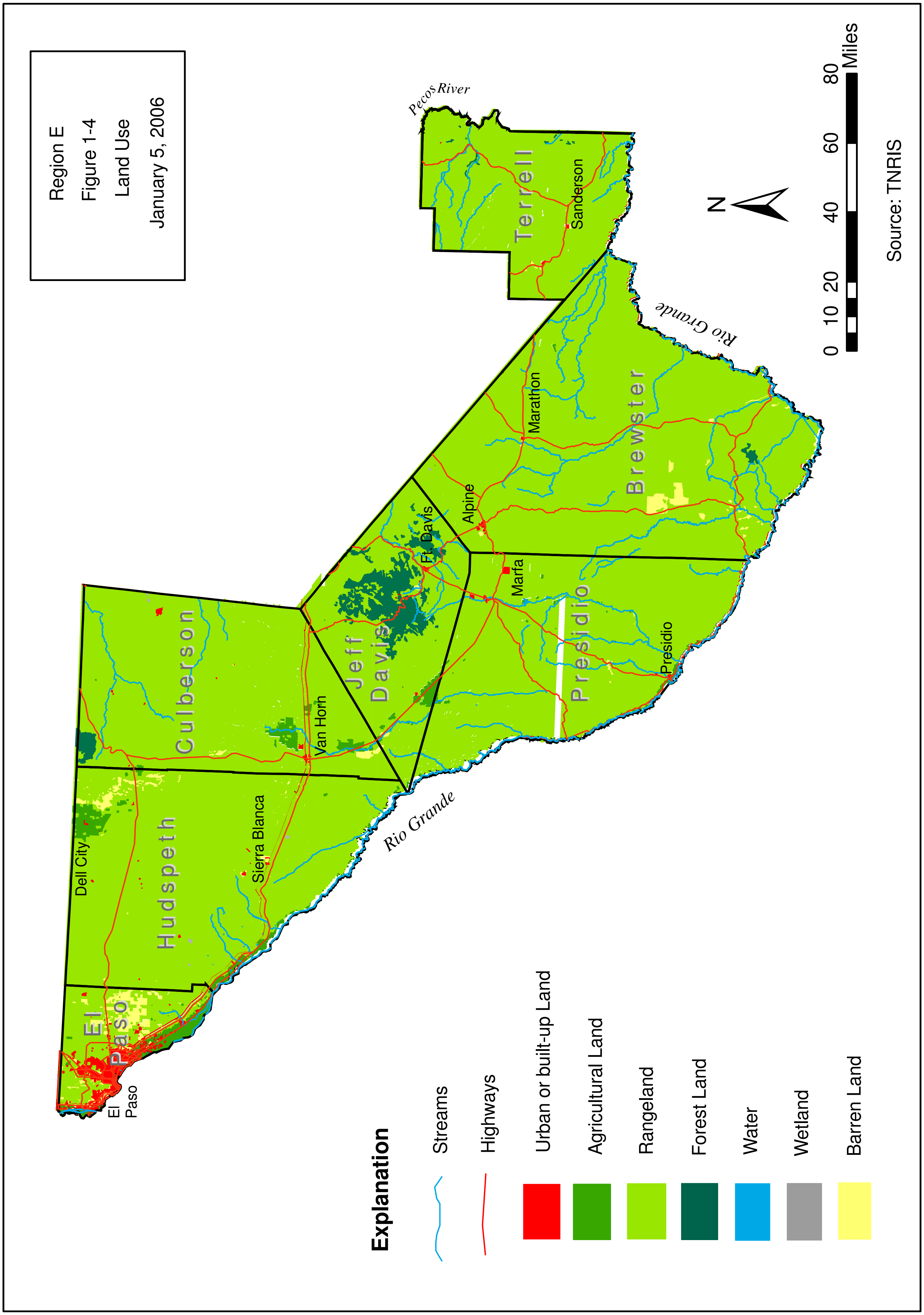

FIGURE 1-4. LAND USE

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1.3.5 Climate

Far West Texas, the most arid region in the State, is positioned in the northern part of the Chihuahuan Desert, a large arid zone that extends southward into Mexico. Only the highest altitudes occurring in the eastern part of the region receive sufficient precipitation to be considered semiarid, rather than true desert.

The mean annual temperature of the Region is approximately 65° F. The average annual low temperature ranges between 45° F and 54° F, and the average high is 77° F to 80° F. During summer months, afternoon temperatures often exceed 100° F. In the winter, lows in the mountains and the high desert plateaus can plummet to less than 10°F.

The Region usually reports the lowest annual precipitation (the regional average is 12.9 inches) and the highest lake-surface evaporation (the regional average is 70 inches) in Texas (Figures 1-5 and 1-6). The combination of low rainfall and high evaporation creates what would be considered drought conditions in any other part of the State.

From highest to lowest values, average annual rainfall at selected locations is reported as follows:

- Mount Locke, Jeff Davis County (20.8 in)
- Alpine, Brewster County (16.9 in)
- Marfa, Presidio County (15.9 in)
- Sanderson, Terrell County (14.3 in.)
- Van Horn, Culberson County (13.1 in)
- Presidio, Presidio County (10.8 in)
- Hudspeth County (10 in)
- City of El Paso, El Paso County (8.8 in)

Most rainfall occurs between the months of June and October, as indicated by a graph of average monthly rainfall for selected stations (Figure 1-7). Rainfall during the spring and summer months is dominated by widely scattered thunderstorms. Because of the convective nature of thunderstorms, the amount of spring and summer precipitation in the region increases with elevation.

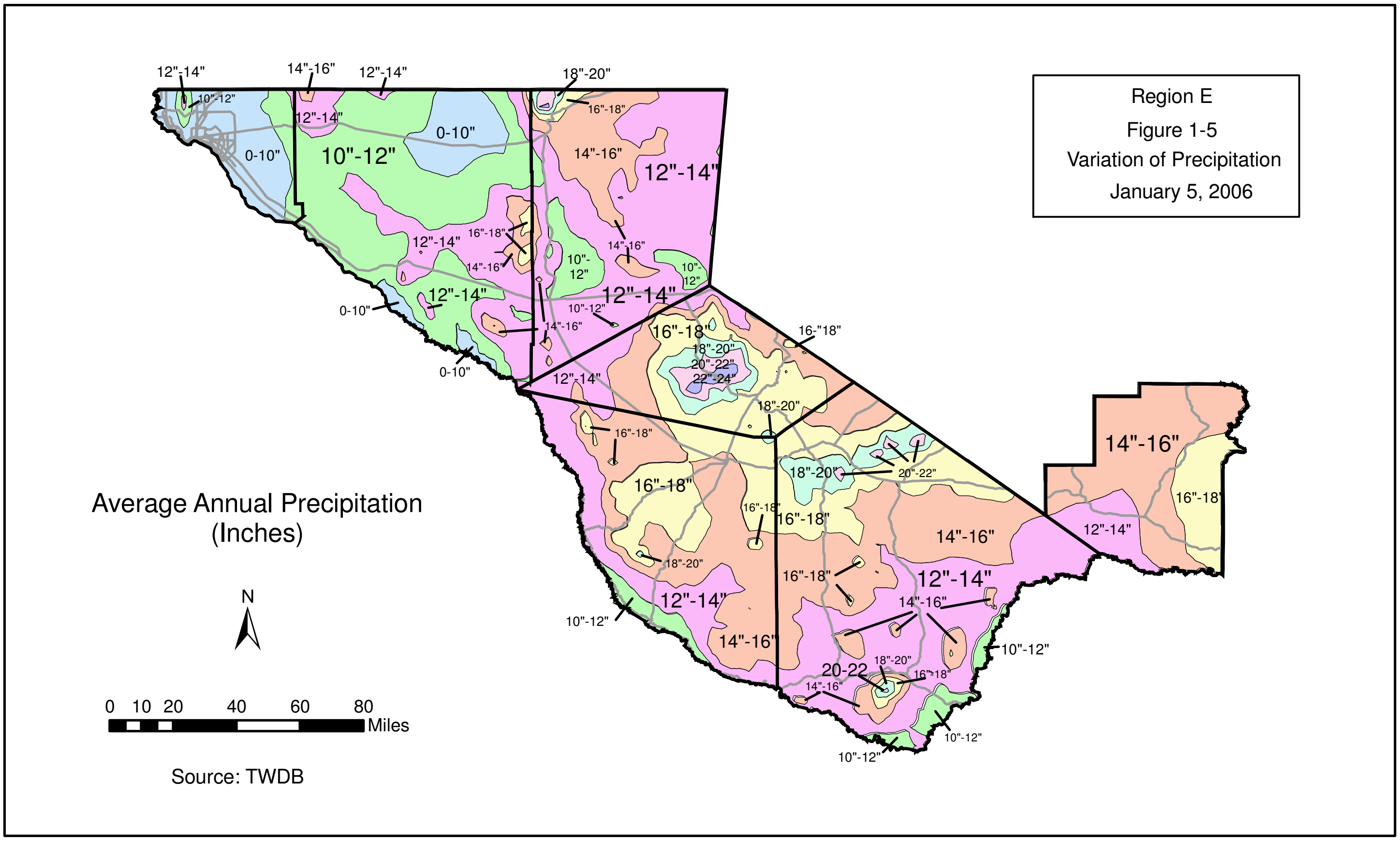


FIGURE 1-5. VARIATION OF PRECIPITATION, 1961-1990

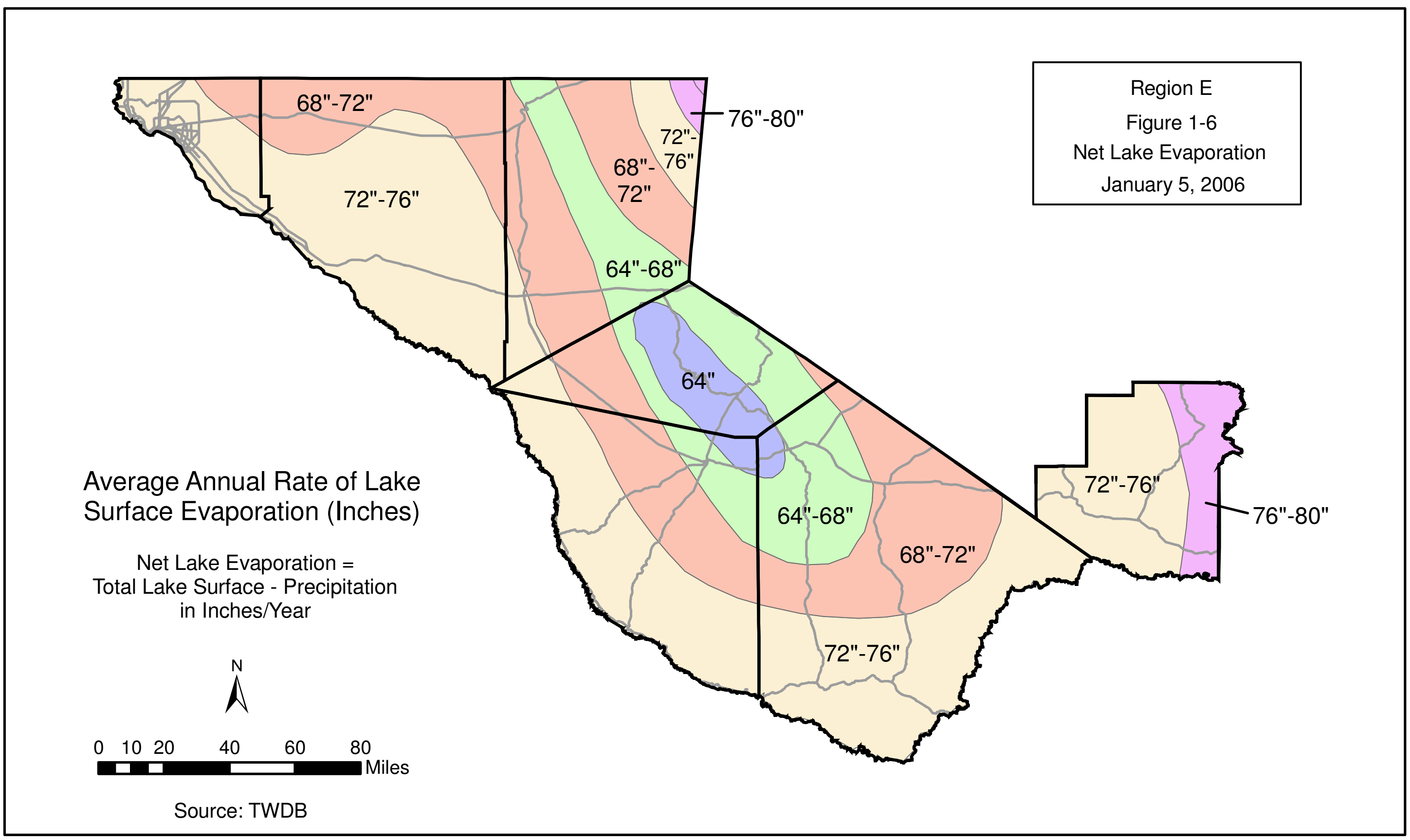
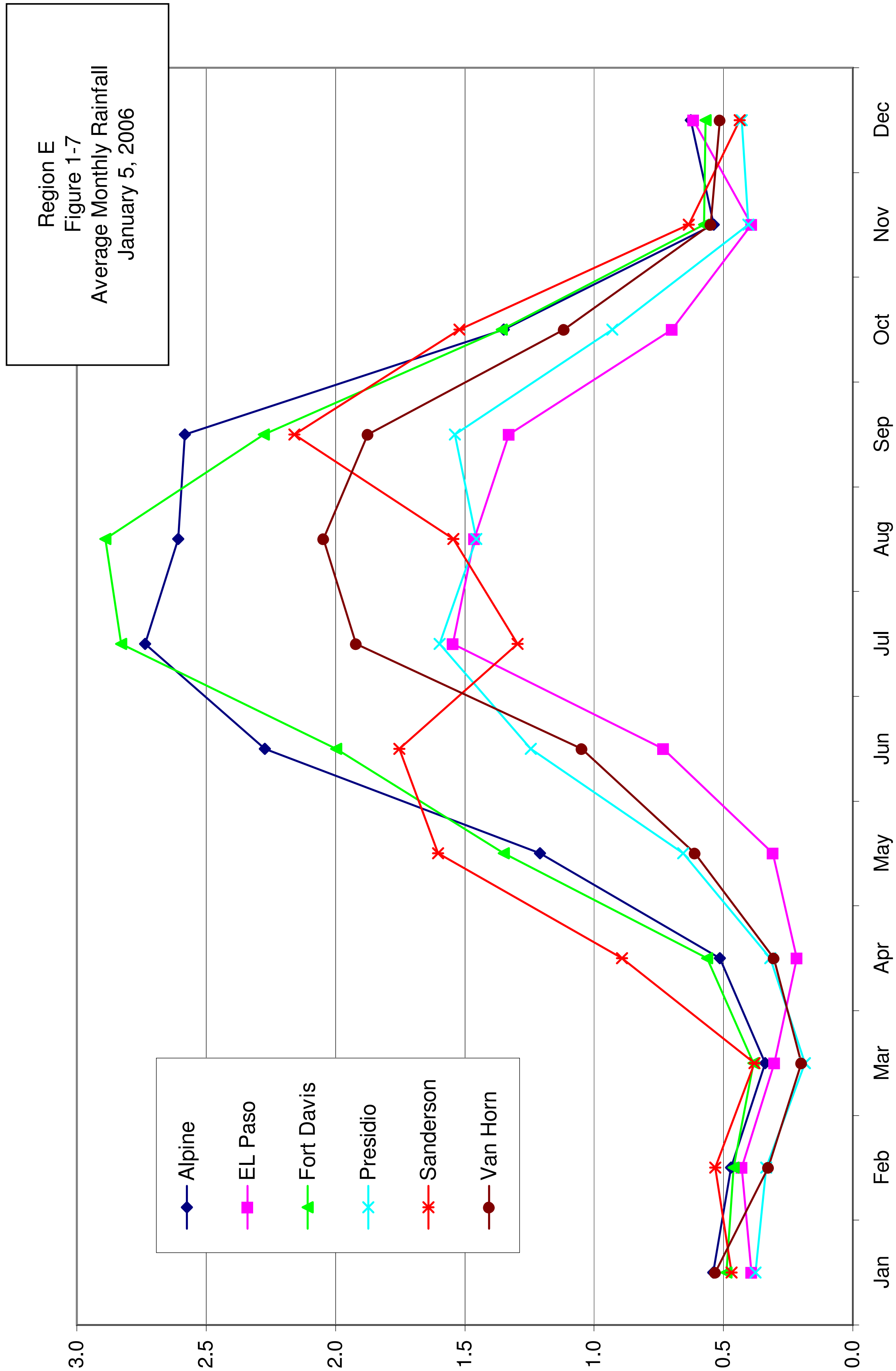


FIGURE 1-6. NET LAKE SURFACE EVAPORATION, 1940-1978



Source: Utah State University
Climate Center, 2005

FIGURE 1-7. AVERAGE MONTHLY RAINFALL FOR SELECTED STATIONS

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Drought conditions are assumed in the planning process to insure that adequate infrastructure and planning is in place under severe water shortage conditions. Drought is generally defined as a period of abnormally dry weather of sufficient length to cause a serious hydrologic imbalance, which may be observed in any of the following conditions:

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

Drought can also be defined in the following operational definitions:

Meteorologic drought is defined as an interval of time, usually over a period of months or years, during which precipitation cumulatively falls short of 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 to support 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 groundwater supplies, the drying up of lakes and reservoirs, and the reduction or cessation of springflow or streamflow.

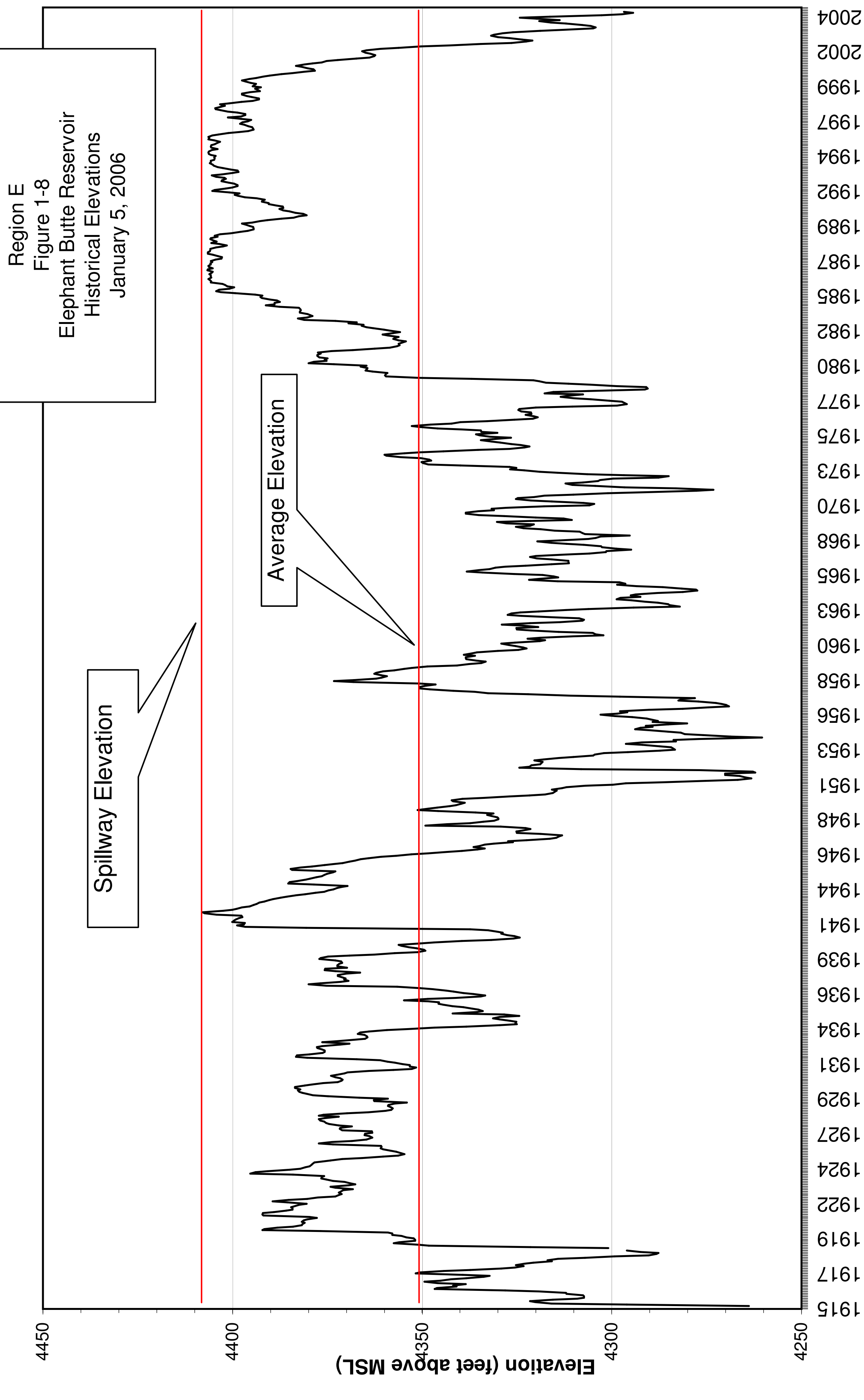
Although agricultural drought and hydrologic drought are consequences of meteorological drought, the occurrence of meteorological drought does not guarantee that either one or both of the others will develop. With regard to the upper segment of the Rio Grande, drought is more significantly influenced by the amount of snowmelt in southern Colorado and northern New Mexico that affects the amount of water in storage in Elephant Butte Reservoir (Figure 1-8). For Far West Texas and particularly those who rely on the Rio Grande, an operational drought definition is more appropriate.

River drought above Fort Quitman is a period when the Rio Grande and its storage facilities (reservoirs) have reached a stage where water deliveries are less than full allocation. There may be a drought in all other definitions, but if there is adequate storage in the local reservoir (ie. Elephant Butte), there is no “river drought” and no reduction in surface water deliveries.

River drought below confluence of Rio Conchos may be defined as any time the combined flows of the Rio Grande and Rio Conchos falls below 250 cubic feet per second (cfs) for more than 90 consecutive days.

Consistent flows below 250 cfs below Presidio have reduced to bare remnants an agricultural economy on land that has been continuously cultivated longer than anywhere else in North America. Consistent low water threatens important wildlife habitat and river recreation resources that are essential building blocks for rural economies downstream of El Paso.

The westernmost part of Texas, as well as the headwaters of the Rio Grande in Colorado and New Mexico, have been experiencing drought conditions for much of the past eight to ten years. Only during the later part of 2004 and early 2005 have meteorological conditions been average or even slightly above average. In 2004, Elephant Butte Reservoir reached a low of 4.5 percent capacity. With this years (2005) anticipated snow melt in Colorado and improved climatic conditions downstream, the first near-full allotment in three years of Rio Grande water is planned to occur; however, Elephant Butte will likely remain at low capacity.



Source: U.S. Dept. of the Interior, Bureau of Reclamation, 2005

FIGURE 1-8. HISTORICAL END-OF-MONTH ELEVATIONS FOR ELEPHANT BUTTE RESERVOIR

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1.3.6 Native Vegetation and Ecology

Arid vegetation native to the Chihuahuan Desert is closely tied to the region's precipitation and evaporation potential. This area typically receives most of its precipitation in the summer in the form of convective storms, which are typically characterized by intense rainfall concentrated in small areas. Winter precipitation comes from frontal systems, which are generally soaking rains covering larger areas. Due to their nature, the summer precipitation generally wets only the shallow subsurface soil layer, whereas, winter rains are more likely to percolate deeper into the subsurface.

According to the Chihuahuan Desert Research Institute, vegetation native to Far West Texas can be classified into two groups, intensive water users and extensive water users. Intensive water users include short grasses and cacti, which have short root systems and respond quickly to small amounts of moisture that is available in the soil profile for only a limited time. Extensive water users have both shallow roots capable of capturing soil moisture as well as deep roots that penetrate downward to the water table. Thus, summer rainfall favors grasslands, while winter rainfall favors scrubs. Although a shift in predominate precipitation patterns from summer to winter has not been clearly recognized, local observations indicate that scrubs are becoming more predominate. Likewise, it is becoming increasingly clear that the ongoing drought conditions in Far West Texas is placing a serious strain on vegetation, especially the oak and conifer woodlands in the higher elevations.

1.3.7 Agricultural Resources

Agriculture, including both the beef industry and irrigated farming, is the most significant economic activity in Far West Texas. The raising of beef cattle occurs in all seven counties, with Brewster County accounting for the greatest number of range cattle. The dairy industry primarily occurs in El Paso County.

With an average annual rainfall of less than 13 inches, the raising of crops in this region requires irrigation. Most irrigated farming occurs along the flood plains of the Rio Grande in El Paso, Hudspeth, and Presidio Counties, where water is diverted from the River to grow vegetables, cotton, various grain crops, and orchards. Inland, groundwater sources are pumped to the surface to irrigate crops primarily in Hudspeth (Dell Valley), Culberson (Diablo Farms, and Wild Horse and Lobo Flats), and Jeff Davis (Ryan and Lobo Flats) Counties.

Agricultural activities in the Region that rely on surface water are designed to accommodate the intermittent nature of the supply. In some cases, this means that agricultural water supply needs will be supplemented by groundwater sources, or that irrigation activities will cease until river supplies are replenished.

1.3.8 Natural Resources

Far West Texas boasts the highest and most scenic desert communities in Texas. The natural resources of the Region include the groundwater and surface water sources described in Section 1.5 of this chapter and in Chapter 3. Terrestrial and aquatic habitats that provide beautiful vistas, recreational opportunities, and unique wildlife habitats are also natural resources. Understandably, both local residents and tourists make use of these resources in their enjoyment of the numerous public parks within the Region. Big Bend National Park, Guadalupe Mountains National Park, and Big Bend Ranch State Park are three of the largest protected areas in the Region.

Natural resources also include the great diversity of plant and animal wildlife that inhabit these environments. Texas Parks and Wildlife Department’s Natural Diversity Database is a comprehensive source of information on rare, threatened, and endangered plants and animals. Species listed in the counties of Far West Texas are provided in Appendix 1A.

Both plant and animal species endemic to this region have developed a tolerance for the intermittent nature of surface water availability; however, significantly long drought conditions can have a sever effect on these species. Riparian water needs for birding habitat are particularly critical. Springs (cienegas) emanating from shallow groundwater sources often provide the most constant water supply available for aquatic habitat. Appendix 1B of this chapter describes a number of “major springs”, while “ecologically unique river and stream segments” are described in Chapter 8.

Of recognized importance to the water planning process is the concern of the effect that future development of water supplies might have on the diversity of species in the region. Water-supply deficit strategies developed in Chapter 4 of this plan include an evaluation of each strategy’s potential impact on the environment and natural resources.

1.4 REGIONAL WATER DEMAND

1.4.1 Major Demand Centers

Total estimated year-2000 water consumptive use in Far West Texas was 665,793 acre-feet. The largest category of use was irrigation (508,266 acre-feet), followed by municipalities (139,690 acre-feet), manufacturing (7,750 acre-feet), livestock (4,843 acre-feet), steam-electric cooling (2,962 acre-feet), and mining (2,282 acre-feet). The significance of irrigation as a source of demand is further underscored by the accompanying pie chart (Figure 1-9), which shows that 76 percent of water use is by the agricultural sector in support of irrigation. Twenty-one percent is used by municipalities, and the remaining 3 percent supports manufacturing, steam-electric cooling, livestock, and mining. Current and projected water demand for all water-use types are discussed in detail in Chapter 2.

1.4.2 Agriculture

The cultural and physical landscape of Far West Texas has more in common with the desert southwest than with other areas of Texas. The dominant commercial land use throughout the rural areas of the Region is extensive cattle grazing. Aridity and historic land-tenure practices have combined to produce large ranches and low animal densities. The total volume of water used in livestock production in the region in the year 2000 was 4,843 acre-feet. The single largest area of livestock demand is in El Paso County, where 1,742 acre-feet

(36 percent of total livestock demand in the region) are used by ranches and dairy farms. In the six rural counties, total livestock demand ranges from a high of 707 acre-feet in Brewster County to a low of 307 acre-feet in Terrell County. The lower numbers associated with the rural counties may be a reflection of the lack of dairy farms outside of El Paso County.

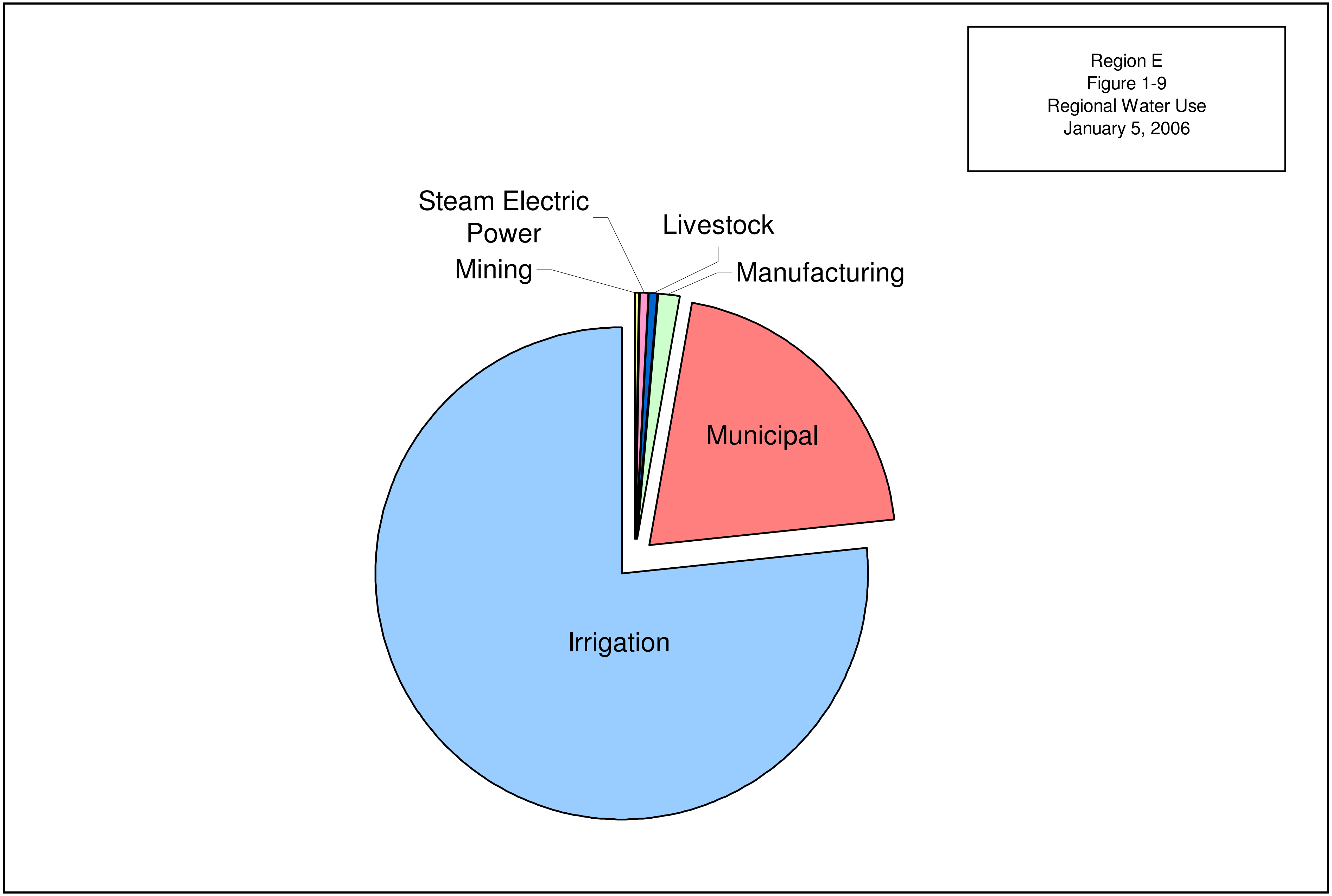

FIGURE 1-9. YEAR 2000 REGIONAL WATER USE BY WATER USE CATEGORY

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Total irrigation use in the Region in the year 2000 was 508,266 acre-feet. El Paso and Hudspeth Counties account for the greatest amount of irrigation with 270,424 and 186,494 acre-feet of usage, respectively. Along the Rio Grande corridor in these two counties, irrigation water is diverted from the River, except during years when flow is significantly below normal. In northeastern Hudspeth County, the Dell Valley farming area irrigates cropland with groundwater pumped from the underlying Bone Spring-Victorio Peak aquifer. Approximately 188,000 acre-feet of groundwater was applied to 37,113 acres in 2000.

Irrigation in El Paso and Hudspeth Counties represents 90 percent of total irrigation water use in the Region. Most of the remaining 10 percent of irrigation demand is centered in Presidio and Culberson Counties, where 20,475 and 29,593 acre-feet, respectively, are used to support irrigated agriculture. Greenhouse farming operations near Fort Davis and Marfa have the highest crop (tomatoes) yield per volume of water applied.

There is virtually no rain-fed agriculture (dry-land farming), and even irrigated agriculture is confined to a small fraction of the region. Floodplain-irrigated agriculture is found along the Rio Grande extending above and below El Paso and into southern Hudspeth County. A much smaller irrigated strip also occurs along the River near Presidio. Currently, irrigated agriculture based on groundwater pumping is essentially limited to Dell Valley in northeastern Hudspeth County, Diablo Farms in northwestern Culberson County, and Wild Horse and Lobo Flats near Van Horn. High quality cotton, pecans, alfalfa, and vegetables such as tomatoes, onions, and chilies are the major crops of the region.

The area of land actually irrigated in the El Paso County Water Improvement District #1 in any given year varies from 40,000 to 50,000 acres. The total water rights acreage in the District, however, is 69,010. The City of El Paso currently owns or leases land with rights to use water for approximately 13,000 acres.

Despite the relatively small area of irrigated land, the annual value of crop production is as much as $36.7 million in El Paso County, $16.5 million in Hudspeth County, and $4.9 million in Presidio County.

Cow and calf operations dominate the livestock industry in every county except Terrell, where sheep and goats predominate. In addition to livestock, many of the ranches supplement revenue through hunting leases. Dairy operations in El Paso County represent the largest proportion of the market valuation for livestock, as El Paso County traditionally ranks in the top five dairy-production counties in Texas. Agricultural water-demand projections addressed in Chapter 2 consider irrigation and livestock needs separately.

Crop production in Far West Texas is not sustainable without a source of irrigation water. A reduction in the quantity of water available for irrigation will cause a reduction in the number of acres that can be irrigated profitably. Similarly, cutbacks in the supply of water for livestock will cause a reduction in herd size. As water supplies are depleted, modifications will be required to use the available rangeland resource, and water hauling within a given ranch may be required to better distribute water to livestock.

Although drought-like conditions are a relative constant in the Region, extended periods of below-normal rainfall can have significant and long-lasting harmful effects on the rangeland resource. Reduction of livestock numbers because of drought usually lags behind the impact of drought on the range-grass ecosystem. Extended periods of drought can lead to the depletion of grass species and to an increase in shrub species. This leads to a decrease in soil cover and increases the potential for erosion by water and wind.

A decrease in water quality has a greater impact on crop production than on livestock output. As the salinity of irrigation water increases, the amount of irrigation water applied must also increase. This satisfies the leaching requirement, and keeps the root zone salinity at levels that allow for economic crop production. If salinity levels increase, the mixture of crops may change to include crops with greater tolerance to soil salinity.

Groundwater use for irrigated farming principally occurs in Dell Valley, Diablo Farms, and along the various flats that comprise the Salt Basin bolson valley. Principal aquifers from which irrigation water is withdrawn include the Rio Grande Alluvium, Bone Spring-Victorio Peak, Capitan Reef, and the Wild Horse-Michigan, Lobo, and Ryan Flats of the West Texas Bolson aquifers. Characteristics of these aquifers are described in Chapter 3.

Future availability of water for agricultural use from these aquifers varies. During times of insufficient river flow farmers may use groundwater from the Rio Grande Alluvium to sustain crops. However, because of its high mineral content, this water can only be used on a short-term basis. In Dell Valley, groundwater from the Bone Spring-Victorio Peak aquifer has deteriorated in quality particularly in the central part of the valley as a result of repeated irrigation water return flow. The aquifer should remain viable in the future as the Hudspeth County Underground Water District #1 limits permitted withdrawals to 63,000 or less acre-feet annually. Water levels have declined in the past in most parts of the Salt Basin aquifers but have generally recovered due to a decrease in pumpage in recent years.

1.4.3 Municipal

The municipal 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. Total municipal water demand in the seven counties in the year 2000 was 139,690 acre-feet.

The City of El Paso, with a water use of 116,413 acre-feet in the year 2000, represents 83 percent of the total municipal water use in the Region. The City's water demand has been decreasing over the last several years due to diligent enforcement of conservation measures. Total municipal water use in El Paso County (134,065 acre-feet in 2000), which includes all other communities and rural domestic supply, represents 96 percent of the regional total.

El Paso Water Utilities (EPWU), which serves the City of El Paso, obtains approximately half of its water from the Rio Grande in full river water supply conditions. The remainder is groundwater pumped from well fields in the Mesilla Bolson and Hueco Bolson aquifers. The Utility also supplies water to other incorporated areas and to businesses within El Paso County. Other entities in El Paso County not served by EPWU rely exclusively on groundwater resources. All of the cities and unincorporated areas of the six rural counties likewise depend entirely on groundwater resources from aquifers located in their respective areas.

Following necessary treatment, water supplies 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 Commission on Environmental Quality. "Primary standards" address dissolved particulates (e.g., heavy metals and organic contaminants) that are known to have adverse effects on human health. "Secondary standards" address factors that affect the aesthetic quality (e.g., taste and odor) of drinking water.

Within the Region, water quality varies widely. In much of the rural counties, groundwater is of sufficient quality that only chlorination is required as a means of treatment. In other areas, various methods of treatment are required to bring the water into compliance with primary and secondary standards. For example, Dell City, El Paso, and Horizon Regional MUD operate desalination plants or well head facilities to reduce the concentration of total dissolved solids (TDS) in groundwater extracted from local aquifers.

The City of El Paso (EPWU) actively treats available water supplies to meet drinking-water standards. These operations include the blending of fresh water with marginally elevated TDS water to increase available supplies, and the tertiary treatment of wastewater to generate supplies for reuse. El Paso is presently in the process of updating treatment facilities to accommodate the recently lowered arsenic concentration standard. Fort Bliss and the City of El Paso are collaborating to build a 27.5 MGD desalination plant that makes use of brackish groundwater in the Hueco Bolson aquifer, thus preserving fresh water in the aquifer for drought protection and emergency use.

1.4.4 Wholesale Water Providers

A wholesale water provider is defined as any entity that had contracts to sell more than 1,000 acre-feet of water wholesale in any one year during the five years immediately preceding the adoption of the last regional water plan (2001), or that is expected to enter into contracts to sell more than 1,000 acre-feet of water per year wholesale during the period covered by this Plan (2001–2006). Entities meeting this definition and entities to which they contract are as follows:

El Paso County Water Improvement District #1

- El Paso Water Utilities

El Paso Water Utilities

- Lower Valley Water District
- Homestead MUD
- Fort Bliss
- Vinton
- County Other
- El Paso Electric
- Manufacturing
- Mining

El Paso County Water Control and Improvement District #4

- Fabens
- County Other

Horizon Regional MUD

- Horizon City
- County Other

Lower Valley Water District

- Socorro
- San Elizario
- Clint
- County Other

The El Paso County Water Improvement District #1 primarily delivers water from the Rio Grande to area irrigators. However, it also sells water from the Rio Grande to the City of El Paso through EPWU. In 2002, the District provided 58,743 acre-feet to EPWU. During the drought years 2003 and 2004, EPWU only received 24,992 and 29,794 acre-feet respectively.

EPWU obtains raw surface water from the El Paso County Water Improvement District #1 as explained above, and groundwater from its own wells in the Hueco and Mesilla Bolson aquifers. While most of this water is used within the City, as much as 8,407 acre-feet was sold in 2004 to numerous other public supply, manufacturing, and industrial entities. In 2002, the highest amount of water sold on record by EPWU was 8,989 acre-feet. One of the primary buyers is the Lower Valley Water District who likewise distributes water to other entities.

The El Paso County Water Control and Improvement District #4 also obtains water from its own wells in the Rio Grande Alluvium/Hueco Bolson aquifer. The Horizon Regional MUD's water supply is derived from its own wells and is delivered to a number of entities, Horizon City being the most prominent. The Lower Valley Water District is a significant supplier of water to other entities and receives all of its supply from the El Paso Water Utilities.

1.4.5 Industrial, Manufacturing, Electric Power Generation, and Mining

Manufacturing and industrial companies represent a significant component of the economy of Far West Texas. Most of these businesses, however, are located in El Paso County. The degree to which these businesses are concentrated in El Paso County is shown by the fact that all but 7 acre-feet of the 14,793 acre-feet of water used in the Region by the manufacturing and industrial sector in the year 2000 was used in El Paso County. The mining sector accounts for the smallest area of demand, with 3,366 acre-feet of total usage in the region in 2000.

El Paso Electric Company located in El Paso County is the only facility within the Region that uses water in the form of steam to generate electricity. Anticipated local population growth, as well as increasing commercial and manufacturing power needs, means that the quantity of water needed to produce electricity will likewise increase. El Paso Electric currently purchases most of its water supply from El Paso Water Utilities.

The industrial, manufacturing and power generation sector purchases water from the City of El Paso, or is self-supplied by water wells. In some cases, companies use treated wastewater provided by the El Paso Water Utilities through the utilities' purple-pipe program. Chemical quality standards for water used for industrial purposes vary greatly with the type of industry utilizing the water. The primary concern with many industries is that the water not contain constituents that are corrosive or scale forming. Also of concern are those minerals that affect color, odor, and taste; therefore, water with a high concentration of dissolved solids is avoided in many manufacturing processes.

1.4.6 Environmental And Recreational Water Needs

Environmental and recreational water use in Far West Texas is recognized as being an important consideration as it relates to the natural community in which the residents of this region share and appreciate. In addition, for rural counties, tourism activities based on natural resources offer perhaps the best hope for modest economic growth to areas that have seen a long decline in traditional economic activities such as agriculture and mining.

Natural and environmental resources are often overlooked when considering the consequences of prolonged drought conditions. All living organisms require water. The amount and quality of water required to maintain a viable population, whether it be plant or animal, is highly variable. As water supplies diminish during drought periods, the balance between both human and environmental water requirements becomes increasingly competitive. A goal of this plan is to provide for the health, safety, and welfare of the human community, with as little detrimental effect to the environment as possible. To accomplish this goal, the evaluation of strategies to meet future water needs includes a distinct consideration of the impact that each implemented strategy might have on the environment.

Recreation activities involve human interaction with the outdoor environment. Many of these activities are directly dependent on water resources such as fishing, swimming, and boating; while a healthy environment enhances many others, such as hiking and bird watching. Thus, it is recognized that the maintenance of the regional environmental community's water supply needs serves to enhance the lives of citizens of Far West Texas as well as the tens of thousands of annual visitors to this region. Environmental and recreational water needs are further discussed throughout the plan and especially in Chapters 2, 3, 4 and 8.

1.5 WATER SUPPLY SOURCES

1.5.1 Surface Water

1.5.1.1 Rio Grande

The Rio Grande originates in southwestern Colorado and northern New Mexico, where it derives its headwaters from snowmelt in the Rocky Mountains. The Elephant Butte Dam and Reservoir in New Mexico is approximately 125 miles north of El Paso and can store over two million acre-feet of water (Figure 1-10). Water in the reservoir is stored to meet irrigation demands in the Rincon, Mesilla, El Paso, and Juarez Valleys and is released in a pattern for power generation. Above El Paso, flow in the River is largely controlled by releases from Caballo Reservoir located below Elephant Butte; while downstream from El Paso to Fort Quitman, flow consists of treated municipal wastewater from El Paso, untreated municipal wastewater from Juarez, and irrigation return flow. Below the El Paso-Hudspeth County line, flow consists mostly of return flow and occasional floodwater and runoff from adjacent areas. Channel losses are significant enough that the Rio Grande is often dry from below Fort Quitman to the confluence with the Mexican river, the Rio Conchos, upstream of Presidio. There are no significant perennial tributaries, other than the Rio Conchos, in the 350 miles between Elephant Butte Reservoir and Presidio.

The Rio Grande is unique in its complexity of distribution management. Because the waters of the River must be shared between three U.S. states and the nation of Mexico, a system of federal, state and local programs has been developed to oversee the equitable distribution of water. The compacts, treaties and projects that currently provide the River's management framework are discussed in Chapter 3.

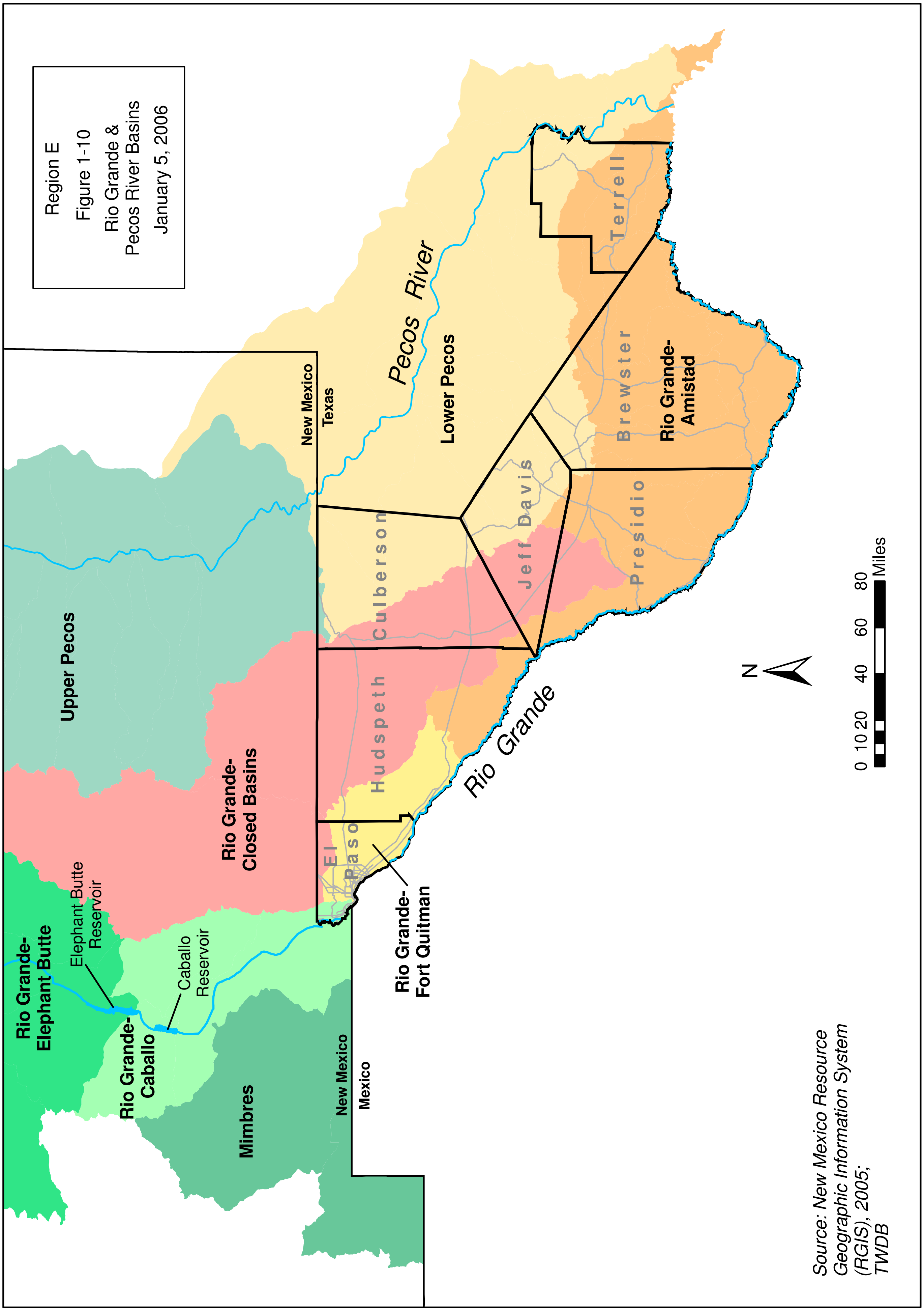

FIGURE 1-10. RIO GRANDE AND PECOS RIVER BASINS AND SUB-BASINS ON THE U.S. SIDE OF THE INTERNATIONAL BORDER

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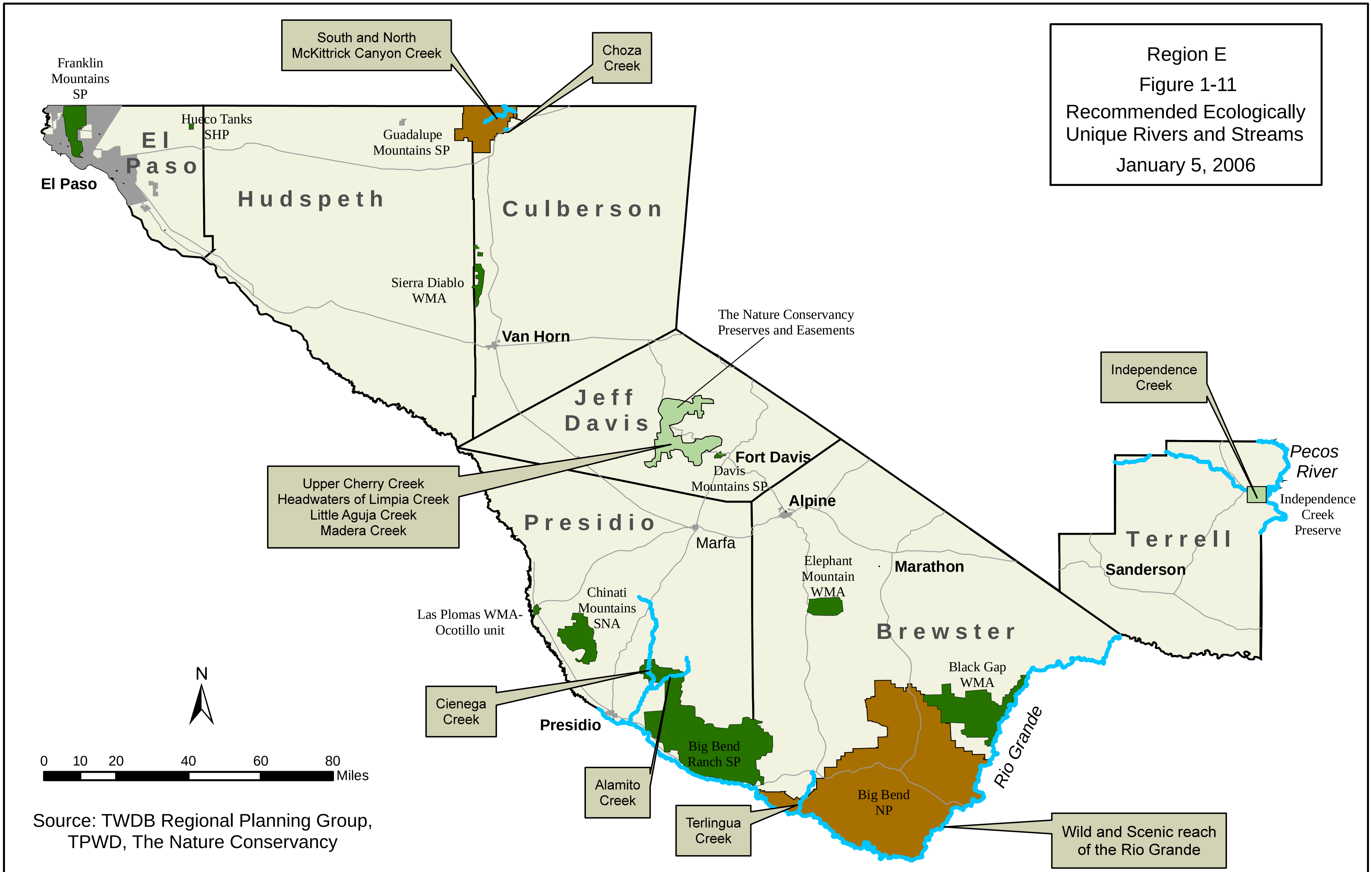
1.5.1.2 Pecos River

The Pecos River forms the eastern boundary of Far West Texas only for a short distance at the northeast corner of Terrell County (Figure 1-10). As a major tributary to the Rio Grande, the headwaters of the Pecos River originate as snowmelt east of Santa Fe, New Mexico in the Sangre de Cristo Mountains. The River flows southward through eastern New Mexico, where Red Bluff Lake impounds it at the Texas-New Mexico border. The Pecos River Compact provides the apportionment and division of Pecos River waters between New Mexico and Texas and is administered by the Pecos River Compact Commission. Although Pecos River water is typically too salty for human consumption, it has been a source for irrigation in Pecos, Reeves and Ward Counties. Downstream in Terrell County, water in the Pecos is mostly relegated to livestock use.

1.5.1.3 Ecologically Unique River and Stream Segments

As a part of the planning process, regional planning groups may include <u>recommendations</u> of ecologically unique river and stream segments in their adopted regional water plans (31 TAC 357.8). The Texas Legislature may <u>designate</u> a river or stream segment of unique ecological value following the recommendations of a regional water planning group. As per §16.051(f) of the Texas Water Code, this designation solely means that a state agency or political subdivision of the State may not finance the actual construction of a reservoir in a specific river or stream segment designated by the legislature under this subsection.

The FWTWPG chooses to respect the privacy of private lands and therefore recommends as "Ecologically Unique River and Stream Segments" (Figure 1-11) three streams that lie within the boundaries of state-managed properties, three within National Park boundaries, and specified streams managed by the Texas Nature Conservancy. These stream and river segments are described in Chapter 8.



The FWTWPG recommends only these parts of river and streams segments that are within the management boundaries of State and National Parks, and conservation lands managed by the Texas Nature Conservancy.

FIGURE 1-11. RECOMMENDED ECOLOGICALLY UNIQUE RIVER AND STREAM SEGMENTS

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1.5.2 Groundwater

Outside of the Rio Grande corridor, almost all water supply needs are met with groundwater withdrawn from numerous aquifers in the Region (Figure 1-12). Depth to water, well yields, and chemical quality dictate how these resources are used. A more thorough discussion of the aquifers, especially as it relates to water supply availability, can be found in Chapter 3. Aquifers recognized in the Region include the following:

- Hueco Bolson
- Mesilla Bolson
- Edwards-Trinity (Plateau) including geologically similar formations in South Brewster County sometimes referred to as the "Santa Elena" aquifer or "Cretaceous" aquifer
- Bone Spring-Victorio Peak
- Capitan Reef
- Davis Mountains Igneous
- Marathon
- Rustler
- West Texas Bolsons
- Rio Grande Alluvium
- Other locally recognized groundwater sources

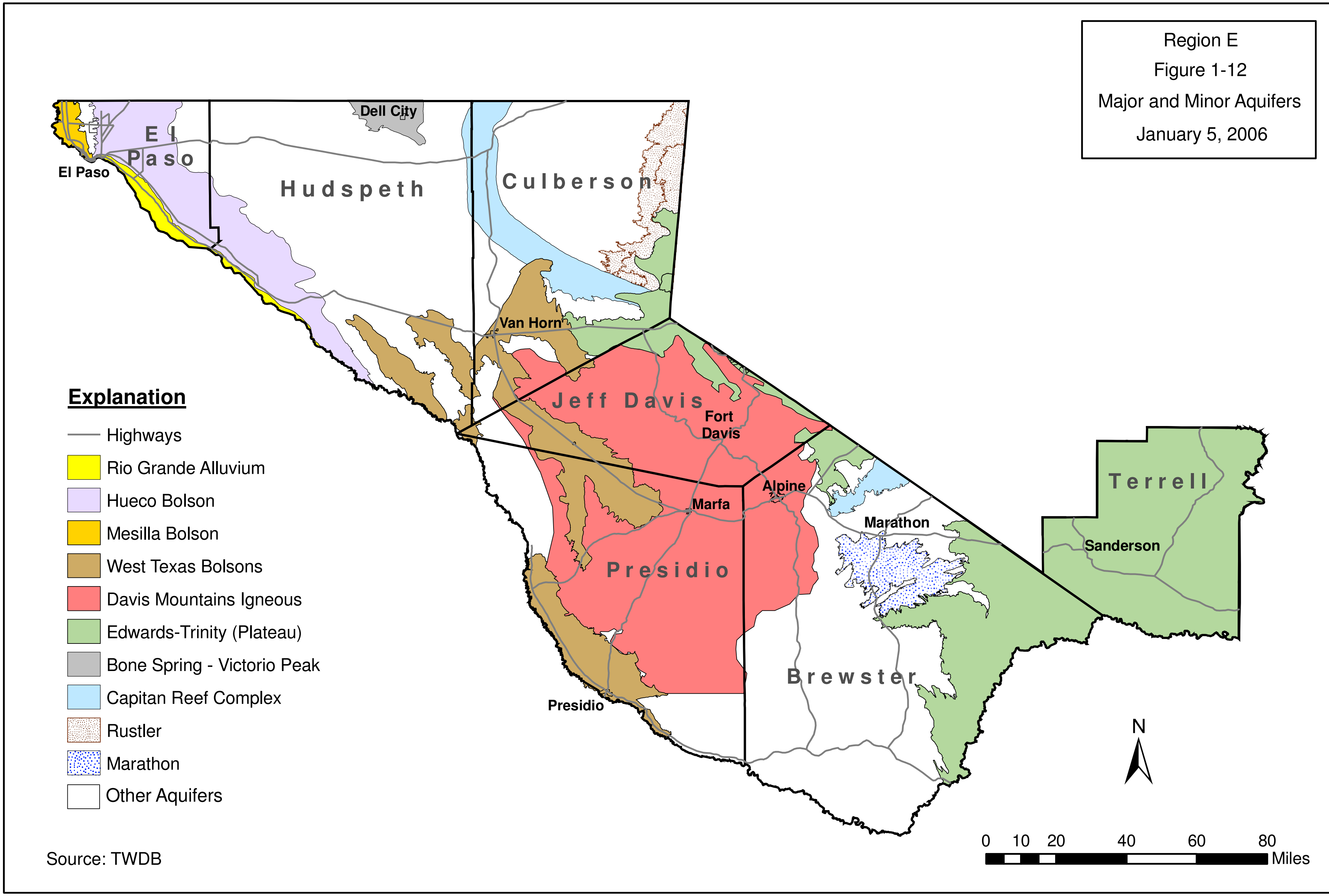

FIGURE 1-12. MAJOR AND MINOR AQUIFERS OF FAR WEST TEXAS

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1.5.2.1 Hueco Bolson Aquifer

The Hueco Bolson aquifer extends from east of the Franklin Mountains in El Paso County southeastward into southern Hudspeth County, and is bounded on the west and north by the Hueco Mountains, the Diablo Plateau, and the Quitman Mountains. The aquifer also continues south a short distance into Mexico. The Hueco Bolson along with the Mesilla Bolson aquifer provides approximately half of the municipal supply for the City of El Paso.

The Hueco Bolson aquifer is one of the sources of municipal supply for Ciudad Juarez; the second source now under study is the Conejos Medanos in northwest Ciudad Juarez, Mexico. Large-scale groundwater withdrawals, especially from municipal well fields in areas of El Paso and Ciudad Juarez, have caused significant declines in the water table.

In the previous regional water plan, fresh water in the aquifer was anticipated to be depleted by the year 2030, which resulted in an unmet supply need following 2030 for eight communities, including the City of El Paso. Through the use of the model, El Paso Water Utilities was able to develop a conjunctive use management plan that utilizes groundwater from the Hueco Bolson aquifer in a sustainable manner. El Paso Water Utilities is also actively developing a new water supply by desalinating the previously unused brackish portion of the aquifer.

1.5.2.2 Mesilla Bolson Aquifer

The Mesilla Bolson aquifer lies in the Upper Rio Grande Valley west of the Franklin Mountains and extends to the north into New Mexico where it is primarily used for agricultural and public supply purposes in New Mexico. In Texas, the agricultural use of this aquifer is much less than in New Mexico. The City of El Paso's Canutillo well field is located in the Mesilla Bolson.

1.5.2.3 Edwards-Trinity (Plateau) Aquifer

The Edwards-Trinity (Plateau) aquifer underlies the Edwards Plateau east of the Pecos River and the Stockton Plateau west of the Pecos River, and provides water to all or parts of 38 Texas counties. The aquifer extends from the Hill Country of Central Texas to the Trans-Pecos region of Far West Texas, where it is a minor source of water in Culberson, Jeff Davis, Brewster and Terrell Counties. There is relatively little pumpage from the aquifer over most of its extent in Far West Texas. Consequently, water levels have remained constant or have fluctuated only in response to seasonal precipitation. The City of Sanderson in Terrell County is the only municipality in the Region that pumps water from this aquifer.

1.5.2.4 Bone Spring-Victorio Peak Aquifer

The Bone Spring-Victorio Peak aquifer is located in northeast Hudspeth County along the eastern edge of the Diablo Plateau, west of the Guadalupe Mountains, and extends northward into the Crow Flats area of New Mexico. Water occurs in joints, fractures and solution cavities that have developed in the nearly 2,000 feet of limestone. Permeability is highly variable and well yields differ widely from about 150 gpm to more than 2,000 gpm.

The aquifer is used primarily as a source of irrigation water. Dell City is the only municipality that relies on the aquifer as a source of public supply; however, the City must filter the water through a desalination process to render the water supply potable. Although the water table has declined since pre-irrigation development, water levels have remained relatively constant since the late 1970s. The Hudspeth County Underground Water Conservation District #1 regulates the quantity of water withdrawn from the aquifer.

1.5.2.5 Capitan Reef Aquifer

The Capitan Reef aquifer is contained within a relatively narrow strip of limestone formations (10 to 14 miles wide) that formed along the shelf edge of the ancestral Permian Sea. In Texas, the reef formations are exposed in the Guadalupe, Apache, and Glass Mountains and trend northward into New Mexico, where the aquifer is a source of abundant fresh water for the City of Carlsbad. Within Far West Texas, the aquifer underlies sections of Culberson County and a small area of northern Brewster County. The City of El Paso has recently purchased approximately 29,000 acres overlying the Capitan Reef aquifer in northwestern Culberson County.

1.5.2.6 Davis Mountains Igneous Aquifer

The Davis Mountains Igneous aquifer occurs in the Davis Mountains of Jeff Davis County and extends outward into Brewster and Presidio Counties. The extent of the Davis Mountains Igneous aquifer as illustrated in Figure 1-12 represents a new boundary established in recent studies of the aquifer system. Groundwater is stored in the fissures and fractures of intrusive and extrusive rocks of volcanic origin. The chemical quality of the aquifer is generally good to excellent and well yields generally range from small to moderate. The Cities of Alpine, Fort Davis and Marfa rely on the aquifer as a source of municipal supply.

1.5.2.7 Marathon Aquifer

The Marathon aquifer is located entirely within north-central Brewster County and is used primarily as a municipal water supply by the Community of Marathon and for rural domestic and livestock purposes. Groundwater occurs in numerous crevices, joints and cavities at depths ranging from 350 feet to about 900 feet, and well yields range from 10 gpm to more than 300 gpm. Many of the shallow wells in the area actually produce water from alluvial deposits that overlie rocks of the Marathon aquifer. Groundwater is typically of good quality but hard.

1.5.2.8 Rustler Aquifer

The Rustler Formation is exposed in eastern Culberson County and plunges eastward into the subsurface of adjacent counties. The aquifer is principally located beneath Loving, Pecos, Reeves and Ward Counties, where it yields water for irrigation, livestock and water-flooding operations in oil-producing areas. Water occurs in highly permeable solution zones in dolomite, limestone and gypsum beds of the Rustler Formation. Large concentrations of dissolved solids render the water unsuitable for human consumption.

1.5.2.9 West Texas Bolsons Aquifer

Several deep bolsons, or basins, filled with sediments eroded from the surrounding highlands underlie Far West Texas. In places, the bolsons contain significant quantities of groundwater. These bolsons are referred to as Red Light Draw, Eagle Flat, Green River Valley, Presidio-Redford, and the Salt Basin. The Salt Basin is subdivided from north to south into the Wild Horse, Michigan, Lobo, and Ryan Flats. The upper part of the Salt Basin extending north of Wild Horse Flat contains groundwater with total dissolved solids well in excess of 3,000 mg/l. The bolson aquifers provide variable amounts of water for irrigation and municipal water supplies in parts of Culberson, Hudspeth, Jeff Davis and Presidio Counties. The communities of Presidio, Sierra Blanca, Valentine and Van Horn rely on the bolson aquifers for municipal water supplies.

1.5.2.10 Rio Grande Alluvium Aquifer

The Rio Grande Alluvium aquifer consists of Quaternary floodplain sediments laid down by the Rio Grande as the river cut into the surface of the Hueco Bolson. The floodplain forms a narrow valley within the topographically lowest part of the Hueco Bolson and extends nearly 90 miles from El Paso to Fort Quitman, where the valley is constricted between the Sierra de la Cienguilla of Chihuahua and the Quitman Mountains of Hudspeth County. The aquifer is hydrologically connected with the underlying Hueco Bolson, and is occasionally a source of irrigation water for farms in El Paso and Hudspeth Counties.

1.5.2.11 Other Groundwater Resources

Also shown in Figure 1-12 are large areas of Far West Texas that are not underlain by major or minor aquifers. The map, however, should not be interpreted as an indication that such areas are devoid of groundwater, but rather as a reflection of the current level of understanding of the extent of known groundwater resources in the Region. For example, the rocks that make up the subsurface of the Diablo Plateau of central and northern Hudspeth County may in fact have significant volumes of groundwater in storage. Because relatively few exploration wells have been drilled on the plateau, the aquifer has not been sufficiently evaluated to warrant definite conclusions regarding its status as a potential source of groundwater.

Similarly, very little hydrologic data has been collected in much of the remote areas of the rural counties in the Region. In southern Brewster County, the communities of Lajitas, Study Butte, and Terlingua, as well as much of Big Bend National Park, withdraw their municipal supplies from Cretaceous limestone aquifers. Further evaluation will be needed to arrive at a better understanding of the water-resource development potential in these areas.

1.5.3 Major Springs

Springs and seeps are found in all seven of the Far West Texas counties and have played an important role in the development of the Region. Springs were important sources of water for Native Americans, as indicated by the artifacts and petroglyphs found in the vicinity of many of the springs. In the 18th and 19th centuries, locations of transportation routes including supply and stage coach lines, military outposts, and early settlements and ranches were largely determined by the occurrence of springs that issued from locations in the mountains and along mountain fronts. Figure 1-13 shows the regional distribution of documented springs in the region that are currently in existence or are of historical significance.

Springs contribute to the esthetic and recreational value of private land and parkland in Far West Texas - especially in the Big Bend area, where a number of thermal springs discharge along the banks of the Rio Grande. Springs are significant sources of water for both aquatic and terrestrial wildlife as they form small wetlands that attract migratory birds and other fowl that inhabit the region throughout the year. As documented by the Texas Parks and Wildlife Department, springs also provide habitat for threatened and endangered species of fish (such as the Pecos and the Big Bend Gambusia).

The FWTWPG recognizes the importance of all springs in this desert community for their contribution as a water supply source and as a natural habitat. However, the FWTWPG chooses to respect the privacy of private lands and therefore specifically identifies the following "Major Springs" occurring only on state, federal, or privately owned conservation managed lands (Figure 1-14). These springs are discussed in detail in Appendix 1B. Many of these springs also are the primary source of flow to the "ecologically unique river and stream segments" described in Chapter 8.

- La Baviza Spring, Chinati Mountains State Natural Area - Presidio County

- Big Bend National Park / Rio Grande Wild and Scenic River Spring – Brewster County
  1. Gambusia Hot Springs Complex
  2. Outlaw Flats Spring Complex
  3. Las Palmas Spring Complex
  4. Madison Fold Spring Complex

- Guadalupe Mountains National Park – Culberson County
  1. Bone Spring
  2. Dog Canyon Spring
  3. Frijole Spring
  4. Goat Seep
  5. Guadalupe Spring
  6. Juniper Spring
  7. Manzanita Spring
  8. Smith Spring
  9. Upper Pine Spring

- Texas Nature Conservancy – Independence Creek Preserve – Terrell County
  1. Caroline Spring

- Texas Nature Conservancy – Davis Mountains Preserve – Jeff Davis County
  1. Tobe Spring
  2. Bridge Spring
  3. Pine Spring
  4. Limpia Spring

Source: Heitmuller and Reece, 2003
Database of Historically Documented Springs
and Spring Flow Measurements in Texas;
USGS OFR 03-315

FIGURE 1-13. LOCATIONS OF DOCUMENTED SPRINGS

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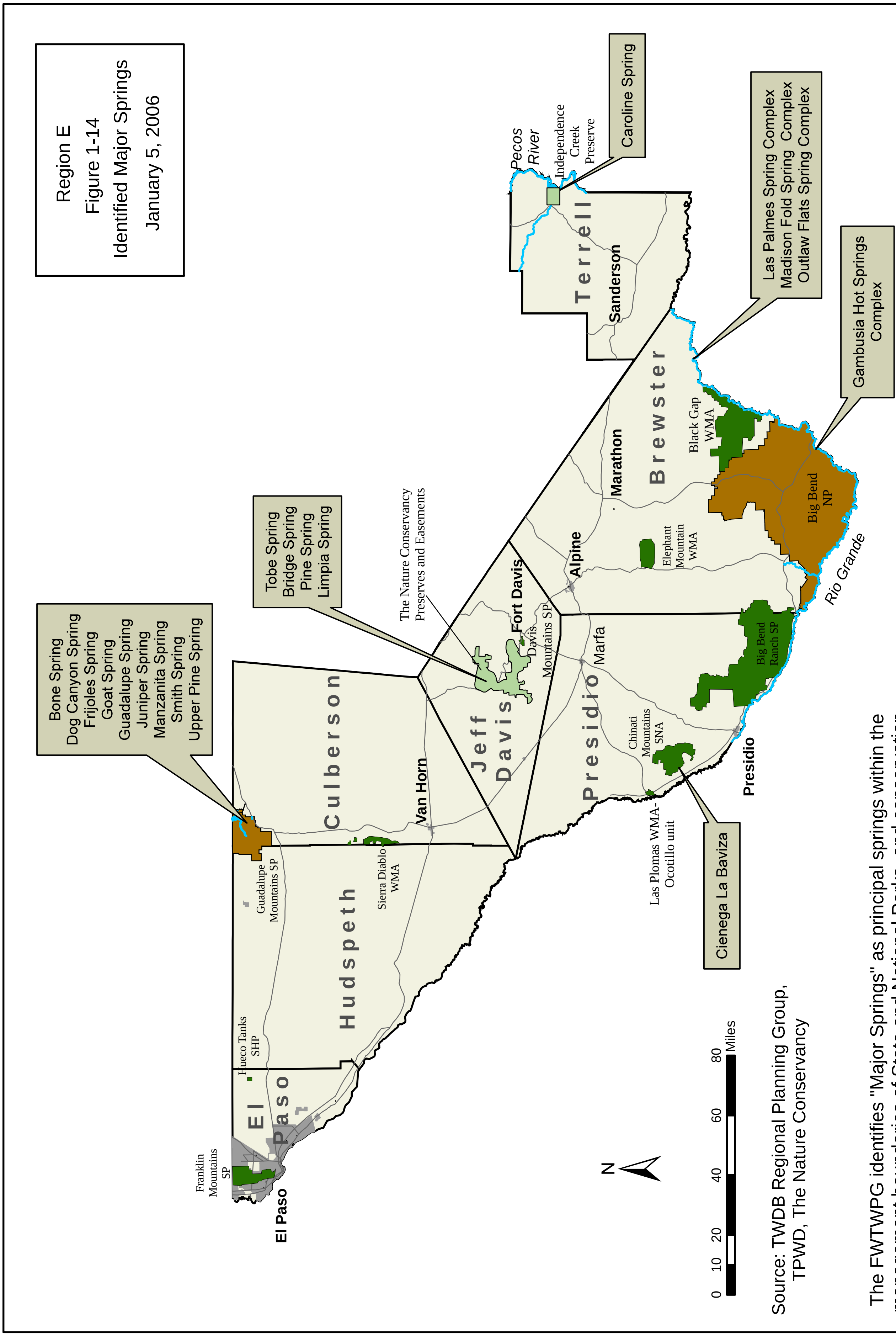
1.5.4 Reuse

El Paso has nearly 40 miles of reclaimed-water pipelines (purple pipeline) in place in all areas of the City. Reclaimed water serves the landscape irrigation demand of golf courses, parks, schools, and cemeteries, and also provides water supplies for steam electric plants and industries within the City. The supply from the direct reuse program is expected to increase from 5,000 acre-feet per year in 2000 to over 23,000 acre-feet per year by 2060. Projected expanded use of reclaimed water by decade is listed in Table 3-1 in Chapter 3.



Source: TWDB Regional Planning Group, TPWD, The Nature Conservancy

The FWTWPG identifies "Major Springs" as principal springs within the management boundaries of State and National Parks, and conservation lands managed by the Texas Nature Conservancy.

FIGURE 1-14. LOCATION OF IDENTIFIED MAJOR SPRINGS

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1.6 WATER MANAGEMENT PLANNING

1.6.1 State Water Planning

The Texas Water Development Board adopted *Water for Texas - 2002* on December 12, 2001 as the official Texas State Water Plan. The Texas Water Code directs the TWDB to periodically update this comprehensive water plan, which is used as a guide to State water policy. The 2002 State Water Plan was the first water plan to incorporate water management and policy decisions made at the regional level as expressed in the 16 approved regional water plans. Key points mentioned in the State plan for Far West Texas include:

- No new reservoirs
- Eight cities with unmet needs by 2050
- 23 water user groups with projected needs by 2050
- Fresh groundwater supplies available to El Paso depleted by 2030
- Rio Grande water unavailable during drought-of-record
- Desalination of groundwater increasingly important to El Paso
- Impacts of groundwater transfers from rural counties to be examined

In this current *2006 Far West Texas Water Plan*, the above issue of unmet water needs is addressed. Through the conjunctive use of local groundwater and surface water supplies, desalination of brackish groundwater, increased emphasis on conservation and reuse, and augmented by imported supplies in the future, non-agricultural entities in the El Paso County area now have an integrated management plan to meet their water-supply needs throughout the 50-year planning horizon.

1.6.2 Water Management and Drought Contingency Plans

Far West Texas is perennially under drought or near-drought conditions compared with more humid areas of Texas. Although residents of the Region are generally accustomed to these conditions, the low rainfall and the accompanying high levels of evaporation underscore the necessity of developing plans that respond to potential disruptions in the supply of groundwater and surface water caused by drought conditions. New El Paso County subdivision ordinances are intended to prevent the establishment of new housing developments without adequate water and wastewater facilities. Entities filing water conservation and drought contingency plans are listed in Chapter 6.

1.6.3 El Paso Water Utilities/Public Service Board as the Declared Regional Water Supply Planner

In 1995, the Texas Legislature passed Senate Bill 450 designating the El Paso Water Utilities/Public Service Board as the regional water and wastewater planner for El Paso County. The purpose of the Bill is to improve regional water and wastewater planning for El Paso County and encourage increased consultation, coordination, and cooperation in the management of regional water resources. The City of El Paso serves a pivotal role in all future planning and expansion projects. The City, through the EPWU/PSB, receives priority consideration for public funding for the planning, design, and construction of water supply and wastewater systems within the County. The intent of Senate Bill 450 is to address regional planning issues by the following seven actions:

- Coordinate water and wastewater management on a regional watershed basis.
- Address water quality and quantity conditions adversely affecting the public health and the environment.
- Provide efficient planning and management of water resources to mitigate existing and avoid future negative colonia conditions.
- Participate in water and wastewater planning with adjacent counties and the border states of New Mexico and Chihuahua, Mexico, to address transboundary water issues.
- Encourage conjunctive management for the protection and preservation of the limited surface-water and groundwater resources.
- Maximize the amounts and provide for the efficient use of public funding to implement the purposes of Senate Bill 450.

- Provide intergovernmental cooperation with water utilities to encourage their planning to be consistent with the regional plan.

1.6.4 Groundwater Conservation Districts

The Texas Legislature has established a process for local management of groundwater resources through groundwater conservation districts. Groundwater conservation districts are charged to manage groundwater by providing for the conservation, preservation, protection, recharging and prevention of waste of the groundwater within their jurisdictions. An elected or appointed board governs these districts and establishes rules, programs and activities specifically designed to address local problems and opportunities. Texas Water Code §36.0015 states, in part, "Groundwater Conservation Districts created as provided by this chapter are the State's preferred method of groundwater management." Five districts are currently in operation within the planning region (Figure 1-15) and their management goals are discussed in further detail in Chapter 6.

Brewster County Groundwater Conservation District

Culberson County Groundwater Conservation District

Hudspeth County Underground Water Conservation District #1

Jeff Davis County Underground Water Conservation District

Presidio County Underground Water Conservation District

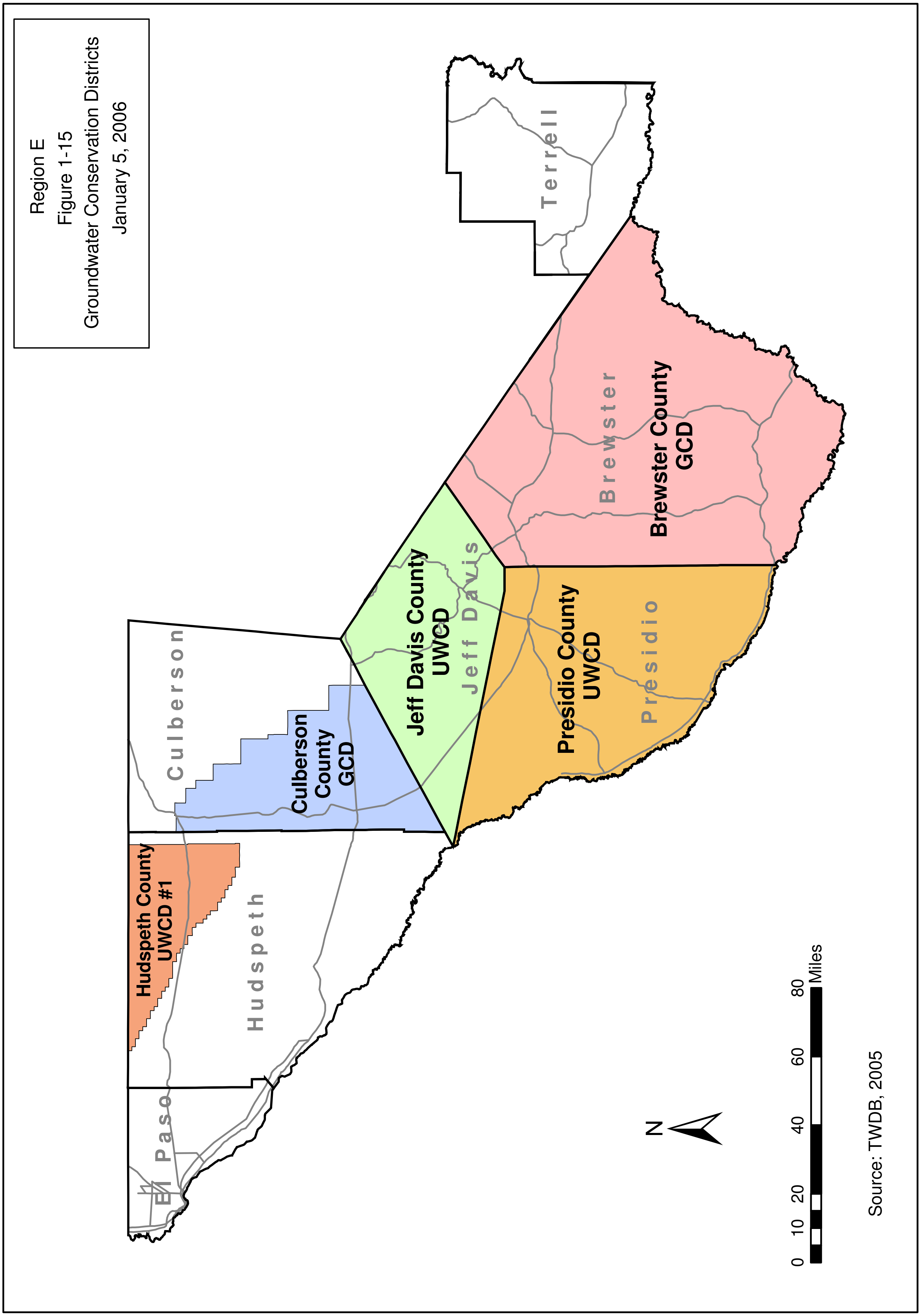

FIGURE 1-15. GROUNDWATER CONSERVATION DISTRICTS

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1.6.5 El Paso County Priority Groundwater Management Area

In 1985, the 69th Texas Legislature recognized that certain areas of the State were experiencing or were expected to experience critical groundwater problems. House Bill 2 directed the Texas Department of Water Resources (later to become the Texas Water Commission (TWC) and the Texas Water Development Board (TWDB)) to identify the critical groundwater areas in the State, to conduct studies in those areas, and to make recommendations on whether a groundwater conservation district should be established in critical areas.

The TWC and TWDB evaluated groundwater supply conditions in El Paso County in 1990 as part of the "Critical Area" program. An overview evaluation (TWDB Report 324) recognized that the Hueco Bolson aquifer had a long history of water-level decline and water-quality deterioration, and the expected life of the aquifer, under then current conditions, was about 60 years at best. Rather than declaring the area "Critical," the TWC place a moratorium over the declaration until after the completion of a 50-year City of El Paso water management plan.

Senate Bill 1 changed the name of "Critical Area" to "Priority Groundwater Management Area" (PGMA) and mandated that the Texas Natural resource Conservation Commission (TNRCC - successor agency to the TWC and later to be named TCEQ) complete reviews of all pending PGMA studies. The TNRCC requested a technical update study of El Paso County (TWDB Open-File Report, Preston 1998) and (TPWD Report, El-Hage and Moulton, 1998). These studies were completed in the spring of 1998. The TWDB report concluded that water-level declines and quality deterioration are still present in the Hueco Bolson, but did not address El Paso's plans to remedy the problems and provide long-term management. The TPWD reported no known effect on wildlife as a result of water-level declines in the Hueco Bolson aquifer. TNRCC staff then completed their analysis and recommended to their Commissioners that the area identified by the TWDB as the Hueco Bolson aquifer in El Paso County be declared a PGMA (TNRCC File Report, Musick, 1998).

The Commissioners, subsequently, declared "the area of El Paso County overlying the Hueco Bolson aquifer, including its subcrops and outcrops" as a Priority Groundwater Management Area. However, the Commissioners stated that "El Paso has clearly demonstrated a significant effort toward regional cooperation, planning, and voluntary implementation of actions to address water supply problems" and that "it is not clear that creating a groundwater conservation district for the area of El Paso County overlying the Hueco Bolson aquifer would be in the public interest, meet a public need, or benefit the property therein at this time" (TNRCC Docket No. 98-0999-MLM, SOAH Docket No. 582-98-1540).

1.6.6 Hudspeth County Priority Groundwater Management Area Consideration

In March 2005, Texas Commission on Environmental Quality (TCEQ) released a report titled Evaluation for the Hudspeth County Priority Groundwater Management Study area. The purpose of this evaluation was to determine if the Hudspeth County area is experiencing, or is expected to experience within the next 25 years, critical groundwater problems, and whether a groundwater conservation district should be created to address such problems. The study area included all of Hudspeth County; however only the area outside of the Hudspeth County Underground Water Conservation District No. 1 was considered for priority groundwater management area (PGMA) designation.

For this report, TCEQ staff considered comments, data, and information provided by a number of different sources including water stakeholders from within the study area, the TWDB, the TPWD, the FWTWPG, and independent research by the staff. The report discusses the available authority and management practices of existing groundwater management entities within and adjacent to the study area, and makes recommendations on appropriate strategies needed to conserve and protect local groundwater resources.

The water supply problems identified in the study area include widespread total dissolved solids concentrations in groundwater and the lack of firm alternative supplies for irrigation use in the Rio Grande Valley during drought-of-record conditions. Groundwater concerns expressed by area stakeholders included sustainability, water quality, availability, access to alternative water supplies, and the possibility of water exportation.

The TCEQ concluded that the identified water supply and water quality issues are not presently critical problems and are not anticipated to be critical during the next 25-year planning horizon, and that the Hudspeth County study area should not be designated as a PGMA at this time. However, the TCEQ also acknowledges that the creation of a groundwater conservation district is a feasible and practicable groundwater management option for citizens of the study area to consider.

1.6.7 Water-Supply Source Vulnerability

Following the events of September 11th, Congress passed the Bio-Terrorism Preparedness and Response Act. Drinking water utilities serving more than 3,300 people were required and have completed vulnerability preparedness assessments and response plans for their water, wastewater, and stormwater facilities. The U.S. Environmental Protection Agency (EPA) funded the development of three voluntary guidance documents, which provide practical advice on improving security in new and existing facilities of all sizes. The documents include:

- Interim Voluntary Security Guidance for Water Utilities www.awwa.org
- *Interim Voluntary Security Guidance for Wastewater/Stormwater Utilities* www.wef.org
- *Interim Voluntary Guidelines for Designing an Online Contaminant Monitoring System* www.asce.org

1.7 COLONIAS

Colonias represent a special and growing subset of municipal water demand in the Region, and present a challenge to water suppliers. While some colonias in the Region are century-old historic settlements, most are substandard subdivisions in unincorporated areas located along the United States/Mexico international border that have been illegally subdivided into small parcels characterized by a lack of basic services. These small parcels do not have a drinking water supply, wastewater services, paved roads, or proper drainage, and are typically sold to individuals of modest means who may be unaware of the negative consequences of purchasing illegally subdivided property. Public health problems are often associated with these colonias.

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/waste systems services to the colonias. An economically distressed area is defined as one in which water supply or wastewater systems are not adequate to meet minimal State standards, financial resources are inadequate to provide services to meet those needs, and there was an established residential subdivision on June 1, 1989. Affected counties are counties adjacent to the Texas/Mexico border, or that have per capita income 25 percent below the State average and unemployment rates 25 percent above the State average for the most recent three consecutive years for which statistics are available. Additional information pertaining to eligibility and requirements for this program are available on the TWDB web site http://www.twdb.state.tx.us/assistance/financial/fin_infrastructure/edapfund.asp

EDAP projects in Far West Texas are located in El Paso, Hudspeth, and Terrell Counties and are described in the following table. Data pertaining to all EDAP projects in the State can be accessed through the TWDB web site http://www.twdb.state.tx.us/publications/reports/Colonias/status.pdf.

TABLE 1- 1. ECONOMICALLY DISTRESSED AREA PROGRAM PROJECTS IN FAR WEST TEXAS

County	Sponsor	Project	Activity	Citizens Served	Cost (Millions)	Status
El Paso	City of El Paso	Canutillo	Wastewater	2,846	$11.06	Completed 4/30/02
El Paso	City of El Paso	Westway II	Water and wastewater	8,187	$5.75	Completed 5/23/00
El Paso	El Paso County	East Montana	Water	7,929	$13.73	Completed 3/10/99
El Paso	Lower Valley Water District	Socorro Bauman	Water	3,927	$1.80	Completed 8/17/94
El Paso	Lower Valley Water District	Socorro Phase II	Water and wastewater	9,299	$14.74	Completed 5/13/98
El Paso	Lower Valley Water District	Socorro / San Elizario	Water and wastewater	26,403	$55.43	Completed 4/02/02
El Paso	El Paso WCID	Westway	Water	9,052	$1.44	Completed 5/02/94
El Paso	Homestead MUD	East Montana	Water	16,750	$9.24	Completed 7/01/98
El Paso	El Paso WID	Tornillo	Wastewater	1,460	$5.49	Preparing plans and specifications
El Paso		Village of Vinton	Water and wastewater	633	$0.04	Contract terminated 12/15/00
Hudspeth	Hudspeth WCID #1	Sierra Blanca	Wastewater	1,100	$2.23	Completed 7/28/00
Terrell	Terrell County WCID #1	Sanderson	Wastewater	1,128	$4.18	Completed 9/2/04

1.7.1 El Paso County Colonias

In December 1998, the TWDB estimated that there were 172 colonias within the El Paso area. In El Paso County alone, 156 colonias were recognized. Culberson County was the only county within Far West Texas that did not have a colonia.

The EPWU has served as a program manager to assist outlying water districts in applying for funding, master planning, design, and construction management. As regional planner for El Paso County, EPWU continues to work with various water districts in an effort to consolidate efforts in securing adequate water supplies and to capitalize on economies of scale.

Additional funding from NAD Bank ($1.9 million) and the Paso Del Norte Health Foundation ($1 million), and excess Lower Valley EDAP Phase II funds from TWDB ($0.85 million) are being used to fund qualified private (customer) wastewater service line and connection projects within the Lower Valley Water District. A total of 1,193 households will be provided service by the two projects that are under construction. Construction consists of installing the pipeline from a house to a collector line located at the street, associated clean-outs, and emptying and abandoning the existing septic tank.

Similarly, El Paso County has received $0.9 million from the Texas Department of Housing and Community Affairs (TDHCA) earmarked for qualified private (customer) water and wastewater service line and connection projects in the communities of Westway and Canutillo. It is estimated that 280 wastewater and 33 water connections will be made in Westway, and approximately 700 wastewater connections in Canutillo.

Title 30, Texas Administrative Code, Chapter 285 and the Texas Health and Safety Code, Chapter 366, §366.032 requires residents in rural areas of the county who do not have piped sewer infrastructure to comply with septic tank installation standards and receive a certificate of compliance prior to receiving water, gas, and electric utility service. Known as the On Site Septic Facility (OSSF) program, this program is intended to prevent unhealthy conditions and protect underground water, and is enforced by the El Paso City/County Health and Environmental District.

1.7.2 Rural County Colonias

Fewer colonias occur in the rural counties; however, their needs are of similar importance. The following is a summary of each rural county's colonias, associated projects and costs where available (source: TWDB EDAP database and local input).

- Brewster County
  Marathon - Water Supply/Wastewater $112,600

  Study Butte - Water Supply $1,257,000
- Hudspeth County

  Acala - Planning Studies/Water Supply $521,208

  Villa Alegre - Wastewater

  Fort Hancock East Unit #1 and Unit #2
- Jeff Davis County
  Fort Davis - Wastewater $462,534

  Valentine - Wastewater
- Presidio County

  Candelaria - Water Supply/Wastewater $300,000

  Shafter - Water Supply/Wastewater

  Las Pampas (Larson Ranch) - Water Supply/Wastewater

  Ruidosa - Water Supply/Wastewater $315,000

  Loma Pelona (Bald Hills) - Water Supply $515,000

  Redford - Water Supply/Wastewater $572,200

  Pueblo Nuevo (Millington Addition) - Water Supply $500,000

1.8 INTERNATIONAL WATER ISSUES

1.8.1 Ciudad Juarez

Ciudad Juarez is located across the Rio Grande from the City of El Paso and currently is 100 percent dependent on the Hueco Bolson aquifer to satisfy all of its municipal and industrial demands. El Paso is dependent on the Hueco Bolson aquifer to satisfy approximately 40 percent of its municipal and industrial needs.

Since 1989, El Paso has been reducing its pumping from the Hueco. In 2002, EPWU Hueco pumping was 39,151 acre-feet/yr, an amount that was similar to the pumping in 1968. The large reduction in El Paso's dependence on Hueco groundwater can be traced to (1) the

City's increasing use of surface water, (2) the adoption of water-conservation programs, (3) the initiation of pricing strategies that discourage excessive water consumption, and (4) an increase in the use of reclaimed water. Pumping from the Hueco by Ciudad Juarez since 2000 is summarized below:

Year	Ciudad Juarez Hueco Groundwater Pumping (acre-feet/yr)
2000	126,172
2001	124,735
2002	124,676
2003	125,144
2004	119,420

Pumping over the last five years has shown small variation, and possibly a slight decline. Water conservation efforts in Ciudad Juarez have essentially offset increased population and increased service connections to existing areas.

With a growing population that is currently estimated to be over 1.3 million, Ciudad Juarez recognizes the limitations of the Hueco Bolson to supply future demands. Current planning calls for capping Hueco pumping at about 122,000 acre-feet/yr, and supply increased demands through 2020 from the following "imported" groundwater sources:

- Conejos Medanos (38,000 acre-feet/yr)
- Bismark Mine (26,000 acre-feet/yr)
- Mesilla (26,000 acre-feet/yr)
- Somero (28,000 acre-feet/yr)
- Profundo (31,000 acre-feet/yr)

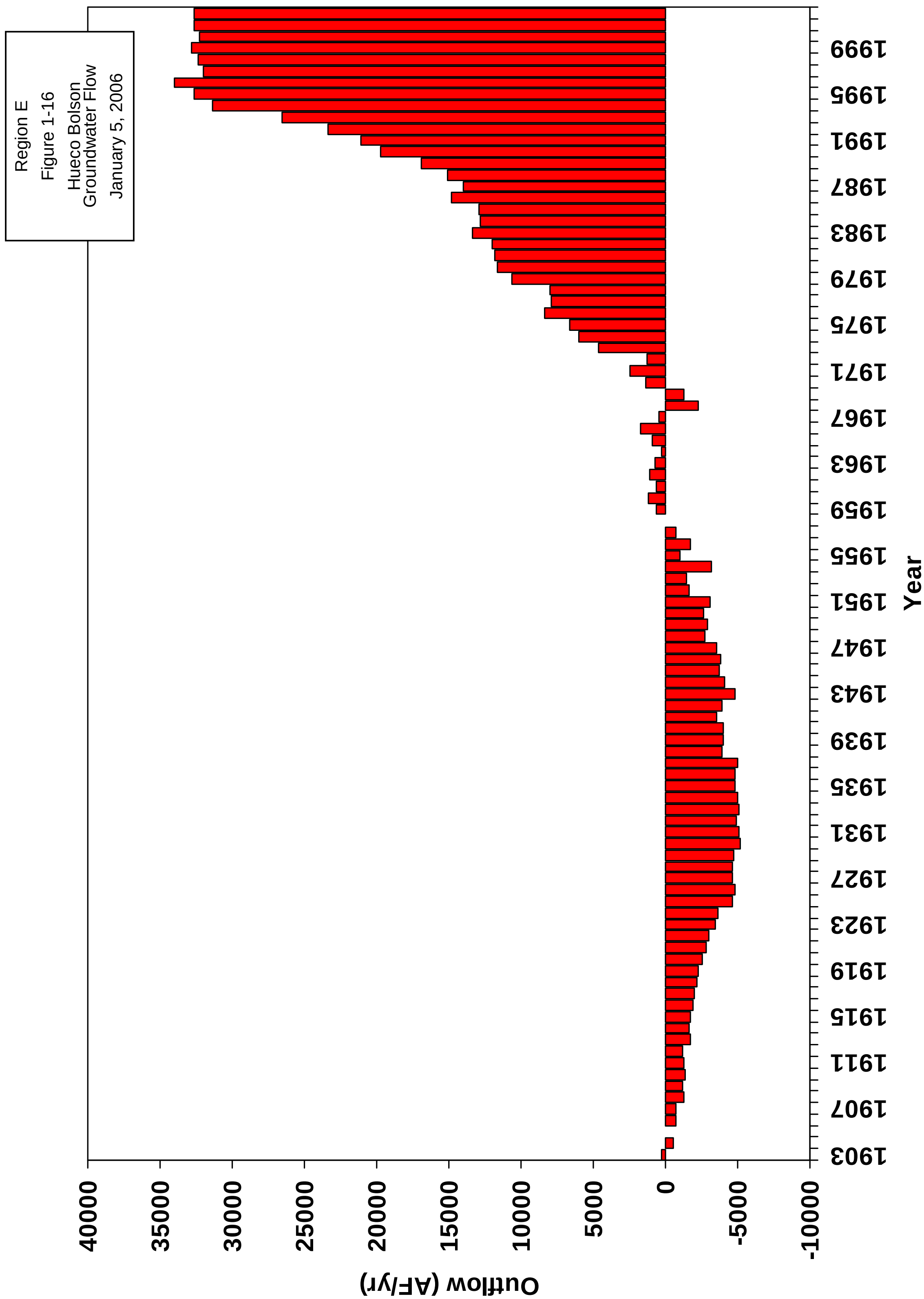
In addition, plans are also being developed to convert 38,000 acre-feet/yr of surface water from the Rio Grande (Rio Bravo) for use as municipal supply. Currently, Mexico's allocation from the Rio Grande Project of 60,000 acre-feet/yr is used for irrigated agriculture. The conversion would involve supplying wastewater effluent to farmers in exchange for surface water. Of these projects, the first phase of the Conejos Medanos is expected to be operational in 2006.

1.8.2 Transboundary Effects of Groundwater Pumpage

Prior to 1960, up to 5,000 acre-feet/yr of groundwater flowed from Mexico to Texas as a result of higher pumping in El Paso than in Juarez. Since 1960, groundwater has generally flowed from Texas into Mexico due to increases in Juarez pumping. The rate of flow has been about 33,000 acre-feet/yr over the last decade. Figure 1-16 (Figure 6-20 from Hutchison, 2004) graphically displays this phenomenon.

With continuous pumping from both Ciudad Juarez and El Paso, both cites have experienced extensive water-level drawdowns and water-quality degradation due to lateral brackish water intrusion into the fresh water zones. Brackish water intrusion from irrigation return flow drains continues to expand laterally and vertically, and to degrade water quality in the shallow alluvium along the Rio Grande.

Hutchison (2004) presented the results of simulations of future management alternatives for the Texas portion of the Hueco that included the assumption that Juarez pumping would remain at about 122,000 acre-feet/yr. These simulations showed that EPWU pumping of 40,000 acre-feet/yr in years with full allocation of surface water and 75,000 acre-feet/yr in drought years would result in minor storage declines that would not impact existing infrastructure for at least 100 years ("nearly sustainable"). As part of the results of these simulations, groundwater flow from Texas into Mexico would vary between about 34,000 acre-feet/yr and 36,000 acre-feet/yr over the next 50 years.



(Hutchison, 2004)

FIGURE 1-16. RATE OF FLOW OF HUECO BOLSON GROUNDWATER FROM TEXAS TO MEXICO

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1.9 STATE AND FEDERAL AGENCIES WITH WATER RESPONSIBILITIES

1.9.1 Texas Water Development Board (TWDB)

The TWDB, especially the Water Resources Planning Division, is at the center of the Senate Bill 1 regional water 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. Results of the 16 regional water plans are then incorporated by the TWDB into a State Water Plan. The TWDB also administers financial grant and loan programs that provide funding for water research and facility planning projects.

1.9.2 Texas Commission on Environmental Quality (TCEQ)

The TCEQ strives to protect the State's natural resources, consistent with a policy of sustainable economic development. TCEQ's goal is clean air, clean water, and the safe management of waste, with an emphasis on pollution prevention. The TCEQ is the major State agency with regulatory authority over State waters in Texas. The TCEQ has inventoried the water-right filings and claims within the Upper Rio Grande Basin as part of the water-rights adjudication process, but has not completed this process. To make this process complete, the adjudication would have to be evaluated and ruled upon by District Court. The TCEQ is also responsible for ensuring that all public drinking-water systems are in compliance with the strict requirements of the State of Texas.

1.9.3 Texas Parks and Wildlife Department (TPWD)

The TPWD 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.

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, nationally, and internationally; (2) assisting in the development of the agribusiness in Texas; (3) regulating 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.

1.9.5 Texas State Soil and Water Conservation Board (TSSWCB)

The TSSWCB is charged with the overall responsibility for administering the coordination of 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 forest nonpoint source pollution. Currently, the agricultural/forest 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 United States, which govern these waters; the treaties are discussed in detail elsewhere in this report. The IBWC is continuing discussions with Mexico on the issue of making up "water debt" under the 1944 treaty; however, as of the printing of this plan, Mexico has repaid its entire water debt.

1.9.7 United States Bureau of Reclamation

The stretch of the Rio Grande from Elephant Butte Dam (approximately 100 miles north of El Paso) to Fort Quitman, Texas, is within a federal reclamation project known as the Rio Grande Project. The Bureau of Reclamation manages the Elephant Butte Dam and the Caballo Reservoir, and determines the amount and timing of all water releases to Texas, with the input of the El Paso County Water Improvement District #1. The Bureau is guided by the terms of the Rio Grande Compact. The Bureau has asserted title to all of the water in the Project in a lawsuit styled United States v. EBID, et al, which is currently being litigated.

1.9.8 United States Geological Survey (USGS)

The USGS is responsible for fulfilling the Nation's needs for reliable, impartial scientific information to describe and understand the Earth. This information is used to minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect the quality of life. The USGS is the Federal Government's principal civilian map-making agency; the primary source of its data on the quality and quantity of the Nation's water resources; the Nation's primary provider of earth-science information on natural hazards, mineral and energy resources, and the environment; and the major partner in developing the Nation's understanding of the status and trends of biological resources and the ecological factors affecting living resources.

1.9.9 United States Environmental Protection Agency (EPA)

The mission of the EPA is to protect 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.

1.9.10 United States Fish and Wildlife Service (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 distributes money for fish and wildlife restoration, hunter education, and related projects across the country.

1.10 LOCAL ORGANIZATIONS AND UNIVERSITIES

The public and even those involved in water planning and management find it difficult to know about or keep track of the large number and wide array of organizations involved with water resource issues in Far West Texas. Following is a list of a number of these organizations that have been identified as being involved in some manner in water resource issues. Because of the hydrologic, cultural and economic connections of Far West Texas with Southern New Mexico and Mexico, this list includes water organizations in this expanded region. The list is likely incomplete as there are certainly other organizations deserving of being included. Appendix 1C provides information about each organization's purpose and points of contact.

- Alliance for the Rio Grande Heritage
- Border Environmental Cooperation Commission
- City Of El Paso
  Water Conservation Advisory Board
  Rio Grande Riverpark Task Force
- City Of Las Cruces
  Rio Grande Riparian Ecological Corridor Project
- Consortium for Hi-Technology Investigations in Water and Waste Water
- Environmental Defense
- Forest Guardians

- Hudspeth Directive for Conservation
- New Mexico State University
  New Mexico Lower Rio Grande Regional Water Users Org.
  New Mexico Water Conservation Alliance
  New Mexico Water Resources Research Institute
  New Mexico Water Task Force
  WERC
- New Mexico Water Trust Board
- North American Commission for Environmental Cooperation
- New Mexico-Texas Water Commission
- North American Development Bank
- Paso Del Norte Watershed Council
- Paso Del Norte Water Task Force
- Project Del Rio
- Rio Grande/Rio Bravo Basin Coalition
- Rio Grande Council Of Governments
- Rio Grande Institute
- Rio Grande Watershed Federal Coordinating Committee
- Southwest Environmental Center
- The Texas A&M University System
  El Paso Agricultural Research and Extension Center, Texas Agricultural Experiment Station
  Texas Cooperative Extension
  Rio Grande Basin Initiative
  Texas Water Resources Institute
- Texas State University System
  Sustainable Agricultural Water Conservation in the Rio Grande Basin Project

- Texas Water Matters

  Lone Star Chapter of the Sierra Club

  National Wildlife Federation

  Environmental Defense
- Tularosa Basin National Desalination Research Facility
- University of Texas at El Paso

  Center for Environmental Resource Management

  Rio Bosque Wetlands Park

  Southwest Consortium for Environmental Research and Policy of the Southwest
- U. S. Mexico Border Coalition of Resource Conservation and Development Councils
- World Wildlife Fund – Chihuahuan Desert Program

APPENDIX 1A

RARE, THREATENED, AND ENDANGERED SPECIES

Source Citation:

Texas Parks and Wildlife Department, Wildlife Division, Non-game and Rare Species and Habitat Assessment programs. County Lists of Texas' Special Species:

Brewster County	Last Revision 1 Sept 2005
Culberson County	Last Revision 2 Jun 2005
El Paso County	Last Revision 26 Aug 2005
Hudspeth County	Last Revision 2 Jun 2005 (Draft, Species Might be Added/Deleted During Quality Control)
Jeff Davis County	Last Revision 1 Sept 2005 (Draft, Species Might be Added/Deleted During Quality Control)
Presidio County	Last Revision 6 Aug 2005 (Draft, Species Might be Added/Deleted During Quality Control)
Terrell County	Last Revision 6 Aug 2005 (Draft, Species Might be Added/Deleted During Quality Control)

BREWSTER COUNTY

	Federal Status	State Status
***** BIRDS *****		
American Peregrine Falcon (*Falco peregrinus anatum*) - resident in west Texas	DL	E
Arctic Peregrine Falcon (*Falco peregrinus tundrius*) - potential migrant	DL	T
Baird's Sparrow (*Ammodramus bairdii*) - shortgrass prairie with scattered low bushes and matted vegetation		
Black-capped Vireo (*Vireo atricapilla*) - oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous and broad-leaved shrubs and trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level, and required structure; nesting season March-late summer	LE	E
Common Black Hawk (*Buteogallus anthracinus*) - cottonwood-lined rivers and streams; willow tree groves on the lower Rio Grande floodplain; formerly bred in Texas		T
Gray Hawk (*Asturina nitida*) – locally and irregularly along U.S.-Mexico border; mature riparian woodlands and nearby semiarid mesquite and scrub grasslands; breeding range formerly extended north to southernmost Rio Grande floodplain of Texas		T
Interior Least Tern (*Sterna antillarum athalassos*) – this subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish & crustaceans, when breeding forages within a few hundred feet of colony	LE	E
Montezuma Quail (*Cyrtonyx montezumae*) – open pine-oak or juniper-oak with ground cover of bunch grass on flats and slopes of semi-desert mountains and hills; travels in pairs or small groups; eats succulents, acorns, nuts, and weed seeds, as well as various invertebrates		
Mountain Plover (*Charadrius montanus*) – shortgrass plains and plowed fields (bare, dirt fields); primarily insectivorous		
Northern Aplomado Falcon (*Falco femoralis septentrionalis*) - open country, especially savanna and open woodland, and sometimes in very barren areas; grassy plains and valleys with scattered mesquite, yucca, and cactus; nests in old stick nests of other bird species	LE	E
Southwestern Willow Flycatcher (*Empidonax traillii extimus*) - thickets of willow, cottonwood, mesquite, and other species along desert streams	LE	E

Species	Federal Status	State Status
Western Burrowing Owl (*Athene cunicularia hypugaea*) - open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows and man-made structures, such as culverts		
Yellow-billed Cuckoo (*Coccyzus americanus*) - status applies only west beyond the Pecos River Drainage; breeds in riparian habitat and associated drainages; springs, developed wells, and earthen ponds supporting mesic vegetation; deciduous woodlands with cottonwoods and willows; dense understory foliage is important for nest site selection; nests in willow, mesquite, cottonwood, and hackberry; forages in similar riparian woodlands; breeding season mid-May-late Sept	C1	
Zone-tailed Hawk (*Buteo albonotatus*) - arid open country, including open deciduous or pine-oak woodland, mesa or mountain county, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
***** FISHES *****		
Big Bend Gambusia (*Gambusia gaigei*) – presently restricted to one artificial springfed pool in Big Bend National Park close to the Rio Grande; type locality described as a marshy cattail slough fed by springs	LE	E
Bluntnose Shiner (*Notropis simus*) (extirpated) - main river channels, often below obstructions over substrate of sand, gravel, and silt; damming and irrigation practices presumed major factors contributing to decline		T
Blue Sucker (*Cycleptus elongatus*) - larger portions of major rivers in Texas; usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles		T
Chihuahua Shiner (*Notropis chihuahua*) – clear, cool water that is often associated with nearby springs; often in pools with slight current or riffles over a gravel or sand bottom where vegetation may be present		T
Conchos Pupfish (*Cyprinodon eximius*) – Rio Grande and Devils River basins; sloughs, backwaters, and margins of larger streams, channels of creeks, and mouths		T

Headwater Catfish (*Ictalurus lupus*) – originally throughout streams of the Edwards Plateau and the Rio Grande basin, currently limited to Rio Grande drainage, including Pecos River basin; springs, and sandy and rocky riffles, runs, and pools of clear creeks and small rivers

Maravillas red shiner (*Cyprinella lutrensis blairi*)(extinct) – found in Maravillas Creek, reported extinct in 1989

Mexican Stoneroller (*Campostoma ornatum*) – in Texas, Big Bend region; clear, fast riffles, chutes, and pools in small to medium-sized creeks with gravel or sand bottoms — T

Rio Grande Shiner (*Notropis jemezanus*) – large, open, weedless rivers or large creeks with bottom of rubble, gravel and sand, often overlain with silt

Rio Grande Silvery Minnow (*Hybognathus amarus*) (extirpated) - historically Rio Grande and Pecos River systems and canals; pools and backwaters of medium to large streams with low or moderate gradient in mud, sand, or gravel bottom; ingests mud and bottom ooze for algae and other organic matter; probably spawns on silt substrates of quiet coves. — LE — E

West Mexican Redhorse (*Scartomyzon austrinus*) – known only from Alamito Creek, Big Bend region; restricted to rocky riffles of creeks and small to medium rivers, often near boulders in swift water

***** INSECTS *****

Blanchards' Sphinx Moth (*Amplypterus blanchardi*) – unknown, but may be confined to the deciduous forest in Upper Green Gulch to Panther Pass summit of Big Bend National Park; host plant undetermined; May-June adult emergence

Bonita Diving Beetle (*Deronectes neomexicana*) – predatory, feeding on other water insects and insect larvae; spend majority of life underwater, surfacing only to create an air bubble held under the wing covers for breathing

***** MAMMALS *****

Big Free-tailed Bat (*Nyctinomops macrotis*) – habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undetermined, but may hibernate in the Trans-Pecos; opportunistic insectivore

Black-tailed Prairie Dog (*Cynomys ludovicianus*) – dry, flat, shortgrass grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups

	Federal Status	State Status
Black Bear (*Ursus americanus*) - within historical range of Louisiana Black Bear in eastern Texas, Black Bear is federally listed threatened and inhabits bottomland hardwoods and large tracts of undeveloped forested areas; in remainder of Texas, Black Bear is not federally listed and inhabits desert lowlands and high elevation forests and woodlands; dens in tree hollows, rock piles, cliff overhangs, caves, or under brush piles	T/SA NL	T
Cave Myotis Bat (*Myotis velifer*) - roosts colonially in caves, rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (*Petrochelidon pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum caves of Panhandle during winter; opportunistic insectivore		
Davis Mountains Cottontail (*Sylvilagus floridanus robustus*) – brushy pastures, brushy edges of cultivated fields, and well-drained streamsides; active mostly at twilight and at night, where they may forage in a variety of habitats, including open pastures, meadows, or even lawns; rest during daytime in thickets or in underground burrows and small culverts; feed on grasses, forbs, twigs and bark; not sociable and seldom seen feeding together		
Desert Bighorn Sheep (*Ovis canadensis mexicana*) – rough, rocky mountainous terrain; bluffs ans steep slopes with sparse vegetation		
Fringed Bat (*Myotis thysanodes*) – habitat variable, ranging from mountainous pine, oak, and pinyon-juniper to desert-scrub, but prefers grasslands at intermediate elevations; highly migratory species that arrives in Trans-Pecos by May to form nursery colonies; single offspring born June-July; roosts colonially in caves, mine tunnels, rock crevices, and old buildings		
Ghost-faced Bat (*Mormoops megalophylla*) - colonially roosts in caves, crevices, abandoned mines, and buildings; insectivorous; breeds late winter-early spring; single offspring born per year		
Gray Wolf (*Canis lupus*) (extirpated) – formerly known throughout the western two-thirds of the state in forests, brushlands, or grasslands	LE	E
Greater Long-nosed Bat (*Leptonycteris nivalis*) – in Texas, Big Bend region; colonial, cave-dwelling species that usually inhabits deep caverns; nectivorous, with *Agave* spp. preferred; breeding season April-June, with single offspring born in Mexico prior to migration to Texas	LE	E
Greater Western Mastiff Bat (*Eumops perotis californicus*) – diurnal roosts in rock crevices of vertical cliffs; colony size varies from several individuals to several dozen; males and females may remain together throughout the year; single offspring (occasionally twins) born June-July		

Species	Federal Status	State Status
Limpia Creek Pocket Gopher (*Thomomys bottae texensis*) – throughout Davis Mountains; habitat variable, ranging from lower canyons to higher coniferous woodlands; loose sands and silts to tight clays; dry deserts to montane meadows; active year round, mostly underground; diet variable, but mostly roots and tubers; breeds continuously, but main season in spring		
Limpia Southern Pocket Gopher (*Thomomys bottae limpiae*) - Limpia Canyon area of Davis Mountains; habitat variable, ranging from loose sands and silts to tight clays; active year round, mostly underground; diet variable, but mostly roots and tubers; breeds continuously, but main season in spring		
Long-legged Bat (*Myotis volans*) – in Texas, Trans-Pecos region; high, open woods and mountainous terrain; nursery colonies (which may contain several hundred individuals) form in summer in buildings, crevices, and hollow trees; apparently do not use caves as day roosts, but may use such sites at night; single offspring born June-July		
Ocelot (*Leopardus pardalis*) - dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	LE	E
Pale Townsend's Big-eared Bat (*Corynorhinus townsendii pallescens*) - roosts in caves, abandoned mine tunnels, and occasionally old buildings; hibernates in groups during winter; in summer months, males and females separate into solitary roosts and maternity colonies, respectively; single offspring born May-June; opportunistic insectivore		
Spotted Bat (*Euderma maculatum*) – in Texas, Big Bend region; preferred habitat not fully understood, but species reported from pine forests at high elevations to open, desert scrub; reproduction data sparse, but single offspring born June-July		T
Western Small-footed Bat (*Myotis ciliolabrum*) - mountainous regions of the Trans-Pecos, usually in wooded areas, also found in grassland and desert scrub habitats; roosts beneath slabs of rock, behind loose tree bark, and in buildings; maternity colonies often small and located in abandoned houses, barns, and other similar structures; apparently occurs in Texas only during spring and summer months; insectivorous		
Western Yellow Bat (*Lasiurus xanthinus*) - forages over water both perennial and intermittent sources, found at low elevations (< 6,000 feet), roosts in vegetation (yucca, hackberry, sycamore, cypress, and especially palm); also hibernates in palm; locally common in residential areas landscaped with palms in Tuscon and Phoenix, Arizona; young born in June; insectivore		

	Federal Status	State Status
White-nosed Coati (*Nasua narica*) – woodlands, riparian corridors and canyons; most individuals in Texas probably transients from Mexico; diurnal and crepuscular; very sociable; forages on ground and in trees; omnivorous		T
Yellow-nosed Cotton Rat (*Sigmodon ochrognathus*) – higher elevations in the Chisos Mountains, Davis Mountains, and Sierra Vieja; rocky slopes with scattered bunches of grass; underground dens and aboveground nests in various locations, including at base of agaves or roots of junipers; active in daytime; several litters possible during breeding season of March-October		
Yuma Myotis Bat (*Myotis yumanensis*) - desert regions; most commonly found in lowland habitats near open water, where forages; roosts in caves, abandoned mine tunnels, and buildings; single offspring born May-early July		

MOLLUSKS

	Federal Status	State Status
Chisos Mountains Threeband (*Humboldtiana chisosensis*) – known from the Chisos Mountains, Big Bend National Park; in xeric rockslides along the lower margin of the evergreen woodland		
False Spike Mussel *(Quincuncina mitchelli*) - substrates of cobble and mud, with water lilies present; Rio Grande, Brazos, Colorado, and Guadalupe (historic) river basins		
Salina Mucket *(Potamilus metnecktayi*) - lotic waters; other habitat requirements are poorly understood; Rio Grande Basin		
Stockton Plateau Threeband (*Humboldtiana texana*) - rocky hill country with short grasses and some dwarf oaks on the hills; elevation about 1200-1500 m (3900-5000 ft)		
Texas Hornshell *(Popenaias popeii*) - both ends of narrow shallow runs over bedrock, in areas where small-grained materials collect in crevices, along river banks, and at the base of boulders; not known from impoundments; Rio Grande Basin and several rivers in Mexico	C	

*** REPTILES ***

	Federal Status	State Status
Trans-Pecos Black-headed Snake (*Tantilla cucullata*) – small size with a uniform body color and a small, dark head; secretive; fossorial; mostly nocturnal; mesquite-creosote and pinyon-juniper-oak; eggs laid June-August; eat insects, spiders, and other invertebrates		T
Big Bend Slider (*Trachemys gaigeae*) – almost exclusively aquatic, sliders (*Trachemys* spp.) prefer quiet bodies of fresh water with muddy bottoms and abundant aquatic vegetation, which is their main food source; will bask on logs, rocks or banks of water bodies; breeding March-July		

	Federal Status	State Status
Chihuahuan Desert Lyre Snake (*Trimorphodon vilkinsonii*) – mostly crevice-dwelling in predominantly limestone-surfaced desert northwest of the Rio Grande from Big Bend to the Franklin Mountains, especially in areas with jumbled boulders and rock faults/fissures; secretive; egg-bearing; eats mostly lizards		T
Chihuahuan Mud Turtle (*Kinosternon hirtipes murrayi*) - semi-aquatic, prefers bodies of fresh water with abundant aquatic vegetation; eats invertebrates; breeds March-July		T
Reticulated Gecko (*Coleonyx reticulatus*) – rocky desert areas of the Big Bend region; terrestrial and nocturnal; reproduction not well known, but captive individuals laid eggs in July		T
Texas Horned Lizard (*Phrynosoma cornutum*) – open, arid and semi-arid regions with sparse vegetation, which could include grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September		T
***** VASCULAR PLANTS *****		
Appressed two-bristle rock-daisy (*Perityle bisetosa* var. *appressa*) - crevices in limestone exposures on bluffs and other rock outcrops; flowering late summer-fall		
Big Bend hop-hornbeam (*Ostrya chisosensis*) - mixed woodlands on mesic rocky igneous slopes at high elevations in the Chisos Mountains; flowering May-June		
Bigpod bonamia (*Bonamia ovalifolia*) - alluvial sand among boulders on rocky lower slopes in canyons of the Rio Grande; flowering (May-) July-November		
Boquillas lizardtail (*Gaura boquillensis*) - mostly in sandy soils in desert canyons and arroyos, occasionally in gravelly limestone soils in Chihuahuan Desert scrub at low elevations; flowering March-August		
Brush-pea (*Genistidium dumosum*) - Chihuahuan Desert scrub on rocky limestone hills at lower elevations; flowering June-September		
Bunched cory cactus (*Coryphantha ramillosa* ssp. *ramillosa*) - rocky slopes, ledges, and flats in the Chihuahuan Desert, most frequently on exposures of Santa Elena Limestone or the Boquillas Formation between about 750-1050 m (2500-3500 ft) elevation; flowering (April?-) July-August	LT	T
Bushy wild-buckwheat (*Eriogonum suffruticosum*) - sparsely vegetated rocky limestone slopes, low hills, and clay flats; flowering March-April; in full fruit by May		
Chaffey's cory cactus (*Escobaria dasyacantha* var. *chaffeyi*) - evergreen woodlands on rocky limestone soils at about 1750-2150 m (5800-7000 ft).; flowering April-May; fruiting June-September		

	Federal Status	State Status
Chisos agave (*Agave glomeruliflora*) - grasslands or oak-juniper woodlands at elevations of about 1050-1850 m (3500-6000 ft); flowering July-August		
Chisos coral-root (*Hexalectris revoluta*) - humus in oak groves along rocky creekbeds at higher elevation. in the Glass Mountains, it has been found "among lechuguilla and shinnery oak on the sunny slopes and ridges"; flowering June-July, sometimes in May when spring rains are abundant		
Chisos Mountains hedgehog cactus (*Echinocereus chisoensis* var. *chisoensis*) - desert grasslands or open shrublands on unconsolidated gravelly fan and terrace deposits on desert flats and low hills at moderate elevations of about 600-750 m (2000-2500 ft) in the Chihuahuan Desert; flowering March-early June, or April-July; fruit maturing May-August	LT	T
Chisos oak (*Quercus graciliformis*) - oak woodlands in dry rocky canyons, usually associated with a high water table; in moister portions of canyons of the Chisos Mountains, above about 1650 m (5400 ft) elevation; fruiting July-early September		
Chisos pinweed (*Lechea mensalis*) - open pine-oak woodlands over igneous rock outcrops at high elevations in mountains of the Trans Pecos; presumably flowering June-August		
Cliff bedstraw (*Galium correllii*) - dry, steep or vertical limestone cliff faces of various exposures in Chihuahuan Desert along Rio Grande and tributaries, at elevations between about 450-500 m (1500-1650 ft); flowering April-November; fruiting May-December		
Correll's green pitaya (*Echinocereus viridiflorus* var. *correllii*) - among grasses on rock crevices on low hills in desert or semi-desert grassland, occasionally on novaculite		
Cox's dalea (*Dalea bartonii*) - semi-desert shortgrass grasslands with scattered pinyon pine and juniper in gravelly soils on limestone hills; the one known location reportedly lies at an altitude of about 1100 m (3600 ft); probably flowering in June, fruiting in July		
Cutler's twistflower (*Streptanthus cutleri*) - open shrublands or grasslands on calcareous gravel of talus slopes, rocky hillsides and gravelly stream beds, at moderate elevations in the Chihuahuan Desert; flowering mostly February-March, sometimes into May		
Davis' green pitaya (*Echinocereus viridiflorus* var. *davisii*) - novaculite outcrops in full sun among sparse Chihuahuan Desert scrub usually hidden in mats of *Selaginella*; flowering late March-April	LE	E

	Federal Status	State Status
Desert night-blooming cereus (*Peniocereus greggii* var. *greggii*) - shrublands in lower elevation desert flats and washes; visually similar to dead stems of woody plants; flowering concentrated during a few nights in late May-late June		
Duncan's cory cactus (*Escobaria dasyacantha* var. *duncanii*) - Chihuahuan Desert scrub on low to moderate elevation hills, ledges, and benches; in Texas on outcrops of Boquillas Formation limestone; flowering mid April to early May; fruits mature late May-early June		
Durango yellow-cress (*Rorippa ramosa*) - moist, fine textured, alluvial soils on floodplains and in beds of intermittent streams; flowering March-May		
Dwarf broomspurge (*Chamaesyce jejuna*) - endemic; according to specimen collections, found in grama-grass prairie on caliche uplands, dry caliche slopes, and limestone hills; flowering late March-late July		
Glass Mountains rock-daisy (*Perityle vitreomontana*) - crevices in limestone exposures on cliffs and rock outcrops in the Glass Mountains; flowering June-October		
Golden-spine hedgehog cactus (*Echinocereus chloranthus* var. *neocapillus*) - sparsely vegetated desert grasslands over novaculite outcrops		
Golden-spine prickly-pear (*Opuntia aureispina*) - desert flats on slabs and fractured Boquillas Limestone, Chihuahuan Desert near Rio Grande, at about 600 m (1900 ft) elevation		
Green spikemoss (*Selaginella viridissima*) - shaded or sheltered igneous rock ledges and cliffs in the Chisos and Davis mountains; spore bearing June-August		
Guadalupe Mountains fescue (*Festuca ligulata*) - woodlands and grasslands on mesic slopes and in creekbottoms above 6000 feet in the Guadalupe and Chisos mountains; substrates in the Chisos Mountains are gravelly and sandy loams derived from igneous materials; substrate in the Guadalupe Mountains unknown but presumed to be loamy soils over limestone; flowering August-September	C1	
Havard's stonecrop (*Sedum havardii*) - crevices in igneous rock outcrops, sometimes loose igneous talus, in oak-pinyon woodlands and chaparral at medium to high elevations in the Chisos and Davis mountains; flowering June-September		
Heather leaf-flower (*Phyllanthus ericoides*) - crevices in limestone on dry canyon walls and other rock outcrops; flowering in October, and presumably other months, given sufficient moisture		

	Federal Status	State Status
Hester's cory cactus (*Escobaria hesteri*) - grasslands on dry gravelly limestone hills and alluvial fans at about 1200-1500 m (4000-5000 ft); often on novaculite; flowering May-early June; fruiting June-July		
Hinckley's brickellbush (*Brickellia hinckleyi* var. *hinckleyi*) - mixed woodlands or forests on rocky slopes in higher-elevation mountain canyons; most specimens are from canyons on the north flank of Mt. Livermore in the Davis Mountains, where substrates are igneous; flowering July-October		
Hinckley's oak (*Quercus hinckleyi*) – arid limestone slopes at mid elevations in Chihuahuan Desert; produces acorns late August to early September	LT	T
Jackie's bluet (*Stenaria mullerae* var. *pooleana*) - north- to east-facing vertical limestone cliff faces in mid-elevation canyons in mountains in the Chihuahuan Desert, known locations lie at elevations between about 1450-1500 m (4,800-4,900 ft); flowering May, perhaps to September		
Kay's grama (*Bouteloua kayi*) - gravelly soils on desert flats and on limestone ledges along bluffs; flowering May-November		
Lateleaf oak (*Quercus tardifolia*) - mixed evergreen-deciduous woodlands in moist canyon bottoms at about 2150 m (7000 ft) elevation in the Chisos Mountains		
Leatherweed croton (*Croton pottsii* var. *thermophilus*) - sparingly vegetated desert grasslands on extremely xeric sites at low elevations of about 500-800 m (1650-2600 ft), on substrates ranging from sand to limestone and basalt; flowering spring-fall		
Leoncita false foxglove (*Agalinis calycina*) - grasslands on moist heavy alkaline/saline calcareous silty clays and loams in and around cienegas (desert springs); flowering September-October		
Little-leaf brongniartia (*Brongniartia minutifolia*) - Chihuahuan Desert shrublands at lower elevations of about 750 (2500 ft), in blackish sand, gravel, volcanic ash and other substrates, often in or along arroyos or shallow drainages; flowering June-August		
Lloyd's mariposa cactus (*Sclerocactus mariposensis*) - among low shrubs and rosette-forming perennials in gravelly soils on arid limestone slopes in the Chihuahuan Desert, mostly on Boquillas Formation; elevation 750-1050 m (2500-3500 ft); flowering February-early March	LT	T
Longstalk heimia (*Nesaea longipes*) - moist or subirrigated alkaline or gypsiferous clayey soils along unshaded margins of cienegas and other desert wetlands; including somewhat saline silt loams on terraces of spring-fed streams in a grassland; also in moderately alkaline clay along perennial streams and subirrigated wetlands atop poorly-defined spring system; flowering May-September		

	Federal Status	State Status
Many-flowered unicorn-plant (*Proboscidea spicata*) - dry sandy alluvial and/or eolian soils on terraces along Rio Grande; also in disturbed sandy soils at scattered sites along roadsides elsewhere in the Trans Pecos; flowering May-June (-August)		
Maravillas milkwort (*Polygala maravillasensis*) - crevices of limestone exposed on canyons walls, mostly along the Rio Grande and its tributaries, in low desert mountains at about 450-950 m (1500-3100 ft) elevation; flowering May-October		
Mary's bluet (*Stenaria butterwickiae*) - shallow pockets or crevices in limestone bedrock on ridgetops; flowering or fruiting at least May-August		
Murray's plum (*Prunus murrayana*) - deciduous woodlands on steep rocky slopes in mesic, high elevation mountain canyons on both igneous and sedimentary substrates; flowering March-April; fruiting June-August		
Nellie's cory cactus (*Escobaria minima*) - novaculite outcrops in full sun among Chihuahuan Desert scrub; flowering March-June, fruiting June-October	LE	E
Old blue pennyroyal (*Hedeoma pilosum*) - open exposed limestone		
Orcutt's senna (*Senna orcuttii*) - gravelly soil on limestone slopes and in beds of intermittent streams, within various mid- to lower-elevation Chihuahuan Desert communities; flowering July-August		
Pale phacelia (*Phacelia pallida*) - Chihuahuan Desert scrub on gypsum or limestone soils at low elevations; flowering May-early August		
Perennial caltrop (*Kallstroemia perennans*) - barren gypseous clays or limestone soils at low elevations in the Chihuahuan Desert; flowering late spring-early fall		
Purple gay-mallow (*Batesimalva violacea*) - among boulders in moist igneous rock canyons, often under small trees and large shrubs; habitat in Mexico dry deciduous forest and brushy field, thickets; flowering/fruiting October-November in Big Bend National Park; possibly throughout the year in Mexico		
Ripley's senna (*Senna ripleyana*) - gravelly hilltops in arid grasslands and creosote flats in Chihuahuan Desert; apparently at elevations of 1200-1500 m (4000-5000 ft); flowering/fruiting July-October		
Robust oak (*Quercus robusta*) – deciduous; mesic drainages within the Chihuahuan Desert; can reach about 5 to 10 m tall (15-35 ft)		
Shinner's tickle-tongue (*Zanthoxylum parvum*) - understory of maple-oak woodlands or evergreen oak shinnery on rocky, well drained, neutral, non-calcareous loams underlain by rhyolite, tuff or other igneous rock, at elevations between about 1400-1750 m (4500-5700 ft); flowering late March-early April		

	Federal Status	State Status
Sierra del Carmen oak (*Quercus carmenensis*) - moist wooded canyon bottoms in the Chisos Mountains at about 4200 feet (1500 m) elevation; flowering spring		
Silver cholla (*Opuntia imbricata* var. *argentea*) - deep soils of mesquite thickets and creosote flats on desert bottomlands and washes; rocky limestone soil; flowering June-July; fruiting September-October		
Slimlobe rock-daisy (*Perityle dissecta*) - perennial; walls of limestone canyons in desert regions; only rock-daisy in west Texas with finely dissected hairy leaves; flowering/fruiting spring-fall		
Stairstep two-bristle rock-daisy (*Perityle bisetosa* var. *scalaris*) - crevices in limestone exposures on bluffs and other rock outcrops; flowering late summer-fall		
Straw-spine glory-of-Texas (*Thelocactus bicolor* var. *flavidispinus*) - gravel hills in desert grasslands or shrublands below about 450 m (1400 ft); in the Marathon Basin of Brewster County; apparently restricted to soils derived from Caballos Novaculite; flowering in May		
Swallow spurge (*Chamaesyce golondrina*) - alluvial or eolian sand along Rio Grande, occasionally on adjacent shale or limestone slopes; flowering June-November		
Terlingua brickellbush (*Brickellia hinckleyi* var. *terlinguensis*) - various situations in Chihuahuan Desert; slopes in the Chisos Mountains; also along creek bottoms; flowering July-October?		
Terlingua Creek cat's-eye (*Cryptantha crassipes*) - community of sparse vegetation that develops on low, seemingly barren, xeric hills of gypseous clay and chalky shales of the Boquillas Formation; flowering late March-early June; fruiting April-July	LE	E
Texas false saltgrass (*Allolepis texana*) - sandy to silty soils of valley bottoms and river floodplains; flowering (June-) July-October		
Texas largeseed bittercress (*Cardamine macrocarpa* var. *texana*) - seasonally (hibernally or vernally) moist loamy soils in pine-oak woodlands at high elevations in the Chisos Mountains; also moderate elevations in pinyon-oak-juniper woodlands in Kinney and Uvalde counties; flowering early spring, sometimes persisting (or flowering again?) through August		
Texas milkvine (*Matelea texensis*) - desert grasslands or shrublands over igneous substrate, at elevations of about 1200-1500 m (4000-5000 ft)		
Texas wolf-berry (*Lycium texanum*) - semi-desert grasslands and thorn shrublands on sandy, gravelly, and/or loamy soils, on very gently sloping terrain as well as in rocky areas in canyons, often over limestone at moderate elevations; flowering March-October		

Federal Status | State Status

Three-tongue spurge (*Chamaesyce chaetocalyx* var. *triligulata*) - steep limestone cliffs and adjacent colluvium, mostly in Chihuahuan Desert; flowering July-October

Trans-Pecos maidenbush (*Andrachne arida*) - crevices in calcareous bedrock exposures on arid mountain slopes, usually with succulents, Texas sites are on Cretaceous limestone; flowering July-October

Two-bristle rock-daisy (*Perityle bisetosa* var. *bisetosa*) - crevices in limestone exposures on bluffs and other rock outcrops; flowering late summer-fall

Warnock's coral-root (*Hexalectris warnockii*) - leaf litter and humus in oak-pinyon-juniper woodlands in the Trans Pecos, primarily on igneous substrates in higher mesic canyons (up to about 2000 m (6500 ft.), but at lower elevations to the east, often on narrow terraces along creekbeds; flowering June-August.

Watson's false clappia-bush (*Pseudoclappia watsonii*) – Chihuahuan Desert shrublands on dry, rocky, gypseous clay hills; flowering May-August

Wendt's malaxis (*Malaxis wendtii*) - in Texas only from oak-juniper-pinyon woodlands in moist canyons and on north-facing slopes in the Chisos Mountains; flowering July-September

White column cactus (*Escobaria albicolumnaria*) - creosote, lechuguilla, or canyon shrublands primarily on nearly level terrain to rolling hills on thin, gravelly soils or limestone bedrock of the Santa Elena, Glen Rose, Boquillas, and Telephone Canyon formations; at lower elevations (ca. 2000-4500 feet) in the Chihuahuan Desert; flowering early March-May

Wilkinson's whitlow-wort (*Paronychia wilkinsonii*) - shallow rocky soils in crevices on novaculite hills or outcrops at low to moderate elevations in the Chihuahuan Desert; flowering April-October

Wright's trumpets (*Acleisanthes wrightii*) - open semi-desert grasslands and shrublands on shallow stony soils over limestone on low hills and flats; flowering spring-fall, probably after rains, also

Wright's water-willow (*Justicia wrightii*) - shortgrass grasslands and/or shrublands, dry gravelly clay soils over limestone on flats and low hills at elevations of 900-1500 m (3000-5000 ft); flowering April-July

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CULBERSON COUNTY

	Federal Status	State Status
*****ARACHNIDS *****		
Guadalupe Cave Pseudoscorpion (*Archeolarca guadalupensis*) - live in leaf mold or decaying vegetation, in soils, beneath bark and stones, and in some mammals' nests; oviparous and may produce more than one brood per year		
***** BIRDS *****		
American Peregrine Falcon (*Falco peregrinus anatum*) - resident in west Texas	DL	E
Arctic Peregrine Falcon (*Falco peregrinus tundrius*) - potential migrant	DL	T
Baird's Sparrow (*Ammodramus bairdii*) - shortgrass prairie with scattered low bushes and matted vegetation		
Common Black-hawk (*Buteogallus anthracinus*) - cottonwood-lined rivers and streams; willow tree groves on the lower Rio Grande floodplain; formerly bred in south Texas		T
Ferruginous Hawk (*Buteo regalis*) - open country, primarily prairies, plains, and badlands; nests in tall trees along streams or on steep slopes, cliff ledges, river-cut banks, hillsides, power line towers		
Mexican Spotted Owl (*Strix occidentalis lucida*) – remote, shaded canyons of coniferous mountain woodlands (pine and fir); nocturnal predator of mostly small rodents and insects; day roosts in densely vegetated trees, rocky areas, or caves	LT	T
Montezuma Quail (*Cyrtonyx montezumae*) – open pine-oak or juniper-oak with ground cover of bunch grass on flats and slopes of semi-desert mountains and hills; travels in pairs or small groups; eats succulents, acorns, nuts, and weed seeds, as well as various invertebrates		
Mountain Plover (*Charadrius montanus*) – breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous		
Northern Aplomado Falcon (*Falco femoralis septentrionalis*) - open country, especially savanna and open woodland, and sometimes in very barren areas; grassy plains and valleys with scattered mesquite, yucca, and cactus; nests in old stick nests of other bird species	LE	E
Prairie Falcon (*Falco mexicanus*) – open, mountainous areas, plains and prairie; nests on cliffs		
Southwestern Willow Flycatcher (*Empidonax traillii extimus*) – thickets of willow, cottonwood, mesquite, and other species along desert streams	LE	E

	Federal Status	State Status
Western Burrowing Owl (*Athene cunicularia hypugaea*) - open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows and man-made structures, such as culverts		
Yellow-billed Cuckoo (*Coccyzus americanus*) - status applies only west beyond the Pecos River Drainage; riparian habitat and associated drainages; springs, developed wells, and earthen ponds supporting mesic vegetation; deciduous woodlands with cottonwood and willow; dense understory foliage important for nest site selection; nests in willow, mesquite, cottonwood, and hackberry; forages in similar riparian woodlands; breeding season mid-May-late Sept	C1 NL	
Zone-tailed Hawk (*Buteo albonotatus*) - arid open country, including open deciduous or pine-oak woodland, mesa or mountain county, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
*****FISHES*****		
Pecos Pupfish (*Cyprinodon pecosensis*) – originally Pecos River basin, presently restricted to upper basin only; shallow margins of clear, vegetated spring waters high in calcium carbonate, as well as in sinkhole habitats		T
*****INSECTS*****		
Guadalupe Mountains Tiger Beetle (*Cicindela politula petrophila*)- open, sunny areas; predaceous and feeds on a variety of small insects; larva lives in vertical burrows in soil of dry paths, fields, or sandy beaches		
Texas Minute Moss Beetle (*Limnebius texanus*) – adult moss beetles of this genus are aquatic and herbivorous; larvae are semiaquatic and carnivorous; found in vegetation along margins of streams		

	Federal Status	State Status
***** MAMMALS *****		
Big Free-tailed Bat (*Nyctinomops macrotis*) – habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, but gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undertermined, but may hibernate in the Trans-Pecos; opportunistic insectivore		
Black Bear (*Ursus americanus*) - within historical range of Louisiana Black Bear in eastern Texas, Black Bear is federally listed threatened and inhabits bottomland hardwoods and large tracts of undeveloped forested areas; in remainder of Texas, Black Bear is not federally listed and inhabits desert lowlands and high elevation forests and woodlands; dens in tree hollows, rock piles, cliff overhangs, caves, or under brush piles	T/SA NL	T
Black-footed Ferret (*Mustela nigripes*) – considered extirpated in Texas; potential inhabitant of any prairie dog towns in the general area	LE	E
Black-tailed Prairie Dog (*Cynomys ludovicianus*) - dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups		
Cave Myotis Bat (*Myotis velifer*) - roosts colonially in caves, rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (*Petrochelidon pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum caves of Panhandle during winter; opportunistic insectivore		
Davis Mountains Cottontail (*Sylvilagus floridanus robustus*) – brushy pastures, brushy edges of cultivated fields, and well-drained streamsides; active mostly at twilight and at night; forages in a variety of habitats, including open pastures, meadows, or even lawns; rests during daytime in thickets, underground burrows, and small culverts; feeds on grasses, forbs, twigs, and bark; not sociable and seldom seen feeding together		
Fringed Myotis Bat (*Myotis thysanodes*) – habitat variable, ranging from mountainous pine-oak and pinyon-juniper to desert-scrub, but prefers grasslands at intermediate elevations; highly migratory species that arrives in Trans-Pecos by May to form nursery colonies; single offspring born June-July; roosts colonially in caves, mine tunnels, rock crevices, and old buildings		
Gray Wolf (*Canis lupus*) (extirpated) – formerly known throughout the western two-thirds of the state in forests, brushlands, or grasslands	LE	E

Federal Status | State Status

Gray-footed Chipmunk (*Tamias canipes*) – forest-dwelling; occur in Texas only in the Sierra Diablo and Guadalupe Mountains in the Trans-Pecos; favorite habitat is downed logs near edges of clearings; also occur in dense stands of mixed timber (oaks, pines, firs) and on brushy hillsides, especially with rock crevices

Guadalupe Southern Pocket Gopher (*Thomomys bottae guadalupensis*) - Trans-Pecos Texas and eastward across western Edwards Plateau; habitat variable, ranging from loose sands and silts to tight clays; dry deserts to montane meadows; active year round, mostly underground; diet variable, but mostly roots and tubers; breeds continuously, but main season in spring

Long-legged Myotis Bat (*Myotis volans*) – in Texas, Trans-Pecos region; high, open woods and mountainous terrain; nursery colonies (which may contain several hundred individuals) form in summer in buildings, crevices, and hollow trees; apparently do not use caves as day roosts, but may use such sites at night; single offspring born June-July

Pecos River Muskrat *(Ondatra zibethicus ripensis*) – creeks, rivers, lakes, drainage ditches, and canals; prefer shallow, fresh water with clumps of marshy vegetation, such as cattails, bulrushes, and sedges; live in dome-shaped lodges constructed of vegetation; diet is mainly vegetation; breed year round

Pale Townsend's Big-eared Bat (*Corynorhinus townsendii pallescens*) - roosts in caves, abandoned mine tunnels, and occasionally old buildings; hibernates in groups during winter; in summer months, males and females separate into solitary roosts and maternity colonies, respectively; single offspring born May-June; opportunistic insectivore

Yellow-nosed Cotton Rat (*Sigmodon ochrognathus*) – higher elevations in the Chisos Mountains, Davis Mountains, and Sierra Vieja; rocky slopes with scattered bunches of grass; underground dens and aboveground nests in various locations, including at base of agaves or roots of junipers; active in daytime; several litters possible during breeding season of March-October

Yuma Myotis Bat (*Myotis yumanensis*) - desert regions; most commonly found in lowland habitats near open water, where forages; roosts in caves, abandoned mine tunnels, and buildings; single offspring born May-early July

	Federal Status	State Status
*****MOLLUSKS*****		
False Spike Mussel *(Quincuncina mitchelli*) - substrates of cobble and mud, with water lilies present; Rio Grande, Brazos, Colorado, and Guadalupe (historic) river basins		
Northern Threeband (*Humboldtiana ultima*) - leaf litter in mesic canyons of limestone mountains; in soil, under rocks		
***** REPTILES *****		
Big Bend Slider (*Trachemys gaigeae*) – almost exclusively aquatic, sliders (*Trachemys* spp.) prefer quiet bodies of fresh water with muddy bottoms and abundant aquatic vegetation, which is their main food source; will bask on logs, rocks or banks of water bodies; breeding March-July; this species found in Big Bend region of Texas and northeastern Mexico		
Chihuahuan Desert Lyre Snake (*Trimorphodon vilkinsonii*) – mostly crevice-dwelling in predominantly limestone-surfaced desert northwest of the Rio Grande from Big Bend to the Franklin Mountains, especially in areas with jumbled boulders and rock faults/fissures; secretive; egg-bearing; eats mostly lizards		T
Chihuahuan Mud Turtle (*Kinosternon hirtipes murrayi*) - semi-aquatic, prefers bodies of fresh water with abundant aquatic vegetation; eats invertebrates; breeds March-July		T
Mountain Short-horned Lizard (*Phrynosoma hernandesi*) - diurnal, usually in open, shrubby, or openly wooded areas with sparse vegetation at ground level; soil may vary from rocky to sandy; burrows into soil or occupies rodent burrow when inactive; eats ants, spiders, snails, sowbugs, and other invertebrates; inactive during cold weather; breeds March-September		T
Texas Horned Lizard (*Phrynosoma cornutum*) – open, arid and semi-arid regions with sparse vegetation, which could include grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September		T
Trans-Pecos Black-headed Snake (*Tantilla cucullata*) – small size with a uniform body color and a small, dark head; secretive; fossorial; mostly nocturnal; mesquite-creosote and pinon-juniper-oak; eggs laid June-August; eat insects, spiders, and other invertebrates		T

	Federal Status	State Status
*****VASCULAR PLANTS*****		
Chisos agave (*Agave glomeruliflora*) - high elevation grasslands or oak-juniper woodlands; known in Guadalupe Mountains from bajada slopes; flowering July-August		
Chisos coral-root (*Hexalectris revoluta*) – humus in oak groves along rocky creekbeds in mountain canyons; flowering June-July		
Foster's rock-daisy (*Perityle fosteri*) – known only from the bluffs of the canyon walls of Panther Canyon in the Apache Mountains		
Guadalupe Mountains columbine (*Aquilegia chrysantha* var. *chaplinei*) – perennially moist to wet limestone canyon walls; moist leaf litter and humus among boulders in wooded mesic canyons; flowering April-September		
Guadalupe Mountains fescue (*Festuca ligulata*) – woodlands and grasslands on mesic slopes and in creek bottoms above 6000 feet in the Guadalupe and Chisos mountains; substrates in the Chisos Mountains are gravelly and sandy loams derived from igneous materials; substrate in the Guadalupe Mountains unknown but presumed to be loamy soils over limestone; flowering in summer	C1	
Guadalupe Mountains mescal bean (*Sophora gypsophila* var. *guadalupensis*) – oneseed juniper (*Juniperus monosperma*) shrublands on dry limestone or gypsum slopes above 5000 feet elevation in Guadalupe Mountains; flowering late March-May		
Guadalupe Mountains pincushion cactus (*Escobaria guadalupensis*) – exposed slabs and fractured limestone rock on steep, mostly south-facing slopes; open coniferous woodlands above 6500 feet elevation in Guadalupe Mountains; flowering April-May; fruiting October-November		
Guadalupe Mountains rabbitbrush (*Chrysothamnus nauseosus* ssp. *texensis*) – limestone ledges and open gravel alluvial areas; flowering September-October		
Guadalupe Mountains violet (*Viola guadalupensis*) – “bullet hole” openings in dolomitized limestone rock faces, open Douglas fir (*Pseudotsuga menziesii*) woodlands at about 8000 feet elevation in the Guadalupe Mountains; flowering March-May		
Gyp locoweed (*Astragalus gypsodes*) – gypsum or stiff gypseous clay soils on low rolling hills, mostly low elevations in areas adjacent to the Guadalupe Mountains; many of the known locations are on the Castile Formation (Permian); flowering April-June		
Murray's plum (*Prunus murrayana*) - deciduous woodlands on steep rocky slopes in mesic, high elevation mountain canyons; known from igneous and sedimentary substrates; flowering March-April		

Federal Status | State Status

Royal red penstemon (*Penstemon cardinalis* ssp. *regalis*) – pine-oak woodlands in canyons at higher elevations in the Davis and Guadalupe mountains; flowering May-June (-August)

Sand sacahuista (*Nolina arenicola*) – windblown Quaternary sand in dune areas east of Van Horn; also in shrublands on steep Permian limestone slopes in the Guadalupe Mountains; flowering March-August

Smooth-stem skullcap (*Scutellaria laevis*) – on mountain slopes and in arroyos along dry streambeds; known from Beach and Guadalupe mountains; flowering April-September

Sparsely-flowered jewelflower (*Streptanthus sparsiflorus*) – shaded areas in dry gravelly limestone canyons and arroyos, especially in McKittrick and Pine canyons in the Guadalupe Mountains; flowering May-June; yearly populations vary widely depending on rainfall

Texas wolf-berry *(Lycium texanum*) - thorn shrublands on sandy soils, in rocky areas on canyons and on roadsides at elevations of 3500-4600 feet; flowering March-October

Warnock's coral root (*Hexalectris warnockii*) - leaf litter and humus in oak-juniper woodlands in mountain canyons in the Trans Pecos but at lower elevations to the east, often on narrow terraces along creekbeds

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EL PASO COUNTY

	Federal Status	State Status
*****AMPHIBIANS *****		
Northern Leopard Frog (*Rana pipiens*) – streams, ponds, lakes, wet prairies, and other bodies of water; will range into grassy, herbaceous areas some distance from water; eggs laid March-May and tadpoles transform late June-August; may have disappeared from El Paso County due to habitat alteration		
***** BIRDS *****		
American Peregrine Falcon (*Falco peregrinus anatum*) - resident in West Texas	DL	E
Baird's Sparrow (*Ammodramus bairdii*) - shortgrass prairie with scattered low bushes and matted vegetation		
Common Black Hawk (*Buteogallus anthracinus*) - cottonwood-lined rivers and streams; willow tree groves on the lower Rio Grande floodplain; formerly bred in south Texas		T
Interior Least Tern (*Sterna antillarum athalassos*) – this subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish & crustaceans, when breeding forages within a few hundred feet of colony	LE	E
Mexican Spotted Owl (*Strix occidentalis lucida*) – remote, shaded canyons of coniferous mountain woodlands (pine and fir); nocturnal predator of mostly small rodents and insects; day roosts in densely vegetated trees, rocky areas, or caves	LT	T
Montezuma Quail (*Cyrtonyx montezumae*) – open pine-oak or juniper-oak with ground cover of bunch grass on flats and slopes of semi-desert mountains and hills; travels in pairs or small groups; eats succulents, acorns, nuts, and weed seeds, as well as various invertebrates		
Mountain Plover (*Charadrius montanus*) – breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous		
Northern Aplomado Falcon (*Falco femoralis septentrionalis*) - open country, especially savanna and open woodland, and sometimes in very barren areas; grassy plains and valleys with scattered mesquite, yucca, and cactus; nests in old stick nests of other bird species	LE	E
Prairie Falcon (*Falco mexicanus*) – open, mountainous areas, plains and prairie; nests on cliffs		

	Federal Status	State Status
Southwestern Willow Flycatcher (*Empidonax traillii extimus*) – thickets of willow, cottonwood, mesquite, and other species along desert streams	LE	E
Western Burrowing Owl (*Athene cunicularia hypugaea*) - open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows and man-made structures, such as culverts		
Yellow-billed Cuckoo (*Coccyzus americanus*) - status applies only west beyond the Pecos River Drainage; breeds in riparian habitat and associated drainages; springs, developed wells, and earthen ponds supporting mesic vegetation; deciduous woodlands with cottonwoods and willows; dense understory foliage is important for nest site selection; nests in willow, mesquite, cottonwood, and hackberry; forages in similar riparian woodlands; breeding season mid-May-late Sept	C1	
Zone-tailed Hawk (*Buteo albonotatus*) - arid open country, including open deciduous or pine-oak woodland, mesa or mountain county, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
*****FISHES*****		
Bluntnose Shiner (*Notropis simus*) (extirpated) - main river channels, often below obstructions over substrate of sand, gravel, and silt; damming and irrigation practices presumed major factors contributing to decline		T
Rio Grande Silvery Minnow (*Hybognathus amarus*) (extirpated) - historically Rio Grande and Pecos River systems and canals; pools and backwaters of medium to large streams with low or moderate gradient in mud, sand, or gravel bottom; ingests mud and bottom ooze for algae and other organic matter; probably spawns on silt substrates of quiet coves.	LE	E

*** MAMMALS ***

Species	Federal Status	State Status
Big Free-tailed Bat (*Nyctinomops macrotis*) – habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, but gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undetermined, but may hibernate in the Trans-Pecos; opportunistic insectivore		
Black-footed Ferret (*Mustela nigripes*) (extirpated) - potential inhabitant of any prairie dog towns in the general area	LE	E
Black-tailed Prairie Dog (*Cynomys ludovicianus*) - dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups		
Black Bear (*Ursus americanus*) - within historical range of Louisiana Black Bear in eastern Texas, Black Bear is federally listed threatened and inhabits bottomland hardwoods and large tracts of undeveloped forested areas; in remainder of Texas, Black Bear is not federally listed and inhabits desert lowlands and high elevation forests and woodlands; dens in tree hollows, rock piles, cliff overhangs, caves, or under brush piles	T/SA NL	T
Cave Myotis Bat (*Myotis velifer*) - roosts colonially in caves, rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (*Petrochelidon pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum caves of Panhandle during winter; opportunistic insectivore		
Davis Mountains Cottontail (*Sylvilagus floridanus robustus*) – brushy pastures, brushy edges of cultivated fields, and well-drained streamsides; active mostly at twilight and at night, where they may forage in a variety of habitats, including open pastures, meadows, or even lawns; rest during daytime in thickets or in underground burrows and small culverts; feed on grasses, forbs, twigs and bark; not sociable and seldom seen feeding together		
Desert Pocket Gopher (*Geomys arenarius*) – in Texas, restricted to the Trans-Pecos; cottonwood-willow association along the Rio Grande in El Paso and Hudspeth counties; live underground, but build large and conspicuous mounds; life history not well documented, but presumed to eat mostly vegetation, be active year round, and bear more than one litter per year		

	Federal Status	State Status
Fringed Myotis Bat (*Myotis thysanodes*) – habitat variable, ranging from mountainous pine, oak, and pinyon-juniper to desert-scrub, but prefers grasslands at intermediate elevations; highly migratory species that arrives in Trans-Pecos by May to form nursery colonies; single offspring born June-July; roosts colonially in caves, mine tunnels, rock crevices, and old buildings		
Gray Wolf (*Canis lupus*) (extirpated) – formerly known throughout the western two-thirds of the state in forests, brushlands, or grasslands	LE	E
Pale Townsend's Big-eared Bat (*Corynorhinus townsendii pallescens*) - roosts in caves, abandoned mine tunnels, and occasionally old buildings; hibernates in groups during winter; in summer months, males and females separate into solitary roosts and maternity colonies, respectively; single offspring born May-June; opportunistic insectivore		
Pecos River Muskrat *(Ondatra zibethicus ripensis*) – creeks, rivers, lakes, drainage ditches, and canals; prefer shallow, fresh water with clumps of marshy vegetation, such as cattails, bulrushes, and sedges; live in dome-shaped lodges constructed of vegetation; diet is mainly vegetation; breed year round		
Yuma Myotis Bat (*Myotis yumanensis*) - desert regions; most commonly found in lowland habitats near open water, where forages; roosts in caves, abandoned mine tunnels, and buildings; single offspring born May-early July		
*****MOLLUSKS*****		
Franklin Mountain Talus Snail (*Sonorella metcalfi*) – terrestrial; bare rock, talus, scree; inhabits igneous talus most commonly of rhyolitic origin		
Franklin Mountain Wood Snail (*Ashmunella pasonis*) - terrestrial; bare rock, talus, scree; talus slopes, usually of limestone, but also of rhyolite, sandstone, and siltstone, in arid mountain ranges		
***** REPTILES *****		
Big Bend Slider (*Trachemys gaigeae*) – almost exclusively aquatic, sliders (*Trachemys* spp.) prefer quiet bodies of fresh water with muddy bottoms and abundant aquatic vegetation, which is their main food source; will bask on logs, rocks or banks of water bodies; breeding March-July; this species found in Big Bend region of Texas and northeastern Mexico		
Chihuahuan Desert Lyre Snake (*Trimorphodon vilkinsonii*) – mostly crevice-dwelling in predominantly limestone-surfaced desert northwest of the Rio Grande from Big Bend to the Franklin Mountains, especially in areas with jumbled boulders and rock faults/fissures; secretive; egg-bearing; eats mostly lizards		T

	Federal Status	State Status
Chihuahuan Mud Turtle (*Kinosternon hirtipes murrayi*) - semi-aquatic, prefers bodies of fresh water with abundant aquatic vegetation; eats invertebrates; breeds March-July		T
Mountain Short-horned Lizard (*Phrynosoma hernandesi*) - diurnal, usually in open, shrubby, or openly wooded areas with sparse vegetation at ground level; soil may vary from rocky to sandy; burrows into soil or occupies rodent burrow when inactive; eats ants, spiders, snails, sowbugs, and other invertebrates; inactive during cold weather; breeds March-September		T
New Mexico Garter Snake (*Thamnophis sirtalis dorsalis*) - nearly any type of wet or moist habitat; irrigation ditches, and riparian-corridor farmlands, less often in running water; home range about 2 acres; active year round in warm weather, both diurnal and nocturnal, more nocturnal during hot weather; bears litter July-August		
Texas Horned Lizard (*Phrynosoma cornutum*) - open, arid and semi-arid regions with sparse vegetation, which could include grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September		T
Trans-Pecos Black-headed Snake (*Tantilla cucullata*) – small size with a uniform body color and a small, dark head; secretive; fossorial; mostly nocturnal; mesquite-creosote and pinon-juniper-oak; eggs laid June-August; eat insects, spiders, and other invertebrates		T
***** VASCULAR PLANTS *****		
Comal snakewood (*Colubrina stricta*) – only known Texas population lies at the base of an igneous rock outcrop in the Chihuahuan Desert east of El Paso; flowering late spring or early summer		
Desert night-blooming cereus (*Peniocereus greggii* var. *greggii*) – shrublands in alluvial or gravelly soils at lower elevations in arroyos, desert flats, and washes; flowering concentrated during a few nights in late May-late June		
Hueco rock-daisy (*Perityle huecoensis*) – dry limestone rock outcrops only known location is in the Hueco Mountains in El Paso County		
Resin leaf brickellbush (*Brickellia baccharidea*) – mixed desert shrublands on gravelly soils derived from limestone and perhaps also from igneous rocks, on bajada slopes and in arroyos; flowering summer-fall		
Sand prickly-pear (*Opuntia arenaria*) – deep, loose sands in sparsely vegetated dune or sandhill areas; flowering May-June		

	Federal Status	State Status
Sneed's pincushion cactus (*Escobaria sneedii* var. *sneedii*) – dry limestone outcrops on rocky slopes in desert mountains of the Chihuahuan Desert; flowering April-September (peak season in April?)	LE	E
Texas false saltgrass (*Allolepis texana*)– deep silty or sandy soil; cultivated and waste meadow lands or sand flats of valley bottoms and river floodplains; flowering (June-) July-October		
Wheeler's spurge (*Chamaesyce geyeri* var. *wheeleriana*) – sparsely vegetated loose sand in reddish sand dunes or coppice mounds; flowering and fruiting August-September?		

HUDSPETH COUNTY

06/02/05***DRAFT*****UNDER CONSTRUCTION ******
SPECIES MIGHT BE ADDED/DELETED DURING QUALITY CONTROL

*** BIRDS ***

Species	Federal Status	State Status
American Peregrine Falcon (*Falco peregrinus anatum*) - resident in west Texas	DL	E
Arctic Peregrine Falcon (*Falco peregrinus tundrius*) - potential migrant	DL	T
Baird's Sparrow (*Ammodramus bairdii*) - shortgrass prairie with scattered low bushes and matted vegetation		
Common Black Hawk (*Buteogallus anthracinus*) - cottonwood-lined rivers and streams; willow tree groves on the lower Rio Grande floodplain; formerly bred in south Texas		T
Interior Least Tern (*Sterna antillarum athalassos*) – this subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish & crustaceans, when breeding forages within a few hundred feet of colony	LE	E
Mexican Spotted Owl (*Strix occidentalis lucida*) – remote, shaded canyons of coniferous mountain woodlands (pine and fir); nocturnal predator of mostly small rodents and insects; day roosts in densely vegetated trees, rocky areas, or caves	LT	T
Montezuma Quail (*Cyrtonyx montezumae*) – open pine-oak or juniper-oak with ground cover of bunch grass on flats and slopes of semi-desert mountains and hills; travels in pairs or small groups; eats succulents, acorns, nuts, and weed seeds, as well as various invertebrates		
Mountain Plover (*Charadrius montanus*) – breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous		
Northern Aplomado Falcon (*Falco femoralis septentrionalis*) - open country, especially savanna and open woodland, and sometimes in very barren areas; grassy plains and valleys with scattered mesquite, yucca, and cactus; nests in old stick nests of other bird species	LE	E
Prairie Falcon (*Falco mexicanus*) – open, mountainous areas, plains and prairie; nests on cliffs		
Southwestern Willow Flycatcher (*Empidonax traillii extimus*) – thickets of willow, cottonwood, mesquite, and other species along desert streams	LE	E

	Federal Status	State Status
Western Burrowing Owl (*Athene cunicularia hypugaea*) - open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows and man-made structures, such as culverts		
West Mexican Redhorse (*Scartomyzon austrinus*) – known only from Alamito Creek, Big Bend region; restricted to rocky riffles of creeks and small to medium rivers, often near boulders in swift water		
Yellow-billed Cuckoo (*Coccyzus americanus*) - status applies only west beyond the Pecos River Drainage; riparian habitat and associated drainages; springs, developed wells, and earthen ponds supporting mesic vegetation; deciduous woodlands with cottonwood and willow; dense understory foliage important for nest site selection; nests in willow, mesquite, cottonwood, and hackberry; forages in similar riparian woodlands; breeding season mid-May-late Sept	C1	
Zone-tailed Hawk (*Buteo albonotatus*) - arid open country, including open deciduous or pine-oak woodland, mesa or mountain county, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T

*** FISHES ***

	Federal Status	State Status
Bluntnose Shiner (*Notropis simus*) (extirpated) - main river channels, often below obstructions over substrate of sand, gravel, and silt; damming and irrigation practices presumed major factors contributing to decline		T
Rio Grande Silvery Minnow (*Hybognathus amarus*) (extirpated) - historically Rio Grande and Pecos River systems and canals; pools and backwaters of medium to large streams with low or moderate gradient in mud, sand, or gravel bottom; ingests mud and bottom ooze for algae and other organic matter; probably spawns on silt substrates of quiet coves.	LE	E

	Federal Status	State Status
*****INSECTS*****		
Barbara Ann's Tiger Beetle *(Cicindela politula barbarannae*) - limestone outcrops either in arid treeless environments or in openings within less arid pine-juniper-oak dominated communities, calcareous clay and in particular, dirt roads, bare areas, and trails, above 1540 meters; larvae burrow into soil		
***** MAMMALS *****		
Big Free-tailed Bat (*Nyctinomops macrotis*) – habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, but gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undertermined, but may hibernate in the Trans-Pecos; opportunistic insectivore		
Black Bear (*Ursus americanus*) - within historical range of Louisiana Black Bear in eastern Texas, Black Bear is federally listed threatened and inhabits bottomland hardwoods and large tracts of undeveloped forested areas; in remainder of Texas, Black Bear is not federally listed and inhabits desert lowlands and high elevation forests and woodlands; dens in tree hollows, rock piles, cliff overhangs, caves, or under brush piles	T/SA NL	T
Black-footed Ferret (*Mustela nigripes*) –extirpated; potential inhabitant of any prairie dog towns in the general area	LE	E
Black-tailed Prairie Dog (*Cynomys ludovicianus*) - dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups		
Cave Myotis Bat (*Myotis velifer*) - roosts colonially in caves, rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (*Petrochelidon pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum caves of Panhandle during winter; opportunistic insectivore		
Davis Mountains Cottontail (*Sylvilagus floridanus robustus*) – brushy pastures, brushy edges of cultivated fields, and well-drained streamsides; active mostly at twilight and at night, where they may forage in a variety of habitats, including open pastures, meadows, or even lawns; rest during daytime in thickets or in underground burrows and small culverts; feed on grasses, forbs, twigs and bark; not sociable and seldom seen feeding together		

	Federal Status	State Status
Desert Pocket Gopher *(Geomys arenarius*) – in Texas, restricted to the Trans-Pecos; cottonwood-willow association along the Rio Grande in El Paso and Hudspeth counties; live underground, but build large and conspicuous mounds; life history not well documented, but presumed to eat mostly vegetation, be active year round, and bear more than one litter per year		
Fringed Myotis Bat (*Myotis thysanodes*) – habitat variable, ranging from mountainous pine, oak, and pinyon-juniper to desert-scrub, but prefers grasslands at intermediate elevations; highly migratory species that arrives in Trans-Pecos by May to form nursery colonies; single offspring born June-July; roosts colonially in caves, mine tunnels, rock crevices, and old buildings		
Gray Wolf (*Canis lupus*) (extirpated) – formerly known throughout the western two-thirds of the state in forests, brushlands, or grasslands	LE	E
Gray-Footed Chipmunk (*Tamias canipes*) – forest-dwelling; occur in Texas only in the Sierra Diablo and Guadalupe mountains in the Trans-Pecos; favorite habitat is downed logs near edges of clearings; also occur in dense stands of mixed timber (oaks, pines, firs) and on brushy hillsides, especially with rock crevices		
Guadalupe Southern Pocket Gopher (*Thomomys bottae guadalupensis*) - Trans-Pecos Texas and eastward across western Edwards Plateau; habitat variable, ranging from loose sands and silts to tight clays; dry deserts to montane meadows; active year round, mostly underground; diet variable, but mostly roots and tubers; breeds continuously, but main season in spring		
Long-legged Myotis Bat (*Myotis volans*) – in Texas, Trans-Pecos region; high, open woods and mountainous terrain; nursery colonies (which may contain several hundred individuals) form in summer in buildings, crevices, and hollow trees; apparently do not use caves as day roosts, but may use such sites at night; single offspring born June-July		
Pale Townsend's Big-eared Bat (*Corynorhinus townsendii pallescens*) - roosts in caves, abandoned mine tunnels, and occasionally old buildings; hibernates in groups during winter; in summer months, males and females separate into solitary roosts and maternity colonies, respectively; single offspring born May-June; opportunistic insectivore		
Pecos River Muskrat *(Ondatra zibethicus ripensis*) – creeks, rivers, lakes, drainage ditches, and canals; prefer shallow, fresh water with clumps of marshy vegetation, such as cattails, bulrushes, and sedges; live in dome-shaped lodges constructed of vegetation; diet is mainly vegetation; breed year round		

	Federal Status	State Status
Yuma Myotis Bat (*Myotis yumanensis*) - desert regions; most commonly found in lowland habitats near open water, where forages; roosts in caves, abandoned mine tunnels, and buildings; single offspring born May-early July		
***** MOLLUSKS *****		
Northern Threeband (*Humboldtiana ultima*) - leaf litter in mesic canyons of limestone mountains; in soil, under rocks		
***** REPTILES *****		
Trans-Pecos Black-headed Snake (*Tantilla cucullata*) – small size with a uniform body color and a small, dark head; secretive; fossorial; mostly nocturnal; mesquite-creosote and pinon-juniper-oak; eggs laid June-August; eat insects, spiders, and other invertebrates		T
Big Bend Slider (*Trachemys gaigeae*) – almost exclusively aquatic, sliders (*Trachemys* spp.) prefer quiet bodies of fresh water with muddy bottoms and abundant aquatic vegetation, which is their main food source; will bask on logs, rocks or banks of water bodies; breeding March-July; this species found in Big Bend region of Texas and northeastern Mexico		
Chihuahuan Desert Lyre Snake (*Trimorphodon vilkinsonii*) – mostly crevice-dwelling in predominantly limestone-surfaced desert northwest of the Rio Grande from Big Bend to the Franklin Mountains, especially in areas with jumbled boulders and rock faults/fissures; secretive; egg-bearing; eats mostly lizards		T
Chihuahuan Mud Turtle (*Kinosternon hirtipes murrayi*) - semi-aquatic, prefers bodies of fresh water with abundant aquatic vegetation; eats invertebrates; breeds March-July		T
Mountain Short-horned Lizard (*Phrynosoma hernandesi*) - diurnal, usually in open, shrubby, or openly wooded areas with sparse vegetation at ground level; soil may vary from rocky to sandy; burrows into soil or occupies rodent burrow when inactive; eats ants, spiders, snails, sowbugs, and other invertebrates; inactive during cold weather; breeds March-September		
Texas Horned Lizard (*Phrynosoma cornutum*) – open, arid and semi-arid regions with sparse vegetation, which could include grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September		T

Federal Status State Status

VASCULAR PLANTS

Chisos agave (*Agave glomeruliflora*) - high elevation grasslands or oak-juniper woodlands; known in Guadalupe Mountains from bajada slopes; flowering July-August

Desert night-blooming cereus (*Peniocereus greggii* var. *greggii*) - shrublands in lower elevation desert flats and washes; flowering concentrated during a few nights in late May to late June

Gyp locoweed (*Astragalus gypsodes*) – gypsum or stiff gypseous clay soils on low rolling hills, mostly at low elevations in areas adjacent to the Guadalupe Mountains; many of the known locations are on the Castile Formation (Permian); flowering April-June

Gypsum scalebroom (*Lepidospartum burgessii*) – grasslands on stabilized gypsum; flowering May-late summer

Sand prickly-pear (*Opuntia arenaria*) – deep, loose sands in sparsely vegetated dune or sandhill areas; flowering May-June

Sand sacahuista (*Nolina arenicola*) – windblown Quaternary sand in dune areas east of Van Horn; also in shrublands on steep Permian limestone slopes in the Guadalupe Mountains; flowering March-August

Smooth-stem skullcap (*Scutellaria laevis*) – on mountain slopes and in arroyos along dry streambeds; known from Beach and Guadalupe mountains; flowering April-September

Swallow spurge (*Chamaesyce golondrina*) - alluvial or eolian sand along Rio Grande, occasionally on adjacent shale or limestone slopes; flowering June-November

Terlingua brickellbush *(Brickellia hinckleyi* var. *terlinguensis*) - various situations in Chihuahuan Desert; collected from slopes in the Chisos and Eagle mountains; also along a creek bottom near Terlingua; flowering July-October?

Texas wolf-berry *(Lycium texanum*) - thorn shrublands on sandy soils, in rocky areas on canyons and on roadsides at elevations of 3500-4600 feet; flowering March-October

Watson's false clappia-bush (*Pseudoclappia watsonii*) – Chihuahuan Desert shrublands on dry, rocky, gypseous clay hills; flowering May-August

Wheeler's spurge (*Chamaesyce geyeri* var. *wheeleriana*) – sparsely vegetated loose sand in reddish sand dunes or coppice mounds; flowering and fruiting August-September?

JEFF DAVIS COUNTY

09/01/05***DRAFT*****UNDER CONSTRUCTION ****
SPECIES MIGHT BE ADDED/DELETED DURING QUALITY CONTROL**

	Federal Status	State Status
***** BIRDS *****		
American Peregrine Falcon (*Falco peregrinus anatum*) - resident in west Texas	DL	E
Arctic Peregrine Falcon (*Falco peregrinus tundrius*) - potential migrant	DL	T
Baird's Sparrow (*Ammodramus bairdii*) - shortgrass prairie with scattered low bushes and matted vegetation		
Common Black Hawk (*Buteogallus anthracinus*) - cottonwood-lined rivers and streams; willow tree groves on the lower Rio Grande floodplain; formerly bred in south Texas		T
Interior Least Tern (*Sterna antillarum athalassos*) – this subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish & crustaceans, when breeding forages within a few hundred feet of colony	LE	E
Mexican Spotted Owl (*Strix occidentalis lucida*) – remote, shaded canyons of coniferous mountain woodlands (pine and fir); nocturnal predator of mostly small rodents and insects; day roosts in densely vegetated trees, rocky areas, or caves	LT	T
Montezuma Quail (*Cyrtonyx montezumae*) – open pine-oak or juniper-oak with ground cover of bunch grass on flats and slopes of semi-desert mountains and hills; travels in pairs or small groups; eats succulents, acorns, nuts, and weed seeds, as well as various invertebrates		
Mountain Plover (*Charadrius montanus*) – breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous		
Northern Aplomado Falcon (*Falco femoralis septentrionalis*) - open country, especially savanna and open woodland, and sometimes in very barren areas; grassy plains and valleys with scattered mesquite, yucca, and cactus; nests in old stick nests of other bird species	LE	E
Prairie Falcon (*Falco mexicanus*) – open, mountainous areas, plains and prairie; nests on cliffs		
Southwestern Willow Flycatcher (*Empidonax traillii extimus*) – thickets of willow, cottonwood, mesquite, and other species along desert streams	LE	E

	Federal Status	State Status
Western Burrowing Owl (*Athene cunicularia hypugaea*) - open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows and man-made structures, such as culverts		
Yellow-billed Cuckoo (*Coccyzus americanus*) - status applies only west beyond the Pecos River Drainage; riparian habitat and associated drainages; springs, developed wells, and earthen ponds supporting mesic vegetation; deciduous woodlands with cottonwood and willow; dense understory foliage important for nest site selection; nests in willow, mesquite, cottonwood, and hackberry; forages in similar riparian woodlands; breeding season mid-May-late Sept	C1	
Zone-tailed Hawk (*Buteo albonotatus*) - arid open country, including open deciduous or pine-oak woodland, mesa or mountain county, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T

CRUSTACEANS

	Federal Status	State Status
Diminutive Amphipod (*Gammarus hyalleloides*) – endemic aquatic amphipod; known only from Phantom Lake Spring; omnivorous; amphipods are active mostly at night and spend daylight hours hiding under vegetation and other cover; vulnerable to reduction of springflow resulting from declining levels of groundwater		

FISHES

	Federal Status	State Status
Chihuahua Catfish (*Ictalurus* sp. 1) (extirpated) - has been identified from the Rio Grande and Rio Conchos of Texas/Mexico.		
Comanche Springs Pupfish (*Cyprinodon elegans*) – originally in Comanche Springs, San Solomon, and Phantom Cave, presently restricted to San Solomon and Phantom Cave and associated springs, and downstream irrigation canals; extirpated from Comanche Springs in Pecos County; found in constantly discharging springs and in swift-flowing water of canals and earthen ditches, vulnerable to hybridization with *C. variegatus*	LE	E
Headwater Catfish (*Ictalurus lupus*) – originally throughout streams of the Edwards Plateau and the Rio Grande basin, currently limited to Rio Grande drainage, including Pecos River basin; springs, and sandy and rocky riffles, runs, and pools of clear creeks and small rivers		

	Federal Status	State Status
Pecos Gambusia (*Gambusia nobilis*) – Pecos River and tributaries; shallow margins of clear, vegetated spring waters high in calcium carbonate, as well as in sinkhole habitats	LE	E
Rio Grande Chub (*Gila pandora*) – in Texas, isolated population in Davis Mountains; formerly widespread in creeks of upper Rio Grande and Pecos watersheds; pools of small to moderate-sized tributaries, often near inflow of riffles and in association with cover such as undercut banks and plant debris		T
*****INSECTS*****		
Texas Minute Moss Beetle (*Limnebius texanus*) – adult moss beetles of this genus are aquatic and herbivorous; larvae are semiaquatic and carnivorous; found in vegetation along margins of streams		
***** MAMMALS *****		
Big Free-tailed Bat (*Nyctinomops macrotis*) – habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, but gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undetermined, but may hibernate in the Trans-Pecos; opportunistic insectivore		
Black Bear (*Ursus americanus*) - within historical range of Louisiana Black Bear in eastern Texas, Black Bear is federally listed threatened and inhabits bottomland hardwoods and large tracts of undeveloped forested areas; in remainder of Texas, Black Bear is not federally listed and inhabits desert lowlands and high elevation forests and woodlands; dens in tree hollows, rock piles, cliff overhangs, caves, or under brush piles	T/SA NL	T
Black-footed Ferret (*Mustela nigripes*) – considered extirpated in Texas; potential inhabitant of any prairie dog towns in the general area	LE	E
Black-tailed Prairie Dog (*Cynomys ludovicianus*) - dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups		
Cave Myotis Bat (*Myotis velifer*) - roosts colonially in caves, rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (*Petrochelidon pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum caves of Panhandle during winter; opportunistic insectivore		

	Federal Status	State Status
Davis Mountains Cottontail (*Sylvilagus floridanus robustus*) – brushy pastures, brushy edges of cultivated fields, and well-drained streamsides; active mostly at twilight and at night, where they may forage in a variety of habitats, including open pastures, meadows, or even lawns; rest during daytime in thickets or in underground burrows and small culverts; feed on grasses, forbs, twigs and bark; not sociable and seldom seen feeding together		
Fringed Myotis Bat (*Myotis thysanodes*) – habitat variable, ranging from mountainous pine, oak, and pinyon-juniper to desert-scrub, but prefers grasslands at intermediate elevations; highly migratory species that arrives in Trans-Pecos by May to form nursery colonies; single offspring born June-July; roosts colonially in caves, mine tunnels, rock crevices, and old buildings		
Ghost-faced Bat (*Mormoops megalophylla*) - colonially roosts in caves, crevices, abandoned mines, and buildings; insectivorous; breeds late winter-early spring; single offspring born per year		
Gray Wolf (*Canis lupus*) (extirpated) – formerly known throughout the western two-thirds of the state in forests, brushlands, or grasslands	LE	E
Greater Long-nosed Bat (*Leptonycteris nivalis*) – in Texas, Big Bend region; colonial, cave-dwelling species that usually inhabits deep caverns; nectivorous, with *Agave* spp. preferred; breeding season April-June, with single offspring born in Mexico prior to migration to Texas	LE	E
Greater Western Mastiff Bat (*Eumops perotis californicus*) – diurnal roosts in rock crevices of vertical cliffs; colony size varies from several individuals to several dozen; males and females may remain together throughout the year; single offspring (occasionally twins) born June-July		
Limpia Creek Pocket Gopher (*Thomomys bottae texensis*) – Trans-Pecos Texas and eastward across western Edwards Plateau; habitat variable, ranging from loose sands and silts to tight clays; dry deserts to montane meadows; active year round, mostly underground; diet variable, but mostly roots and tubers; breeds continuously, but main season in spring		
Limpia Southern Pocket Gopher (*Thomomys bottae limpiae*) - Trans-Pecos Texas and eastward across western Edwards Plateau; habitat variable, ranging from loose sands and silts to tight clays; dry deserts to montane meadows; active year round, mostly underground; diet variable, but mostly roots and tubers; breeds continuously, but main season in spring		

Federal Status | State Status

Long-legged Myotis Bat (*Myotis volans*) – in Texas, Trans-Pecos region; high, open woods and mountainous terrain; nursery colonies (which may contain several hundred individuals) form in summer in buildings, crevices, and hollow trees; apparently do not use caves as day roosts, but may use such sites at night; single offspring born June-July

Pale Townsend's Big-eared Bat (*Corynorhinus townsendii pallescens*) - roosts in caves, abandoned mine tunnels, and occasionally old buildings; hibernates in groups during winter; in summer months, males and females separate into solitary roosts and maternity colonies, respectively; single offspring born May-June; opportunistic insectivore

Swift Fox (*Vulpes velox*) - restricted to shortgrass prairie; western and northern portions of Panhandle

Western Yellow Bat (*Lasiurus xanthinus*) - forages over water both perennial and intermittent sources, found at low elevations (< 6,000 feet), roosts in vegetation (yucca, hackberry, sycamore, cypress, and especially palm); also hibernates in palm; locally common in residential areas landscaped with palms in Tuscon and Phoenix, Arizona; young born in June; insectivore

Yellow-nosed Cotton Rat (*Sigmodon ochrognathus*) – higher elevations in the Chisos Mountains, Davis Mountains, and Sierra Vieja; rocky slopes with scattered bunches of grass; underground dens and aboveground nests in various locations, including at base of agaves or roots of junipers; active in daytime; several litters possible during breeding season of March-October

Yuma Myotis Bat (*Myotis yumanensis*) - desert regions; most commonly found in lowland habitats near open water, where forages; roosts in caves, abandoned mine tunnels, and buildings; single offspring born May-early July

MOLLUSKS

Brune's Tryonia (*Tryonia brunei*) – endemic spring snail; known only from Phantom Lake Spring; vulnerable to declining groundwater resulting in reduction of springflow

Davis Mountains Threeband (*Humboldtiana cheatumi*) - terrestrial snail; deciduous leaf litter in cool, moist upper reaches of canyons in the Davis Mountains

Davis Spring Snail (*Fontelicella davisi*) - freshwater; in and on mud and rocks among patches of watercress in spring-fed rivulets

Mitre Peak Threeband (*Humboldtiana ferrissiana*) - terrestrial snail; higher elevations of the Davis Mts., in leaf litter, under rocks

	Federal Status	State Status
Mount Livermore Threeband (*Humboldtiana palmeri*) – terrestrial snail; highest parts (most mesic) of igneous intrusive mountains; in leaf litter; among boulders		
Phantom Cave Snail (*Cochliopa texana*) – endemic aquatic snail; known only from three spring systems and associated outflows in Jeff Davis and Reeves counties; vulnerable to reduction of springflow resulting from declining levels of groundwater	C1	
Phantom Cave Spring Tryonia (*Tryonia cheatumi*) – endemic aquatic snail; known only from three spring systems and associated outflows in Jeff Davis and Reeves counties; vulnerable to reduction of springflow resulting from declining levels of groundwater	C1	
***** REPTILES *****		
Big Bend Slider (*Trachemys gaigeae*) – almost exclusively aquatic, sliders (*Trachemys* spp.) prefer quiet bodies of fresh water with muddy bottoms and abundant aquatic vegetation, which is their main food source; will bask on logs, rocks or banks of water bodies; breeding March-July; this species found in Big Bend region of Texas and northeastern Mexico		
Chihuahuan Desert Lyre Snake (*Trimorphodon vilkinsonii*) – mostly crevice-dwelling in predominantly limestone-surfaced desert northwest of the Rio Grande from Big Bend to the Franklin Mountains, especially in areas with jumbled boulders and rock faults/fissures; secretive; egg-bearing; eats mostly lizards		T
Chihuahuan Mud Turtle (*Kinosternon hirtipes murrayi*) - semi-aquatic, prefers bodies of fresh water with abundant aquatic vegetation; eats invertebrates; breeds March-July		T
Mountain Short-horned Lizard (*Phrynosoma hernandesi*) - diurnal, usually in open, shrubby, or openly wooded areas with sparse vegetation at ground level; soil may vary from rocky to sandy; burrows into soil or occupies rodent burrow when inactive; eats ants, spiders, snails, sowbugs, and other invertebrates; inactive during cold weather; breeds March-September		T
Texas Horned Lizard (*Phrynosoma cornutum*) – open, arid and semi-arid regions with sparse vegetation, which could include grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September		T
Trans-Pecos Black-headed Snake (*Tantilla cucullata*) – small size with a uniform body color and a small, dark head; secretive; fossorial; mostly nocturnal; mesquite-creosote and pinon-juniper-oak; eggs laid June-August; eat insects, spiders, and other invertebrates		T

VASCULAR PLANTS

Species	Federal Status	State Status
Bearded mock-orange (*Philadelphus crinitus*) – talus slopes (igneous?) in the Davis Mountains; flowering July-August		
Desert night-blooming cereus (*Peniocereus greggii* var. *greggii*) - shrublands in lower elevation desert flats and washes; flowering concentrated during a few nights in late May to late June		
Green spikemoss (*Selaginella viridissima*) – shaded or sheltered igneous rock ledges and cliffs in the Chisos and Davis mountains; sporiferous June-August		
Havard's stonecrop (*Sedum havardii*) – crevices on rock ledges and talus at high elevations in the Chisos and Davis mountains; flowering spring-summer		
Hinckley's bricklellbush (*Brickellia hinckleyi* var. *hinckleyi*) - rocky soils in higher elevation canyons in Davis Mountains and outliers; flowering July-October		
Hinckley's Jacob's-ladder (*Polemonium pauciflorum* ssp. *hinckleyi*) – in Texas, known only from the Davis Mountains; moist humus soils along streams in wooded mountain canyons at about 7500 feet elevation; flowering July-October		
Little Aguja pondweed (*Potamogeton clystocarpus)* – submersed aquatic plant known only from quiet, seepage pools in Little Aguja Creek in the Davis Mountains; fruiting May-October, possibly later	LE	E
Livermore sandwort (*Arenaria livermorensis)* – igneous rock outcrops at high elevations in the Davis Mountains; flowering August-October		
Livermore sweet-cicely (*Osmorhiza mexicana* ssp. *bipatriata*) – wet ground around springs in high mountain canyons; flowering June-July		
Many-flowered unicorn-plant (*Proboscidea spicata*) – dry sandy alluvial and/or eolian soils on terraced along Rio Grande; also in disturbed sandy soils at scattered sites along roadsides elsewhere in the Trans Pecos; flowering May-June (-August)		
Mexican dwarf oak (*Quercus depressipes*) – woodlands at high elevations; known in Texas from north and south facing slopes of Mount Livermore		
Murray's plum (*Prunus murrayana*) - deciduous woodlands on steep rocky slopes in mesic, high elevation mountain canyons; known from igneous and sedimentary substrates; flowering March-April		
Ojinaga ringstem (*Anulocaulis reflexus*) – desert scrub communities on gypseous soils; flowering August-November		
Royal red penstemon (*Penstemon cardinalis* ssp. *regalis*) – pine-oak woodlands in canyons at higher elevations in the Davis and Guadalupe mountains; flowering May-June (-August)		

Federal Status | State Status

Shinner's tickle-tongue (*Zanthoxylum parvum*) – well-drained, neutral, non-calcareous loams underlain by igneous rock on steep slopes; maple-oak woodlands or evergreen oak shinnery; flowering in April

Standley's draba (*Draba standleyi*) – crevices in sparsely vegetated igneous boulders and rock outcrops at high elevations in the Davis Mountains; flowering June-October

Texas false saltgrass (*Allolepis texana*) - deep silty or sandy soil; cultivated and waste meadow lands or sand flats perhaps locally in saline or strongly alkaline soil; flowering (June-) July-October

Texas largeseed bittercress *(Cardamine macrocarpa* var. *texana*) - seasonally (vernally) moist loamy soils in pine-oak woodlands, at high elevations in the Chisos Mountains but at moderate elevations in pinyon-oak juniper woodlands in Kinney nd Uvalde counties; flowering in early spring and withering by beginning of summer; it is unknown whether this species, like many other annual crucifers, blooms occasionally in early winter (December)

Warnock's coral-root (*Hexalectris warnockii*) - leaf litter and humus in oak-juniper woodlands in mountain canyons in the Trans Pecos but at lower elevations to the east, often on narrow terraces along creekbeds

Watson's false clappia-bush (*Pseudoclappia watsonii*) – Chihuahuan Desert shrublands on dry, rocky, gypseous clay hills; flowering May-August

Withered woolly loco (*Astragalus mollissimus* var. *marcidus*) - endemic; gravelly slopes and flats in grasslands at mid to higher elevations; flowering April-July

Young's snowbells (*Styrax platanifolius ssp. youngiae*) – known in Texas from a single specimen collected in 1914 "…in a canyon, Davis Mts., Texas"; presumably on rocky igneous slopes in mountain canyons above 4000 feet elevation; flowering in May?

PRESIDIO COUNTY

08/06/05***DRAFT*****UNDER CONSTRUCTION ****
SPECIES MIGHT BE ADDED/DELETED DURING QUALITY CONTROL**

*** BIRDS ***

	Federal Status	State Status
American Peregrine Falcon (*Falco peregrinus anatum*) - resident in west Texas	DL	E
Arctic Peregrine Falcon (*Falco peregrinus tundrius*) - potential migrant	DL	T
Baird's Sparrow (*Ammodramus bairdii*) - shortgrass prairie with scattered low bushes and matted vegetation		
Gray Hawk (*Asturina nitida*) – locally and irregularly along U.S.-Mexico border; mature riparian woodlands and nearby semiarid mesquite and scrub grasslands; breeding range formerly extended north to southernmost Rio Grande floodplain of Texas		T
Interior Least Tern (*Sterna antillarum athalassos*) – this subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish & crustaceans, when breeding forages within a few hundred feet of colony	LE	E
Mexican Spotted Owl (*Strix occidentalis lucida*) – remote, shaded canyons of coniferous mountain woodlands (pine and fir); nocturnal predator of mostly small rodents and insects; day roosts in densely vegetated trees, rocky areas, or caves	LT	T
Montezuma Quail (*Cyrtonyx montezumae*) – open pine-oak or juniper-oak with ground cover of bunch grass on flats and slopes of semi-desert mountains and hills; travels in pairs or small groups; eats succulents, acorns, nuts, and weed seeds, as well as various invertebrates		
Mountain Plover (*Charadrius montanus*) – breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous		
Northern Aplomado Falcon (*Falco femoralis septentrionalis*) - open country, especially savanna and open woodland, and sometimes in very barren areas; grassy plains and valleys with scattered mesquite, yucca, and cactus; nests in old stick nests of other bird species	LE	E
Prairie Falcon (*Falco mexicanus*) – open, mountainous areas, plains and prairie; nests on cliffs		
Southwestern Willow Flycatcher (*Empidonax traillii extimus*) – thickets of willow, cottonwood, mesquite, and other species along desert streams	LE	E

Species	Federal Status	State Status
Western Burrowing Owl (*Athene cunicularia hypugaea*) - open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows and man-made structures, such as culverts		
Yellow-billed Cuckoo (*Coccyzus americanus*) - status applies only west beyond the Pecos River Drainage; riparian habitat and associated drainages; springs, developed wells, and earthen ponds supporting mesic vegetation; deciduous woodlands with cottonwood and willow; dense understory foliage important for nest site selection; nests in willow, mesquite, cottonwood, and hackberry; forages in similar riparian woodlands; breeding season mid-May-late Sept	C1	
Zone-tailed Hawk (*Buteo albonotatus*) - arid open country, including open deciduous or pine-oak woodland, mesa or mountain county, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T

*** FISHES ***

Species	Federal Status	State Status
Blue Sucker (*Cycleptus elongatus*) - larger portions of major rivers in Texas; usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles		T
Bluntnose Shiner (*Notropis simus*) (extirpated) - main river channels, often below obstructions over substrate of sand, gravel, and silt; damming and irrigation practices presumed major factors contributing to decline		T
Chihuahua Shiner (*Notropis chihuahua*) – Rio Grande drainage in Big Bend region; sandy and rocky pools and runs of creeks and small rivers		T
Conchos Pupfish (*Cyprinodon eximius*) – Rio Grande and Devils River basins; sloughs, backwaters, and margins of larger streams, channels of creeks, and mouths		T
Headwater Catfish (*Ictalurus lupus*) – originally throughout streams of the Edwards Plateau and the Rio Grande basin, currently limited to Rio Grande drainage, including Pecos River basin; springs, and sandy and rocky riffles, runs, and pools of clear creeks and small rivers		
Mexican Stoneroller (*Campostoma ornatum*) – in Texas, Big Bend region; clear, fast riffles, chutes, and pools in small to medium-sized creeks with gravel or sand bottoms		T

	Federal Status	State Status
Rio Grande Silvery Minnow (*Hybognathus amarus*) (extirpated) - historically Rio Grande and Pecos River systems and canals; pools and backwaters of medium to large streams with low or moderate gradient in mud, sand, or gravel bottom; ingests mud and bottom ooze for algae and other organic matter; probably spawns on silt substrates of quiet coves.	LE	E
West Mexican Redhorse (*Scartomyzon austrinus*) – known only from Alamito Creek, Big Bend region; restricted to rocky riffles of creeks and small to medium rivers, often near boulders in swift water		

*** MAMMALS ***

	Federal Status	State Status
Big Free-tailed Bat (*Nyctinomops macrotis*) – habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, but gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undertermined, but may hibernate in the Trans-Pecos; opportunistic insectivore		
Black Bear (*Ursus americanus*) - within historical range of Louisiana Black Bear in eastern Texas, Black Bear is federally listed threatened and inhabits bottomland hardwoods and large tracts of undeveloped forested areas; in remainder of Texas, Black Bear is not federally listed and inhabits desert lowlands and high elevation forests and woodlands; dens in tree hollows, rock piles, cliff overhangs, caves, or under brush piles	T/SA NL	T
Black-footed Ferret (*Mustela nigripes*) – considered extirpated in Texas; potential inhabitant of any prairie dog towns in the general area	LE	E
Black-tailed Prairie Dog (*Cynomys ludovicianus*) - dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups		
Cave Myotis Bat (*Myotis velifer*) - roosts colonially in caves, rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (*Petrochelidon pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum caves of Panhandle during winter; opportunistic insectivore		

	Federal Status	State Status
Davis Mountains Cottontail (*Sylvilagus floridanus robustus*) – brushy pastures, brushy edges of cultivated fields, and well-drained streamsides; active mostly at twilight and at night, where they may forage in a variety of habitats, including open pastures, meadows, or even lawns; rest during daytime in thickets or in underground burrows and small culverts; feed on grasses, forbs, twigs and bark; not sociable and seldom seen feeding together		
Fringed Myotis Bat (*Myotis thysanodes*) – habitat variable, ranging from mountainous pine, oak, and pinyon-juniper to desert-scrub, but prefers grasslands at intermediate elevations; highly migratory species that arrives in Trans-Pecos by May to form nursery colonies; single offspring born June-July; roosts colonially in caves, mine tunnels, rock crevices, and old buildings		
Ghost-faced Bat (*Mormoops megalophylla*) - colonially roosts in caves, crevices, abandoned mines, and buildings; insectivorous; breeds late winter-early spring; single offspring born per year		
Gray Wolf (*Canis lupus*) (extirpated) – formerly known throughout the western two-thirds of the state in forests, brushlands, or grasslands	LE	E
Greater Long-nosed Bat (*Leptonycteris nivalis*) – in Texas, Big Bend region; colonial, cave-dwelling species that usually inhabits deep caverns; nectivorous, with *Agave* spp. preferred; breeding season April-June, with single offspring born in Mexico prior to migration to Texas	LE	E
Greater Western Mastiff Bat (*Eumops perotis californicus*) – diurnal roosts in rock crevices of vertical cliffs; colony size varies from several individuals to several dozen; males and females may remain together throughout the year; single offspring (occasionally twins) born June-July		
Long-legged Myotis Bat (*Myotis volans*) – in Texas, Trans-Pecos region; high, open woods and mountainous terrain; nursery colonies (which may contain several hundred individuals) form in summer in buildings, crevices, and hollow trees; apparently do not use caves as day roosts, but may use such sites at night; single offspring born June-July		
Pale Townsend's Big-eared Bat (*Corynorhinus townsendii pallescens*) - roosts in caves, abandoned mine tunnels, and occasionally old buildings; hibernates in groups during winter; in summer months, males and females separate into solitary roosts and maternity colonies, respectively; single offspring born May-June; opportunistic insectivore		
Pecos River Muskrat *(Ondatra zibethicus ripensis*) – creeks, rivers, lakes, drainage ditches, and canals; prefer shallow, fresh water with clumps of marshy vegetation, such as cattails, bulrushes, and sedges; live in dome-shaped lodges constructed of vegetation; diet is mainly vegetation; breed year round		

	Federal Status	State Status
Presidio Mole (*Scalopus aquaticus texanus*) – in Texas, occur in moist (not wet), sandy soils; live underground in excavated or usurped burrows; uncommon, but will travel overland to seek new locations or mates; solitary most of year, but seek out mates in late winter-early spring; eat invertebrates, mostly earthworms and grubs		
Western Small-footed Bat (*Myotis ciliolabrum*) - mountainous regions of the Trans-Pecos, usually in wooded areas, also found in grassland and desert scrub habitats; roosts beneath slabs of rock, behind loose tree bark, and in buildings; maternity colonies often small and located in abandoned houses, barns, and other similar structures; apparently occurs in Texas only during spring and summer months; insectivorous		
Yellow-nosed Cotton Rat (*Sigmodon ochrognathus*) – higher elevations in the Chisos Mountains, Davis Mountains, and Sierra Vieja; rocky slopes with scattered bunches of grass; underground dens and aboveground nests in various locations, including at base of agaves or roots of junipers; active in daytime; several litters possible during breeding season of March-October		
Yuma Myotis Bat (*Myotis yumanensis*) - desert regions; most commonly found in lowland habitats near open water, where forages; roosts in caves, abandoned mine tunnels, and buildings; single offspring born May-early July		
***** MOLLUSKS *****		
Presidio County Spring Snail (*Fontelicella metcalfi*) - found in the outflows of springs (24 degrees C) in fine mud and dense watercress		
San Carlos Threeband (*Humboldtiana hoegiana praesidii*) - leaf litter and in soil under rocks in higher elevations of desert mountain ranges in Mexico		
***** REPTILES *****		
Big Bend Slider (*Trachemys gaigeae*) – almost exclusively aquatic, sliders (*Trachemys* spp.) prefer quiet bodies of fresh water with muddy bottoms and abundant aquatic vegetation, which is their main food source; will bask on logs, rocks or banks of water bodies; breeding March-July; this species found in Big Bend region of Texas and northeastern Mexico		
Chihuahuan Desert Lyre Snake (*Trimorphodon vilkinsonii*) – mostly crevice-dwelling in predominantly limestone-surfaced desert northwest of the Rio Grande from Big Bend to the Franklin Mountains, especially in areas with jumbled boulders and rock faults/fissures; secretive; egg-bearing; eats mostly lizards		T

	Federal Status	State Status
Chihuahuan Mud Turtle (*Kinosternon hirtipes murrayi*) - semi-aquatic, prefers bodies of fresh water with abundant aquatic vegetation; eats invertebrates; breeds March-July		T
Reticulated Gecko (*Coleonyx reticulatus*) – rocky desert areas of the Big Bend region; terrestrial and nocturnal; reproduction not well known, but captive individuals laid eggs in July		T
Texas Horned Lizard (*Phrynosoma cornutum*) – open, arid and semi-arid regions with sparse vegetation, which could include grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September		T
Trans-Pecos Black-headed Snake (*Tantilla cucullata*) - small size with a uniform body color and a small, dark head; secretive; fossorial; mostly nocturnal; mesquite-creosote and pinon-juniper-oak; eggs laid June-August; eat insects, spiders, and other invertebrates		T

*** VASCULAR PLANTS ***

Boquillas lizardtail (*Gaura boquillensis*) – sandy soils in desert canyons and arroyos; dry gravelly limestone soils in Chihuahuan Desert scrub at low elevations; flowering March-August

Bushy wild-buckwheat (*Eriogonum suffruticosum*) – sparsely vegetated rocky limestone slopes, low hills, and clay flats; flowering March-April; in full fruit by May

Chihuahua scurfpea (*Pediomelum pentaphyllum*) – in Texas, known from a single specimen collected in the 1850's from "fields near the Presidio del Norte," from which it assumed that habitat is alluvial soils along Rio Grande; habitat later described as "sandy soils, 2000 to 4000 ft."; flowering April-May?

Desert night-blooming cereus (*Peniocereus greggii* var. *greggii*) - shrublands in lower elevation desert flats and washes; flowering concentrated during a few nights in late May to late June

Duncan's cory cactus (*Escobaria dasyacantha* var. *duncanii*) - low to moderate elevation limestone hills in Chihuahuan Desert; on outcrops of Boquillas Formation limestone; flowering April-May; fruits mature May-June

Fresno Creek thelypody (*Thelypodium tenue*) – known only from the gravel bed of Fresno Creek, an intermittent desert stream which drains a landscape of varied geology; flowers in early spring

Fringed monkeyflower (*Mimulus dentilobus*) – perennially wet areas near springs, on wet cliff-faces at waterfalls, and in creekbeds, mostly in mountains of the Chihuahuan Desert; flowering June-August

	Federal Status	State Status
Golden-spine hedgehog cactus (*Echinocereus chloranthus* var. *neocapillus*) - sparsely vegetated desert grasslands over novaculite outrcrops		
Guadalupe Mountains columbine (*Aquilegia chrysantha* var. *chaplinei*) – perennially moist to wet limestone canyon walls; moist leaf litter and humus among boulders in wooded mesic canyons; flowering April-September		
Gypsum hotspring aster (*Arida blepharophylla*) - around spring and seeps in gypsum areas; flowering summer and/or fall		
Hinckley's columbine (*Aquilegia chrysantha* var. *hinckleyana*) – perennially moist to wet limestone canyon walls, moist leaf litter and humus among boulders in wooded mesic canyons; flowering April-September		
Hinckley's oak (*Quercus hinckleyi*) – arid limestone slopes at mid elevations in Chihuahuan Desert; produces acorns late August to early September	LT	T
Many-flowered unicorn-plant *(Proboscidea spicata*) – dry sandy alluvial and/or eolian soils on terraced along Rio Grande; also in disturbed sandy soils at scattered sites along roadsides elsewhere in the Trans Pecos; flowering May-June (-August)		
Manystem spiderflower (*Cleome multicaulis*) – habitat variable; in Texas, known from a sacaton (Sporobulus wrightii) flat at the edge of a cienega (desert spring) in soil developed over volcanic ash; flowering/fruiting June-September		
Matt Turner's aster (*Arida mattturneri*) - seepy areas within gypsum-walled canyon in the Chihuahuan Desert; flowering summer (July-?)		
Ojinaga ringstem (*Anulocaulis reflexus*) – desert scrub communities on gypseous soils; flowering August-November		
Perennial caltrop *(Kallstroemia perennans*) – barren gypseous clays or limestone soils at low elevations in the Chihuahuan Desert; flowering late spring-early fall		
Slimlobe rock-daisy *(Perityle dissecta*) – perennial; crevices in limestone bluffs; only rock-daisy in west Texas with finely dissected hairy leaves; flowering spring-fall		
Spiny kidney-wood (*Eysenhardtia spinosa*) – grasslands or shrublands on igneous outcrops or limestone hills in and around the Sierra Vieja Mountains; flowering in August		
Swallow spurge (*Chamaesyce golondrina*) – alluvial or eolian sand along Rio Grande, occasionally adjacent shale or limestone slopes; flowering June-November		

Federal Status | State Status

Texas false saltgrass (*Allolepis texana*) - deep silty or sandy soil; cultivated and waste meadow lands or sand flats perhaps locally in saline or strongly alkaline soil; flowering (June-) July-October

Trans-Pecos maidenbush (*Andrachne arida*) - in Texas, found in crevices on arid Cretaceous limestone slopes; with lechuguilla (*Agave lechuguilla*); flowering July-October

Warnock's coral-root (*Hexalectris warnockii*) - leaf litter and humus in oak-juniper woodlands in mountain canyons in the Trans Pecos but at lower elevations to the east, often on narrow terraces along creekbeds

Watson's false clappia-bush (*Pseudoclappia watsonii*) – Chihuahuan Desert shrublands on dry, rocky, gypseous clay hills; flowering May-August

White column cactus (*Escobaria albicolumnaria*) - sparse desert succulent shrublands on rocky hills or limestone outcrops at lower elevations (ca. 2000-4000 feet) in the Chihuahuan Desert; flowering March-May

Withered woolly loco (*Astragalus mollissimus* var. *marcidus*) - endemic; gravelly slopes and flats in grasslands at mid to higher elevations; flowering April-July

TERRELL COUNTY

08/06/05***DRAFT*****UNDER CONSTRUCTION ******
SPECIES MIGHT BE ADDED/DELETED DURING QUALITY CONTROL

*** BIRDS ***

Species	Federal Status	State Status
American Peregrine Falcon (*Falco peregrinus anatum*) - resident in west Texas	DL	E
Arctic Peregrine Falcon (*Falco peregrinus tundrius*) - potential migrant	DL	T
Audubon's Oriole (*Icterus graduacauda audubonii*) - scrub, mesquite; nests in dense trees, or thickets, usually along water courses		
Baird's Sparrow (*Ammodramus bairdii*) - shortgrass prairie with scattered low bushes and matted vegetation		
Black-capped Vireo (*Vireo atricapilla*) - oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous and broad-leaved shrubs and trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level, and required structure; nesting season March-late summer	LE	E
Common Black Hawk (*Buteogallus anthracinus*) - cottonwood-lined rivers and streams; willow tree groves on the lower Rio Grande floodplain; formerly bred in south Texas		T
Gray Hawk (*Asturina nitida*) – locally and irregularly along U.S.-Mexico border; mature riparian woodlands and nearby semiarid mesquite and scrub grasslands; breeding range formerly extended north to southernmost Rio Grande floodplain of Texas		T
Interior Least Tern (*Sterna antillarum athalassos*) – this subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish & crustaceans, when breeding forages within a few hundred feet of colony	LE	E
Mexican Hooded Oriole (*Icterus cucullatus cucullatus*) - scrub, mesquite; nests in dense trees, or thickets, usually along water courses		
Mexican Spotted Owl (*Strix occidentalis lucida*) – remote, shaded canyons of coniferous mountain woodlands (pine and fir); nocturnal predator of mostly small rodents and insects; day roosts in densely vegetated trees, rocky areas, or caves	LT	T

	Federal Status	State Status
Montezuma Quail (*Cyrtonyx montezumae*) – open pine-oak or juniper-oak with gound cover of bunch grass on flats a,nd slopes of semi-desert mountains and hills; travels in pairs or small groups; eats succulents, acorns, nuts, and weed seeds, as well as various invertebrates		
Mountain Plover (*Charadrius montanus*) – breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous		
Northern Aplomado Falcon (*Falco femoralis septentrionalis*) - open country, especially savanna and open woodland, and sometimes in very barren areas; grassy plains and valleys with scattered mesquite, yucca, and cactus; nests in old stick nests of other bird species	LE	E
Prairie Falcon (*Falco mexicanus*) – open, mountainous areas, plains and prairie; nests on cliffs		
Southwestern Willow Flycatcher (*Empidonax traillii extimus*) – thickets of willow, cottonwood, mesquite, and other species along desert streams	LE	E
Western Burrowing Owl (*Athene cunicularia hypugaea*) - open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows and man-made structures, such as culverts		
White-tailed Hawk (*Buteo albicaudatus*) – near coast it is found on prairies, cordgrass flats, and scrub-live oak; further inland on prairies, mesquite and oak savannas, and mixed savanna-chaparral; breeding March to May		T
Yellow-billed Cuckoo (*Coccyzus americanus*) - status applies only west beyond the Pecos River Drainage; riparian habitat and associated drainages; springs, developed wells, and earthen ponds supporting mesic vegetation; deciduous woodlands with cottonwood and willow; dense understory foliage important for nest site selection; nests in willow, mesquite, cottonwood, and hackberry; forages in similar riparian woodlands; breeding season mid-May-late Sept	C1 NL	
Zone-tailed Hawk (*Buteo albonotatus*) - arid open country, including open deciduous or pine-oak woodland, mesa or mountain county, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T

*** FISHES ***

Species	Federal Status	State Status
Blue Sucker (*Cycleptus elongatus*) - larger portions of major rivers in Texas; usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles		T
Bluntnose Shiner (*Notropis simus*) (extirpated) - main river channels, often below obstructions over substrate of sand, gravel, and silt; damming and irrigation practices presumed major factors contributing to decline		T
Conchos Pupfish (*Cyprinodon eximius*) – Rio Grande and Devils River basins; sloughs, backwaters, and margins of larger streams, channels of creeks, and mouths		T
Headwater Catfish (*Ictalurus lupus*) – originally throughout streams of the Edwards Plateau and the Rio Grande basin, currently limited to Rio Grande drainage, including Pecos River basin; springs, and sandy and rocky riffles, runs, and pools of clear creeks and small rivers		
Pecos Pupfish (*Cyprinodon pecosensis*) – originally Pecos River basin, presently restricted to upper basin only; shallow margins of clear, vegetated spring waters high in calcium carbonate, as well as in sinkhole habitats		T
Proserpine Shiner (*Cyprinella proserpina*) – Rio Grande and Pecos River basin; rocky runs and pools of creeks and small rivers		T
Rio Grande Blue Catfish (*Ictalurus furcatus* ssp.) - spawns in late spring - early summer; deep areas of large rivers, swift chutes, pools with swift currents, reservoirs, fish-farm ponds; tolerates moderate salinities; eggs deposited in nests under logs, brush, or riverbank; bottom feeder; mostly crustaceans and aquatic insects when young, later fish and large invertebrates, also scavenges		
Rio Grande Darter (*Etheostoma grahami*) – Rio Grande and lower Pecos River basins; gravel and rubble riffles of creeks and small rivers		T
Rio Grande Shiner (*Notropis jemezanus*) – large, open, weedless rivers or large creeks with bottom of rubble, gravel and sand, often overlain with silt		
Rio Grande Silvery Minnow (*Hybognathus amarus*) (extirpated) - historically Rio Grande and Pecos River systems and canals; pools and backwaters of medium to large streams with low or moderate gradient in mud, sand, or gravel bottom; ingests mud and bottom ooze for algae and other organic matter; probably spawns on silt substrates of quiet coves.	LE	E
West Mexican Redhorse (*Scartomyzon austrinus*) – known only from Alamito Creek, Big Bend region; restricted to rocky riffles of creeks and small to medium rivers, often near boulders in swift water		

*** MAMMALS ***

	Federal Status	State Status
Big Free-tailed Bat (*Nyctinomops macrotis*) – habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, but gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undetermined, but may hibernate in the Trans-Pecos; opportunistic insectivore		
Black Bear (*Ursus americanus*) - within historical range of Louisiana Black Bear in eastern Texas, Black Bear is federally listed threatened and inhabits bottomland hardwoods and large tracts of undeveloped forested areas; in remainder of Texas, Black Bear is not federally listed and inhabits desert lowlands and high elevation forests and woodlands; dens in tree hollows, rock piles, cliff overhangs, caves, or under brush piles	T/SA NL	T
Black-tailed Prairie Dog (*Cynomys ludovicianus*) - dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle; live in large family groups		
Cave Myotis Bat (*Myotis velifer*) - roosts colonially in caves, rock crevices, old buildings, carports, under bridges, and even in abandoned Cliff Swallow (*Petrochelidon pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum caves of Panhandle during winter; opportunistic insectivore		
Davis Mountains Cottontail (*Sylvilagus floridanus robustus*) – brushy pastures, brushy edges of cultivated fields, and well-drained streamsides; active mostly at twilight and at night, where they may forage in a variety of habitats, including open pastures, meadows, or even lawns; rest during daytime in thickets or in underground burrows and small culverts; feed on grasses, forbs, twigs and bark; not sociable and seldom seen feeding together		
Ghost-faced Bat (*Mormoops megalophylla*) - colonially roosts in caves, crevices, abandoned mines, and buildings; insectivorous; breeds late winter-early spring; single offspring born per year		
Gray Wolf (*Canis lupus*) (extirpated) – formerly known throughout the western two-thirds of the state in forests, brushlands, or grasslands	LE	E
Greater Western Mastiff Bat (*Eumops perotis californicus*) – diurnal roosts in rock crevices of vertical cliffs; colony size varies from several individuals to several dozen; males and females may remain together throughout the year; single offspring (occasionally twins) born June-July		

	Federal Status	State Status
Long-legged Myotis Bat (*Myotis volans*) – in Texas, Trans-Pecos region; high, open woods and mountainous terrain; nursery colonies (which may contain several hundred individuals) form in summer in buildings, crevices, and hollow trees; apparently do not use caves as day roosts, but may use such sites at night; single offspring born June-July		
Pale Townsend's Big-eared Bat (*Corynorhinus townsendii pallescens*) - roosts in caves, abandoned mine tunnels, and occasionally old buildings; hibernates in groups during winter; in summer months, males and females separate into solitary roosts and maternity colonies, respectively; single offspring born May-June; opportunistic insectivore		
Pecos River Muskrat *(Ondatra zibethicus ripensis*) – creeks, rivers, lakes, drainage ditches, and canals; prefer shallow, fresh water with clumps of marshy vegetation, such as cattails, bulrushes, and sedges; live in dome-shaped lodges constructed of vegetation; diet is mainly vegetation; breed year round		
White-nosed Coati (*Nasua narica*) - woodlands, riparian corridors and canyons; most individuals in Texas probably transients from Mexico; diurnal and crepuscular; very sociable; forages on ground and in trees; omnivorous; may be susceptible to hunting, trapping, and pet trade		T
Yuma Myotis Bat (*Myotis yumanensis*) - desert regions; most commonly found in lowland habitats near open water, where forages; roosts in caves, abandoned mine tunnels, and buildings; single offspring born May-early July		
*****MOLLUSKS*****		
False Spike Mussel *(Quincuncina mitchelli*) - substrates of cobble and mud, with water lilies present; Rio Grande, Brazos, Colorado, and Guadalupe (historic) river basins		
Mexican Fawnsfoot *(Truncilla cognata*) - largely unknown; possibly intolerant of impoundment; possibly needs flowing streams and rivers with sand or gravel bottoms based on related species needs; Rio Grande basin		
Salina Mucket *(Potamilus metnecktayi*) - lotic waters; other habitat requirements are poorly understood; Rio Grande Basin		
Texas Hornshell *(Popenaias popeii*) - both ends of narrow shallow runs over bedrock, in areas where small-grained materials collect in crevices, along river banks, and at the base of boulders; not known from impoundments; Rio Grande Basin and several rivers in Mexico	C1	

*** REPTILES ***

Species	Federal Status	State Status
Big Bend Slider (*Trachemys gaigeae*) – almost exclusively aquatic, sliders (*Trachemys* spp.) prefer quiet bodies of fresh water with muddy bottoms and abundant aquatic vegetation, which is their main food source; will bask on logs, rocks or banks of water bodies; breeding March-July; this species found in Big Bend region of Texas and northeastern Mexico		
Chihuahuan Desert Lyre Snake (*Trimorphodon vilkinsonii*) – mostly crevice-dwelling in predominantly limestone-surfaced desert northwest of the Rio Grande from Big Bend to the Franklin Mountains, especially in areas with jumbled boulders and rock faults/fissures; secretive; egg-bearing; eats mostly lizards		T
Chihuahuan Mud Turtle (*Kinosternon hirtipes murrayi*) - semi-aquatic, prefers bodies of fresh water with abundant aquatic vegetation; eats invertebrates; breeds March-July		T
Reticulated Gecko (*Coleonyx reticulatus*) – rocky desert areas of the Big Bend region; terrestrial and nocturnal; reproduction not well known, but captive individuals laid eggs in July		T
Texas Horned Lizard (*Phrynosoma cornutum*) – open, arid and semi-arid regions with sparse vegetation, which could include grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September		T
Texas Tortoise (*Gopherus berlandieri*) – open scrub woods, arid brush, lomas, grass-cactus association; open brush with grass understory preferred; uses shallow depressions at base of bush or cactus or underground burrow or hides under surface cover		T
Trans-Pecos Black-headed Snake (*Tantilla cucullata*) – small size with a uniform body color and a small, dark head; secretive; fossorial; mostly nocturnal; mesquite-creosote and pinon-juniper-oak; eggs laid June-August; eat insects, spiders, and other invertebrates		T

*** VASCULAR PLANTS ***

Species	Federal Status	State Status
Bunched cory cactus (*Coryphantha ramillosa* ssp. *ramillosa*) - rocky slopes, ledges, and flats in the Chihuahuan Desert, most frequently on exposures of Santa Elena Limestone or the Boquillas Formation between 2500-3500 feet elevation; flowering (April?-) July-August	LT	T
Cox's dalea (*Dalea bartonii*) - semi-desert shortgrass grasslands with scattered pinyon pine and juniper in gravelly soils on limestone hills; the one known location reportedly lies at an altitude of about 1100 m (3600 ft); probably flowering in June, fruiting in July		

Federal Status | State Status

Desert night-blooming cereus (*Peniocereus greggii* var. *greggii*) - shrublands in lower elevation desert flats and washes; flowering concentrated during a few nights in late May to late June

Durango yellow-cress (*Rorippa ramosa*) – moist, fine textured, alluvial soils on floodplains and in beds of intermittent streams; flowering March-May

Dwarf broomspurge (*Chamaesyce jejuna*) - endemic; according to specimen collections, found on caliche uplands and slopes, and limestone hills; flowering spring-summer (?)

Grayleaf rock-daisy *(Perityle cinerea*) – crevices in limestone caprock of mesas; flowering spring and fall?

Heather leaf-flower (*Phyllanthus ericoides*) - crevices in limestone on dry canyon walls and other rock outcrops; flowering in October, and presumably other months, given sufficient moisture

Hester's cory cactus (*Escobaria hesteri*) – grasslands on dry gravelly limestone hills and alluvial fans at ca. 4000-5000 feet; often on novaculite; flowering May-June; fruiting June-July

Maravillas milkwort *(Polygala maravillasensis*) - crevices of limestone exposed on canyon walls along Rio Grande and tributaries; flowering June-July

Orcutt's senna *(Senna orcuttii*) - gravelly soil on limestone slopes and in beds of intermittent streams, in various Chihuahuan Desert communities; flowering July-August

Warnock's coral-root *(Hexalectris warnockii*) - leaf litter and humus in oak-juniper woodlands in mountain canyons in the Trans Pecos but at lower elevations to the east, often on narrow terraces along creekbeds

Wright's trumpets *(Acleisanthes wrightii*) - open semi-desert grasslands and shrublands on shallow stony soils over limestone on low hills and flats; flowering spring-fall, probably opportunistically

Status Key:	
LE, LT -	Federally Listed Endangered/Threatened
PE, PT -	Federally Proposed Endangered/Threatened
E/SA, T/SA -	Federally Listed Endangered/Threatened by Similarity of Appearance
C1 -	Federal Candidate for Listing, Category 1; information supports proposing to list as endangered/threatened
DL, PDL -	Federally Delisted/Proposed for Delisting
NL -	Not Federally Listed
E, T -	State Listed Endangered/Threatened
"blank" -	Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

APPENDIX 1B

MAJOR SPRINGS

APPENDIX 1B
MAJOR SPRINGS

The Far West Texas Water Planning Group recognizes the following "Major Springs" occurring on state, federal, or privately owned conservation-managed lands for their importance for natural resource protection.

Chinati Mountains State Natural Area – Cienega La Baviza Spring

Cienega Creek flows downstream from the spring-fed spring, La Baviza, in the 38,187-acre Chinati Mountains State Natural Area in west-central Presidio County. The spring (cienega) forms a fresh to slightly saline marsh with waters that are slightly geothermal. The habitat supports a fairly intact, diverse marsh with saline grasses, rushes, sedges, and perennials. A high diversity of desert bats also use the area for feeding and watering. The adjacent Cienega Creek has very good examples of saline marsh and cottonwood gallery woodlands. It is an important wildlife area and is located in the low Chihuahuan Desert where intact wetlands and riparian habitat are quite rare. Cienega Creek is recommended as an "Ecologically Unique River or Stream Segment" in Chapter 8.

Big Bend National Park / Rio Grande Wild and Scenic River Spring Complexes

River regulation, agricultural and municipal withdrawals and drought have diminished and altered the discharge patterns for the lower Rio Grande in Far West Texas. The physical and ecological system, once adapted to large and rapid fluctuations in flow, is now adapted to lower and more constant flows. The 250-mile reach of the Rio Grande managed by the National Park Service is the only free flowing reach in the lower Rio Grande. A significant portion of the base flows are provided by groundwater contributions from four spring complexes located in Big Bend National Park and along the Rio Grande Wild and Scenic River. Management Plans for both NPS entities list the protection of springs as critical management concerns. A portion of the Rio Grande Wild and Scenic River is recommended by the planning group as an "Ecologically Unique River and Stream

Segment" and is discussed in Chapter 8. NPS staff has identified the following four spring complexes.

Gambusia Hot Springs Complex

River miles	804	814
UTM Coordinates N	3233835	3226468
UTM Coordinates E	702647	694388
Zone 13		

This reach includes hot springs between Mariscal Canyon and Boquillas Canyon. Easily delineated orifices with significant flow include: Gravel Pit, Langford Hot Springs, Lower Hot Springs (a.k.a. VD Springs or Leper Springs), Rio Grande Village Springs 3 and 4, and numerous unnamed springs. Springs on the Mexican side include Ojo Caliente and Boquillas Hot Springs. These springs issue from the upper Cretaceous rock units, the Boquillas and Santa Elena Limestones. Rio Grande Village currently gets its water supply from one of these springs. In addition, this same spring and another nearby spring feed two ponds that contain the world's only population of *Gambusia gaigei*.

Outlaw Flats Spring Complex

River miles	748	762
UTM Coordinates N	3292773	3296392
UTM Coordinates E	725582	716672
Zone 13		

Springs issue from the Glen Rose Limestone. Generally of low volume; however, there is evidence of historical use at a spring on the Texas side (approximately 749.5) near the confluence with Big Canyon. Historical use includes the remains of a spring box.

Las Palmas Spring Complex

River miles	735	742
UTM Coordinates N	3293228	3293608
UTM Coordinates E	737565	732013
Zone 13		

Large volume springs in Del Carmen Limestone. Historical use at Asa Jones waterworks, a withdrawal and distribution system for a candelilla wax camp located on the canyon rim east of Silver Canyon. The system includes pumps, piping, and several rock tanks, one of which is located over a spring emanating from a rock joint. Park Service personnel estimated the spring discharge at 300 gpm. This joint can be followed in both directions beyond the rock walls where additional water discharges. Water enters the river on both sides along a reach approximately 200 feet long. Undocumented Mexican emigrants use this area frequently, as indicated by the presence of discarded clothing and bedrolls. Directly below the Asa Jones Waterworks, on the Texas side is Spigot Spring. River runners use this spring as a water source. Two miles downstream on the Coahuila Mexico, side is Hot Springs, a very popular river camp due to the presence of several warm pools. A road on the Mexican side provides access to the area for the Mexican Army (reports from River District Ranger). Another spring below and on the Texas side is commonly used as a water source for river runners.

Madison Fold Spring Complex

River miles	720	723
UTM Coordinates N	3298065	3296092
UTM Coordinates E	753147	751786
Zone 13		

Low volume springs discharging from the Del Carmen Limestone and the Maxon Sandstone. As these are the last discharges along the river, river runners commonly use the spring on the Texas side and below Lower Madison Falls as a water source.

<u>Guadalupe Mountains National Park Springs Complex</u>

Springs in the Guadalupe Mountains National Park are crucial for maintenance of ecological stability and wildlife health within the Chihuahuan Desert environment. Loss or failure of any of these springs would cause significant environmental stress, even though discharge rates of most are relatively small. Most springs are also historic areas used by pioneers, early ranchers, and settlers. Remains of their homesteads and structures used to manage spring outflow and direct water usage are still visible in and near the springs. The National Park Service is directed to preserve these historic elements and cultural landscapes against unnatural impacts from continued human use, as well as to protect the spring's water quality and quantity from human induced impairment. Specific major natural resource springs are listed in the following table:

SPRINGS IN GUADALUPE MOUNTAINS NATIONAL PARK				
Name	Discharge (gpm)	State Well Number	Position NAD 1927 Conus UTM 13 N northing	Position NAD 1927 Conus UTM 13 N easting
Bone Spring	2-3	-	3527444	512087
Dog Canyon Spring	<1	-	3537770	514918
Frijole Spring	6-13	47-02-801	3530009	518842
Goat Spring	1	-	3529611	511370
Guadalupe Spring	6-10	47-02-701	3526606	514633
Juniper Spring	<1	47-02-502	3531081	519488
Manzanita Spring	10-38	47-02-802	3530317	519111
Smith Spring	13-55	47-02-501	3531248	518287
Upper Pine Spring	8-13	47-02-803	3529514	517274

Texas Nature Conservancy Independence Creek Preserve – Caroline Spring

Caroline Spring is located at the Texas Nature Conservancy's Independence Creek Preserve headquarters in northeastern Terrell County. The spring produces 3,000 to 5,000 gallons per minute and comprises about 25 percent of the creek's flow. Downstream, Independence Creek's contribution increases the Pecos River water volume by 42 percent and reduces the total dissolved solids by 50 percent, thus improving water quantity and quality. The preserve hosts a variety of bird and fish species, some of which are extremely rare. Caroline Spring, along with the entirety of the Independence Creek Preserve (19,740 acres), is a significant piece of West Texas natural heritage.

Texas Nature Conservancy Davis Mountains Preserve – Tobe, Bridge, Pine and Limpia Springs

The wild and remote Davis Mountains is considered one of the most scenic and biologically diverse areas in Texas. Rising above the Chihuahuan desert, the range forms a unique "sky island" surrounded by the lowland desert. Animals and plants living above 5,000 feet are isolated from other similar mountain ranges by vast distances. The Texas Nature Conservancy has established the 32,000-acre Davis Mountains Preserve (with conservation easements on 65,830 acres of adjoining property) in the heart of this region. Tobe, Bridge, Pine and Limpia springs form critical wetland habitat and establish base flow to the downstream creeks.

APPENDIX 1C

LOCAL ORGANIZATIONS AND UNIVERSITIES

APPENDIX 1C
LOCAL ORGANIZATIONS AND UNIVERSITIES

The public and even those involved in water planning and management find it difficult to know about or keep track of the large number and wide array of organizations involved with water resource issues in the Far West Texas region. This list of water resource organizations was developed to identify those involved in water resources and provide information about each organization's purpose and points of contact. Because of the hydrologic, cultural and economic connections of Far West Texas with Southern New Mexico and Mexico, this draft includes water organizations in these regions. The information provided below was obtained from a number of sources including organization web sites, published information and personal communication.

ALLIANCE FOR THE RIO GRANDE HERITAGE

The Alliance is an affiliation of environmental groups and community organizations working to restore the Rio Grande basin. Member organizations working in the Far West Texas portion of the basin include the Forest Guardians, Rio Grande/Rio Bravo Basin Coalition, the Southwest Environmental Center, and World Wildlife Fund.

BORDER ENVIRONMENT COOPERATION COMMISSION

The Border Environment Cooperation Commission (BECC) identifies, supports, evaluates and certifies sustainable environmental infrastructure projects through broad public participation, to improve the quality of life of the people of the U.S. - Mexico border region.

- Contact: Fernando Macias, General Manager, P.O. Box 221648, El Paso, TX 79913, (011-52-656) 688-4600, fmacias@cocef.org, becc@cocef.org, http://www.cocef.org/

CITY OF EL PASO

Water Conservation Advisory Board

The Board was established to advise and provide recommendations to the Mayor and City Council regarding the development and implementation of water conservation and water use monitoring programs. It consists of 9 regular members who are residents of El Paso County.

- Contact: Elza Cushing, Chair, c/o City of El Paso, Planning, Research & Development Department, 2 Civic Center Plaza, El Paso, TX 79901, 505-541-4904, Fax: 505-541-4028, spencernm@elpasotexas.gov

Rio Grande Riverpark Task Force

The Task Force has the goal of providing a contiguous river park along the Rio Grande in the Paso del Norte region by 2010, extending approximately from the New Mexico/Texas state line to Rio Bosque Park. It includes members of El Paso city and county governments, as well as representatives from other stakeholder groups in the area, including the City of Sunland Park (New Mexico), Congressman Silvestre Reyes, Franklin Mountains State Park, Keystone Heritage Park, the National Park Service (representing El Camino Real de Tierra Adentro National Historic Trail), Paso del Norte Health Foundation, Rio Bosque Wetlands Park, Texas Parks and Wildlife, Texas Department of Transportation, U. S. Border Patrol, U. S. Environmental Protection Agency, and Ysleta del Sur Pueblo.

- Contact: Paul Cusumano, National Park Service Rivers and Trails Program, P.O. Box 728, Santa Fe, NM 87505, 505-988-6093, Paul_Cusumano@nps.gov, http://www.epcounty.com/parksandrec/riverpark/vision.htm

CITY OF LAS CRUCES, RIO GRANDE RIPARIAN ECOLOGICAL CORRIDOR PROJECT

In June 2000 the City of Las Cruces received $250,000 from the EPA's Sustainable Development Challenge Grant program to create the Rio Grande Riparian Ecological Corridor Project. "The Project encompasses a distance of eleven linear miles, from the Shalem Colony Bridge to the Mesilla Dam, and is envisioned for both the western and eastern banks of the southern Rio Grande. There are three components to the Project: a Comprehensive Plan, intended as a guide for future development along the river; construction of a one-mile multi-use pathway; construction of a small wetland."

- Contact: Carol McCall, Keep Las Cruces Beautiful Coordinator, Community Development Department, Neighborhood Development and Planning, 575 S. Alameda Boulevard, Las Cruces, NM 88001, 505-528-3148, carolm@las-cruces.org, http://www.las-cruces.org/PDFs/RioGrande.pdf

CONSORTIUM FOR HI-TECHNOLOGY INVESTIGATIONS IN WATER AND WASTE WATER

This Consortium (CHIWAWA) was formed to facilitate and promote the transfer of technology, training, and research among the El Paso Water Utilities Public Service Board, the City of Alamogordo, the Center for Environmental Resource Management at the University of Texas at El Paso, the Water Resources Research Institute at New Mexico State University, and the Texas Agricultural Experiment Station of the Texas A&M University System.

- Contact: Karl Wood, NMWRRI – NMSU, Box 30001, MSC 3167, Las Cruces, NM 88003, 505-646-4337, Fax: 505-646-6418, kwood@wrri.nmsu.edu, http://wrri.nmsu.edu/
- Stephen Riter, UTEP, El Paso, TX 79968, 915-747-7890, sriter@utep.edu

- Ari Michelsen, TAMU-TAES, El Paso Research Center, 1380 A&M Circle, El Paso, TX 79927, 915-859-9111, a-michelsen@tamu.edu, http://agresearch.tamu.edu/El-Paso.htm
- Edmund Archuleta, El Paso Water Utilities, 1154 Hawkins Blvd., El Paso, TX 79961, 915-594-5501, earchuleta@epwu.org, http://www.epwu.org/
- Pat McCourt, City Manager, City of Alamogordo, pmccourt@ci.alamogordo.nm.us, http://ci.alamogordo.nm.us/index.html

ENVIRONMENTAL DEFENSE

Environmental Defense is a leading national nonprofit organization representing more than 400,000 members. Since 1967, we have linked science, economics and law to create innovative, equitable and cost-effective solutions to society's most urgent environmental problems.

- Contact: Carlos Rincon, US - México Project Director, 1100 N. Stanton, Suite 805, El Paso, TX 79902, 915-543-9292, Fax 915-543-9115, crincon@environmentaldefense.org, http://www.environmentaldefense.org

FOREST GUARDIANS

In our work, we aim to: protect and restore the native biological diversity and watersheds of the American Southwest; educate and enlist citizens to support protection of the forests, rivers, deserts and grasslands of this arid region; advocate for the principles of conservation biology in plans to restore degraded ecosystems and watersheds; enforce and strengthen environmental laws; support communities in efforts to protect their land and to practice and promote sustainable use of natural resources.

- Contact: John Horning, Executive Director, 312 Montezuma, Suite A, Santa Fe, NM 87501, 505-988-9126 x153, Fax: 505-989-8623, jhorning@fguardians.org, swwild@fguardians.org, http://fguardians.org/

HUDSPETH DIRECTIVE FOR CONSERVATION

The mission of the Hudspeth Directive for Conservation is to establish long term care for the ecosystem of the High Chihuahuan Desert, including its water, natural habitats and species. They seek to balance this care with a thorough understanding of the complex rural and urban demands upon the Chihuahuan Desert and to identify and promote ways in which our communities can realize stable economies which do not destroy the natural habitat.

- Contact: Linda Lynch, Executive Director, 505-494-5391, dunablanca@aol.com

MULTI-STATE SALINITY COALITION

The Multi-State Salinity Coalition seeks advancements in desalination-related technologies and salinity control strategies to enhance the quality and quantity of water sources. The Coalition is an informal group of water utilities and water districts, and includes the El Paso Water Utilities. The Bureau of Reclamation, Sandia Labs, and several other entities also participate.

- Contact: Ed Archuleta, El Paso Water Utilities, 915-594-5501, earchuleta@epwu.org

NEW MEXICO LOWER RIO GRANDE WATER USERS ORGANIZATION

This organization represents public bodies that reside in south-central New Mexico and has been given the mandate to guide the regional planning effort in this region. Its members include the City of Las Cruces, Dona Ana County, Dona Ana Mutual Domestic Water Consumers Association, the Town of Mesilla, the Anthony

Water and Sanitation District, the Village of Hatch, New Mexico State University, and Elephant Butte Irrigation District. The LRGWUO has defined its boundary for regional planning as Dona Ana County and that portion of Sierra County that is within the EBID boundary. The areas excluded the Tularosa and Mimbres basins in the county.

- Contact: 1-866-DAC-PLAN (322-7526) or in Las Cruces call 505-527-1041, http://wrri.nmsu.edu/lrgwuo/

NEW MEXICO STATE UNIVERSITY

New Mexico Water Resources Research Institute

The New Mexico Water Resources Research Institute (WRRI), authorized by the 1964 Water Resources Act, was formed in 1963 and was one of the first institutes approved in the US. The New Mexico Institute is one of 54 institutes/centers in the U.S. and possessions and a member of the National Institutes for Water Resources and the Powell Consortium. The overall mission of the WRRI is to develop and disseminate knowledge that will assist the state and nation in solving water problems. Through the funding of research and demonstration projects, the institute utilizes the knowledge and experience of researchers throughout the state to solve New Mexico's pressing water problems. Research is conducted by faculty and students within the departmental structure of each New Mexico university campus. In-house staff administers the institute's programs, conducts special research projects, and produces a variety of issue reports.

- Contact: Karl Wood, Director, P.O. Box 30001, MSC 3167, New Mexico State University, Las Cruces, NM 88003-0001, 505-646-4337, Fax: 505-646-6418, kwood@wrri.nmsu.edu, http://wrri.nmsu.edu/

New Mexico Water Task Force

The task force will include about 75 NMSU specialists on water-related issues who will provide rapid responses to public requests for studies, white papers, expert testimony at public hearings and proposed solutions to water problems. It will provide New Mexico with a broad body of experts who can collectively and consistently identify and address water issues on an academic and scientific basis.

- Contact: Craig Runyan, Extension water quality specialist, CES Plant Sciences, NMSU College of Agriculture and Home Economics, P.O. Box 30003, MSC 3AE, Las Cruces, NM 88003, 505-646-1131, crunyan@nmsu.edu, http://www.watertaskforce.org

WERC

Originally known as the Waste-management, Education and Research Consortium, the organization is now called WERC: A Consortium for Environmental Education and Technology Development. It is involved with NMSU's Arsenic Partnership Program, established by Congress in 2003 as a response to new Safe Drinking Water Act requirements that lower the acceptable levels of arsenic in drinking water. It also sponsors the New Mexico Project WET (Water Education for Teachers), an international, interdisciplinary, water science and education program for formal and non-formal educators of K-12 students. As the New Mexico state sponsor for Project WET, WERC provides curriculum materials and educator workshops that are conducted throughout the state. They also sell the manual, "Discover a Watershed: Rio Grande/Rio Bravo Educators Guide."

- Contact: Abbas Ghassemi, Executive Director, WERC/NMSU, P.O. Box 30001, MSC WERC, EC III, 3rd Floor, Suite 300 South, Las Cruces, NM 88003-8001, 505-646-2357, aghassem@nmsu.edu, http://www.werc.net/

NEW MEXICO WATER CONSERVATION ALLIANCE

This is a non-profit organization of people dedicated to water conservation issues. Individuals from municipal, industrial, institutional, and commercial sectors have joined together in an effort to exchange information, provide education, and work collaboratively to help ensure a positive water future for the state. The group sponsors an annual Drought Summit.

- Contact: Cheri Vogel, Alliance Secretary, Water Conservation Education Specialist, New Mexico Office of the State Engineer, 130 South Capitol Street, Concha Ortiz y Pino Building, P.O. Box 25102, Santa Fe, NM 87504-5102, 505-827-4272, Fax: 505-827-3813, cvogel@ose.state.nm.us, http://wrri.nmsu.edu/wrdis/nmwca/alliance.html

NEW MEXICO WATER TRUST BOARD

The board authorizes funding of water related projects such as storage and delivery of water to end users, implementation of the Endangered Species Act, restoration of watersheds and flood protection. It is comprised of ex officio agency officials and citizens representing a variety of interest groups.

- Contact: Water Trust Board Administrator, c/o New Mexico Finance Authority, 409 St. Michaels Drive, Santa Fe, NM 87505, 505-984-1454, Fax: 505-984-0002, agonzales@nmfa.net

NORTH AMERICAN COMMISSION FOR ENVIRONMENTAL COOPERATION

The Commission for Environmental Cooperation (CEC) is an international organization created by Canada, Mexico, and the United States under the North American Agreement on Environmental Cooperation (NAAEC). The CEC was established to address regional environmental concerns, help prevent potential trade and environmental conflicts, and to promote the effective enforcement of environmental law. The CEC has a Joint Public Advisory Committee (JPAC), comprised of 15 members--five each from Canada, Mexico, and the United States--who are appointed by their respective governments. Members act independently and are responsible for advising the environment ministers from each country on all matters that fall within the scope of the NAAEC.

- Contact: info@ccemtl.org, http://www.cec.org

NEW MEXICO-TEXAS WATER COMMISSION

The Commission was formed as part of a settlement agreement between Elephant Butte Irrigation District, the City of El Paso, and New Mexico State University, regarding the supply and use of water in the Rio Grande. Members of the Commission include the El Paso Public Service Board, Elephant Butte Irrigation District, Texas A&M Agricultural Center, City of Las Cruces, New Mexico State University, Dona Ana County, University of Texas at El Paso, and El Paso County Water Improvement District #1. The purpose of the Commission is to identify and address common concerns and objectives with respect to water resources in the region, including the possibility of securing additional supplies of surface water from upstream sources. It is expected to work together in a cooperative effort to maximize the utilization of waters provided to New Mexico and Texas through the Rio Grande Project, provide a forum for routine and regular reporting on water resource-related legislative and administrative actions within each respective state, serve as a central clearinghouse for review and monitoring of water resource plans and reports prepared by or for the Commission members, and provide governance and oversight to the Paso Del Norte Watershed Council and their mission to define, study, and implement environmental enhancements on the Rio Grande Project reach of the river and associated drains and riparian land.

- Contact: Ed Archuleta, Co-Chair, El Paso Water Utilities, P.O. Box 511, El Paso, TX 79961, 915-594-5501, Fax: 915-594-5699, earchuleta@epwu.org, http://www.nm-txwatercomm.org/
- Karl Wood, Co-Chair, Water Resources Research Institute, New Mexico State University, P.O. Box 30001, Dept. 3167, Las Cruces, NM 88003, 505-646-4337, Fax: 505-646-6418, kwood@wrri.nmsu.edu, http://wrri.nmsu.edu/

NORTH AMERICAN DEVELOPMENT BANK

The North American Development Bank (NADBank) and its sister institution, the Border Environment Cooperation Commission (BECC), were created under the auspices of the North American Free Trade Agreement (NAFTA). NADBank is an international financial institution established and capitalized in equal parts by the United States and Mexico for the purpose of financing environmental infrastructure projects. All NADBank-financed environmental projects must be certified by the Border Environment Cooperation Commission (BECC), be related to potable water supply, wastewater treatment or municipal solid waste management and be located within the border region.

- Contact: North American Development Bank, 203 South St. Mary's, Suite 300, San Antonio, TX 78205, 210-231-8000, Fax: 210-231-6232, http://www.nadbank.org/

PASO DEL NORTE WATERSHED COUNCIL

The Paso del Norte Watershed Council investigates, develops, and recommends options for watershed planning and management, and explores how water-related resources can best be balanced to benefit the Rio Grande ecosystem and the interests of all watershed stakeholders. The Council's focus is the Paso del Norte Watershed, defined as the Rio Grande basin between Elephant Butte Dam/Reservoir in southern New Mexico and Fort Quitman, Hudspeth County, Texas. The Council provides an open forum for the encouragement and development of activities that promote a healthy watershed. A website with GIS interface for the Paso del Norte Watershed Coordinated Water Resources Database has been created and can be accessed at http://www.pdnwc.org/.

- Contact: Irene Tejeda, Watershed Council Coordinator, Texas Agricultural Experiment Station, Texas A&M University System, 1380 A & M Circle, El Paso, TX 79927, 915-859-9111, Fax: 915-859-1078, pdnwc@pdnwc.org, http://www.pdnwc.org

PASO DEL NORTE WATER TASK FORCE

The Paso del Norte Water Task Force unites water managers, water users, experts and citizens working cooperatively to promote a tri-state, binational perspective on water issues that impact the future prosperity and long-term sustainability of the region. The Task Force actively promotes the sharing of information and ideas among water management entities and communities throughout the region, identifies water issues of highest priority, studies selected issues, disseminates results, and submits policy recommendations to appropriate authorities.

- Contact: Karl Wood, Chair, Water Resources Research Institute, New Mexico State University, P.O. Box 30001, Dept. 3167, Las Cruces, NM 88003, 505-646-4337, Fax: 505-646-6418, kwood@wrri.nmsu.edu, http://www.sharedwater.org/

PROJECT DEL RIO

Project Del Rio is a binational environmental education program that involves high schools along the Rio Grande in Colorado, New Mexico, Texas, and Mexico.

- Contact: Lisa LaRocque, 1494 A South Solano, Las Cruces, NM 88005, 505-522-7511, Fax: 505-522-0775

RIO GRANDE/RIO BRAVO BASIN COALITION

The Rio Grande/Rio Bravo Basin Coalition is a multi-national, multi-cultural organization with leadership from the United States, Mexico, and the Pueblo nations whose purpose is to help local communities restore and sustain the environment, economies, and social well being of the Rio Grande/Rio Bravo Basin. The Coalition has over 50 partner organizations from around the watershed that share a commitment to the health and long-term sustainability of the Rio Grande/Rio Bravo Basin.

- Currently dormant, http://www.rioweb.org/

RIO GRANDE COUNCIL OF GOVERNMENTS

The Rio Grande Council of Governments (RGCOG) provides a regional forum through which local governments can address issues and develop solutions that contribute to intergovernmental cooperation, improved coordination of activities and promote programs which make the region a better place to live, work and play. The Rio Grande Council of Governments is the administrative entity and public information coordinator for the Far West Texas Water Planning Group.

- Contact: Barbara Kauffman, 1100 N. Stanton, Suite 610, El Paso, TX 79902, 915-533-0998, Fax: 915-532-9385, http://www.riocog.org

RIO GRANDE INSTITUTE

The Rio Grande Institute is working to foster appreciation of the unique economic, cultural and natural resources of the Rio Grande/Rio Bravo basin and to facilitate informed action to conserve those resources and use them for the public good.

- Contact: Tyrus G. Fain, President, Post Office Box 183, Marathon, TX 79842, 432.386.4336, Fax: 432.386.9035, tfain@riogrande.org

RIO GRANDE WATERSHED FEDERAL COORDINATING COMMITTEE

Organized by Congressman Silvestre Reyes in April 2003 this is a consortium consisting of 11 federal agencies with the objective of sharing information about how each agency's programs may be used to assist community partners and potential sponsors in meeting their goals. Its focus is on the entire Rio Grande Watershed. It includes the IBWC, National Park Service, EPA, USACE (Albuquerque, Galveston Districts), USGS, US Bureau of Reclamation, El Paso Field Division, USDA - NRCS, Texas and Regional Office Bureau of Indian Affairs-Southern Plains Region, National Weather Service, and Bureau of Land management.

- Contact: El Paso Office of Congressman Silvestre Reyes, 310 N. Mesa, Suite 400, El Paso, TX 79901, 915-534-4400, Fax: 915-534-7426, https://ars.fws.gov/regmap.cfm?arskey=15530

SOUTHWEST ENVIRONMENTAL CENTER

The Southwest Environmental Center (SWEC) works to protect and restore the stretch of the Rio Grande between Elephant Butte, New Mexico, and Presidio, Texas (and Ojinaga, Chihuahua), and advocates against dependence on Rio Grande water for regional urban growth. SWEC also collaborates with the IBWC to restore riparian habitat in the Las Cruces, New Mexico area.

- Contact: Kevin Bixby, 275 North Downtown Mall, Las Cruces, NM 88005, 505-522-5552, swec@zianet.com, http://www.wildmesquite.org/

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

The Texas Clean Rivers Program

The Texas Clean Rivers Program (CRP) is a State-fee funded water quality monitoring, assessment, and public outreach program. The CRP is a collaboration of 15 partner agencies and the Texas Commission on Environmental Quality (TCEQ). The CRP provides the opportunity to approach water quality issues within a watershed or river basin at the local and regional level through coordinated efforts among diverse organizations. For the Rio Grande Basin, the International Boundary and Water Commission is the partner.

- Contact: Wayne Belzer, 4171 N. Mesa St., Bldg C, Suite 310, El Paso, TX 79902, 915- 832-4703, Fax: 915-832-4166, waynebelzer@ibwc.state.gov, http://www.ibwc.state.gov/CRP/Welcome.htm

THE TEXAS A&M UNIVERSITY SYSTEM

El Paso Agricultural Research and Extension Center, Texas Agricultural Experiment Station

The Center's mission is to serve the needs of the West Texas region and state by leading and conducting innovative water, natural resources, and environmental research, management, and education programs. Center scientists are developing technologies and methods to improve water use efficiency, increase water supplies and protect water quality and are leading research programs in waterborne pathogen detection and control, water and soil salinity management, hydrogeology, water value and riverbasin management, reclaimed water use and urban water conservation.

- Contact: Ari Michelsen, Resident Director, 1380 A & M Circle, El Paso, TX 79927, 915-859-9111, Fax: 915-859-1078, a-michelsen@tamu.edu, http://elpaso.tamu.edu/

Texas Cooperative Extension

Texas Cooperative Extension provides educational programs addressing water issues in Far West Texas Water Planning Group, Region E counties. Examples of programs include: Irrigation Conservation and Water Quality Issues in Crop Production (Hudspeth, El Paso, Presidio), Rainfall Harvesting (Hudspeth, Culberson, Brewster, Jeff Davis, and Terrell), Well Water Testing Programs (Brewster, Terrell, Presidio), and Xeriscaping/Water Conservation in Landscapes (El Paso, Hudspeth, Culberson).

- Contact: Marvin Ensor, Regional Program Director, West Central District, TCE, San Angelo, TX 76901, 325-653-4576, m-ensor@tamu.edu
- Contact: Michael Mecke, Extension Specialist, District 6 Office, TCE, Fort Stockton, TX 79735, 432-336-8585, mbmecke@ag.tamu.edu

Rio Grande Basin Initiative

Congress initially appropriated funds for the Rio Grande Basin Initiative in 2001 and has continued funding each year since then. The initiative is administered through the Cooperative State Research, Education, and Extension Service and the Texas A&M University System Agriculture Program Texas Water Resources Institute.

There are eight task areas including irrigation district programs, incentives for efficient water use, on-farm irrigation system management, urban water conservation, water quality protection, salinity management and water reuse and basin-wide hydrology.

- Contact: B. L. Harris, Texas Water Resources Institute, 2118 TAMU, College Station, TX 77843-2118, 979-845-1851, Fax: 979-845-8554,
- bl-harris@tamu.edu, http://riogrande.tamu.edu/

TEXAS STATE UNIVERSITY SYSTEM

Sustainable Agricultural Water Conservation in the Rio Grande Basin Project

The overall goal of this project is to develop and refine a comprehensive, integrated approach to achieving sustainable water use in the Rio Grande basin, utilizing the diverse expertise and skills of researchers from all the universities in the Texas State University System in addressing specific elements of this approach.

- Contact: K. M. Urbanczyk, Sul Ross State University, Alpine, TX 79832, 432-837-8110, Fax: 432-837-8632, kevinu@sulross.edu, http://srgis.sulross.edu/sawc/sawc.htm

TEXAS WATER MATTERS

Texas Water Matters is a collaborative effort between Environmental Defense, National Wildlife Federation, and Sierra Club. By collaborating with water policy specialists, public officials, and the communities of Texas, the goal is to ensure adequate water for all needs, environmental as well as human consumptive needs, reduce the future demand for water and foster efficient use of existing supplies, educate decision makers and the general public about the environmental and economic impacts of wasteful water development and the availability of cost-effective, environmentally sound alternatives, and involve citizens in decisions about water resource management at the local and state levels.

- Contact: 1-800-919-9151, info@texaswatermatters.org

Lone Star Chapter of the Sierra Club

- Contact: Ken Kramer, State Director, 512-477-1729, Fax: 512-477-8529, Kenwkramer@aol.com

National Wildlife Federation

- Contact: Susan Kaderka, Regional Director, 512-476-9805, Fax: 512-476-9810, kaderka@nwf.org

Environmental Defense

- Contact: Laura Marbury, 512-478-5161, Fax: 512-478-8140, lbrock@environmentaldefense.org

TRANS-PECOS WATER TRUST

The mission of the Trans-Pecos Water Trust is to protect and enhance the Rio Grande and its U.S. tributaries, from Fort Quitman to Amistad Reservoir, a stretch known as the "Forgotten River." Two primary goals of the Trust are (1) to secure and protect instream flows and enhance aquatic and riparian habitat through voluntary market transactions involving leases, purchases or donations of existing water rights, and (2) to assist landowners in protecting springs and restoring riparian and grasslands that benefit both landowners and native fish and wildlife.

- Contact: Michael Davidson, 432-371-2238, mike@blueskybigbend.com, http://www.visitbigbend.com/

TULAROSA BASIN NATIONAL DESALINATION RESEARCH FACILITY

This facility will be a national center for research in the desalting of brackish groundwater found in 'inland' states. The facility will provide all the requirements for researchers working with desalination systems, concentrate management issues, and renewable energy/desalination hybrids. This facility is a function of the U.S. Bureau of Reclamation.

- Contact: http://wrri.nmsu.edu/tbndrc/

UNIVERSITY OF TEXAS AT EL PASO

Center for Environmental Resource Management

This research program at the University of Texas-El Paso brings researchers and students from diverse environmental science backgrounds together to address environmental concerns of the border region.

- Contact: Bob Currey, Director, CERM, University Of Texas at El Paso, 500 W. University Ave., 201A Burges Hall, El Paso, TX 79968-0684, 915-747-8699, Fax: 915-747-5145, cerm@utep.edu,

Rio Bosque Wetlands Park

"Rio Bosque is a 372-acre park owned by the City of El Paso next to the Rio Grande at the southeast edge of the city. The Wetlands Park project is an ambitious effort to restore native wetland and riparian habitats at the site. It is a long-term project now in its early stages. Site preparation took place in 1997 and initial water deliveries were made in winter 1997-98."

- Contact: John A. Sproul, Jr., Program Coordinator/Manager, Rio Bosque Wetlands Park, Center for Environmental Resource Management, University of Texas at El Paso, 500 West University Avenue, El Paso, TX 79968-0645, jsproul@utep.edu, http://research.utep.edu/Default.aspx?alias=research.utep.edu/orsp

Southwest Consortium for Environmental Research and Policy in the Southwest

The Southwest Consortium for Environmental Research and Policy (SCERP) is a consortium of five U. S. and five Mexican universities: Arizona State University, New Mexico State University, San Diego State University, University of Texas at El Paso, University of Utah, El Colegio de la Frontera Norte, Instituto Tecnológico de Ciudad Juárez, Instituto Tecnológico y de Estudios Superiores de Monterrey, Universidad Autónoma de Baja California, and Universidad Autónoma de Ciudad

Juárez. SCERP serves U. S.-Mexican border residents by applying research information, insights, and innovations to environmental challenges in the region. SCERP was created in 1989 to initiate a comprehensive analysis of possible solutions to acute air, water, and hazardous waste problems that plague the United States-Mexican border region.

- Contact: D. Rick Van Schoik, Managing Director, SCERP, 5250 Campanile Drive, San Diego, CA 92182-1913, 619-594-0568, Fax: 619-594-0752, scerp@mail.sdsu.edu, http://www.scerp.org/

U. S. INTERNATIONAL BOUNDARY AND WATER COMMISSION

The U.S. International Boundary and Water Commission (IBWC) and the Comisión Internacional de Límites y Aguas (CILA), its counterpart on the Mexican side, are responsible for the waters of the Rio Grande and the Colorado River; operation and maintenance of international storage dams and reservoirs and plants for generating hydroelectric energy at the dams; regulation of the Colorado River waters allocated to Mexico; protection of lands along the river from floods by levee and floodway projects; solution of border sanitation and other border water quality problems; preservation of the Rio Grande and Colorado River as the international boundary; and demarcation of the land boundary. The IBWC reports to the federal government through the U.S. Department of State.

- Contact: Sally Spener, Public Affairs Specialist, 832-4175, 4171 North Mesa, Suite C-100, El Paso, TX 79902-1441, 1-800-262-8857, sallyspener@ibwc.state.gov, http://www.ibwc.state.gov/

Comisión Internacional deLímites y Aguas

CILA is the official agency for the Mexican section and reports to the Secretaría de Relaciones Exteriores (SRE), the Mexican counterpart to the U.S. Department of State. Under Mexico's Federal Public Administration Law, the Secretariat of External Relations handles all issues regarding international boundaries and waters. SRE undertakes studies and projects concerning the administration and distribution of water of international rivers, including the Rio Grande/Rio Bravo.

- Contact: Ing. Antonio Rascon, Comisionado, CILA, P.O. Box 10525, El Paso, TX 79905; also Ave. Universidad #2180, C.P. 32310, Zona Chamizal, MX, 01152-6566-13-65-20, arascon@cilamexeua.gob.mx, http://www.sre.gob.mx/cila/

Rio Grande Citizens' Forum

The Forum was established in 1999 for the exchange of information regarding USIBWC activities between Percha Dam, New Mexico, and Ft. Quitman, Texas. Its meetings serve as a focal point for the exchange of information between the USIBWC and the local community regarding ongoing and future USIBWC projects in the area. It has 11 board members including 2 chairs. It conducts quarterly public meetings during the evening at alternating sites in Las Cruces and El Paso. Board members serve as volunteers and receive no compensation.

- Contact: Sally Spener, Public Affairs Specialist, 832-4175, 4171 North Mesa, Suite C-100, El Paso, TX 79902-1441, 1-800-262-8857, sallyspener@ibwc.state.gov, http://www.ibwc.state.gov/

U. S. MEXICO BORDER COALITION OF RESOURCE CONSERVATION AND DEVELOPMENT COUNCILS

This group of RC&D councils is organized by the U. S. Department of Agriculture, Natural Resources Conservation Service.

- Contact: Eugene Adkins, Coordinator, Jornada RC&D Council, 2101 S. Broadway, Truth or Consequences, NM 87901, 505-894-6354, Fax: 505-894-2165.

WORLD WILDLIFE FUND – CHIHUAHUAN DESERT PROGRAM

The World Wildlife Fund is a non-profit environmental organization that runs a Chihuahuan Desert Program to educate people about and protect the diverse resources of the southwestern desert. In addition, WWF has joined the Alliance for the Rio Grande Heritage in its efforts to restore the Rio Grande while sustaining the needs of human inhabitants.

- Contact: Beth Bardwell, Program Officer, 100 East Hadley Street, Las Cruces, NM 88001, 505-525-9532, Fax: 505-523-2866, bethbardwell@zianet.com, http://www.worldwildlife.org/

CHAPTER 2

POPULATION AND WATER DEMAND

2.1 INTRODUCTION

Planning for the wise use of the existing water resources in Far West Texas requires a reasonable estimation of current and future water needs for all water-use categories. The Texas Water Development Board (TWDB) regional planning rules specify in Section 357.5 (d) that in developing regional water plans, the Regional Planning Groups shall use for population and water-demand projections one of the following:

- *State population and water demand projections contained in the state water plan or adopted by the board (TWDB) after consultation with the Texas Commission on Environmental Quality, Texas Department of Agriculture (TDA), Texas Parks and Wildlife Department (TPWD), and regional planning groups in preparation for revision of the state water plan; or*
- *Population or water demand projection revisions that have been adopted by the board* (TWDB)*, after coordination with TCEQ, TDA, TPWD, and regional planning groups when the requesting regional planning group demonstrates that the population and water demand projections developed pursuant to paragraph (1) of this subsection no longer represent a reasonable projection of anticipated conditions based on changed conditions and availability of new information.*

Regional population and water demand data was initially provided to the Far West Texas Water Planning Group (FWTWPG) at the beginning of the planning period. This information incorporated data from the State Data Center and from the U.S. Bureau of the Census' 2000 census count. In accordance with the second criteria above, the FWTWPG 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 this chapter are derived from a combination of TWDB data and approved revisions.

2.2 POPULATION AND WATER DEMAND PROJECTION REVISIONS

The FWTWPG solicited all entities within the Region to submit desired changes to the draft population and water-demand projections. Revision requests, along with required back-up documentation, were prepared and submitted to the TWDB. Following review by the TWDB, the FWTWPG was granted formal approval to use the revised population and water-demand projection estimates in the regional planning process. The result of the approved population revisions was a net increase of 5,158 in the year 2000 to 6,955 by the year 2060. Entities affected by the population revision include:

- City of Fort Davis
- Jeff Davis County rural
- City of Marfa
- Presidio County rural
- Fort Bliss
- Lower Valley Water District
- El Paso County WCID #4
- El Paso County rural

Requested revisions in draft water-demand projections fell into two categories, municipal and irrigation. Revised municipal projections for the Cities of El Paso and Van Horn were based on documented changes to per-capita water use; while revisions for Fort Bliss and Presidio County rural were based on a change in the estimated reduction from plumbing code savings.

Projected water demand for irrigation use was also revised in five counties. Irrigation needs were increased in Brewster, Jeff Davis and Presidio Counties as a result of the addition of previously un-surveyed irrigation sources. Culberson County irrigation demand was increased based on documentation of actual metered groundwater withdrawals; while

Hudspeth County irrigation was decreased based on both estimated groundwater withdrawals and measured diversions from the Rio Grande.

2.3 POPULATION

2.3.1 POPULATION PROJECTION METHODOLOGY

Starting with the 2000 census year count, TWDB staff used a cohort-component procedure to calculate population projections. Separate cohorts (age, sex, race, and ethnic groups) and components of cohort change (fertility rates, survival rates, and migration rates) are used to estimate county populations. The projected county population is then allocated to each city containing 500 or more people on the basis of each city's historic share of the county population. In some cases, the water user group (WUG) is a utility. In these cases, the population reported for the utility represents the population served by that utility. The rural "County Other" population is calculated as the difference between the total projected population of the cities and the total projected county population. Population is then projected from the 2000 base year by decade to the year 2060.

2.3.2 CURRENT AND PROJECTED POPULATION

Although the FWTWPG was legally mandated to utilize the 2000 census numbers for the purposes of calculating current and projected population figures, representatives from both urban and rural areas expressed concerns that the census represents a significant undercount of actual residents in the Region. This is especially true in the rural areas, where serious flaws existed with the U.S. Census Bureau's information-gathering techniques. Therefore, an emphasis is being made in this planning document to recognize a need for more water than is justified simply from the population-derived water demand quantities.

Current and projected population by decade for communities, water utilities, and county rural areas in Far West Texas is listed in Table 2-1. The year-2000 population for the entire Region is 705,399 of which 96 percent reside in El Paso County and 80 percent in the City of El Paso (Figure 2-1). The regional population is projected to more than double to 1,527,713 by the year 2060, which is an increase of 822,314 citizens; 80 percent of which will occur in El Paso County (Figures 2-2 and 2-3).

TABLE 2- 1. FAR WEST TEXAS POPULATION PROJECTIONS

COUNTY	WATER USER GROUP*	2000	2010	2020	2030	2040	2050	2060
BREWSTER	Alpine	5,786	6,320	6,742	6,929	7,055	7,398	7,474
	County-Other	3,080	3,148	3,202	3,226	3,242	3,286	3,296
	BREWSTER TOTAL	**8,866**	**9,468**	**9,944**	**10,155**	**10,297**	**10,684**	**10,770**
CULBERSON	Van Horn	2,435	2,743	2,943	3,031	3,060	3,060	3,060
	County-Other	540	608	653	672	678	678	678
	CULBERSON TOTAL	**2,975**	**3,351**	**3,596**	**3,703**	**3,738**	**3,738**	**3,738**
EL PASO	Anthony	3,850	4,586	5,422	6,156	6,789	7,422	8,055
	Clint	980	980	980	980	980	980	980
	City of El Paso (EPWU)**	566,858	637,481	717,651	788,014	848,699	909,384	970,069
	El Paso County WCID #4	8,343	12,507	17,234	21,383	24,961	28,539	32,117
	Fort Bliss	8,264	13,422	13,422	13,422	13,422	13,422	13,422
	Homestead MUD	3,202	4,898	6,823	8,513	9,970	11,427	12,884
	Horizon Regional MUD***	11,866	23,177	36,018	47,288	57,007	66,726	76,445
	Lower Valley Water District	5,144	12,505	19,752	26,113	31,599	37,085	42,571
	San Elizario	11,046	20,444	31,112	40,475	48,551	56,627	64,703
	Socorro	27,152	33,017	39,675	45,519	50,559	55,599	60,639
	El Paso County Tornillo WID	2,767	5,542	8,692	11,457	13,842	16,227	18,612
	Vinton	1,892	3,708	5,769	7,578	9,138	10,698	12,258
	County-Other	28,258	53,795	83,893	110,308	133,092	155,876	178,660
	EL PASO TOTAL	**679,622**	**826,062**	**986,443**	**1,127,206**	**1,248,609**	**1,370,012**	**1,491,415**
HUDSPETH	Sierra Blanca	533	608	661	688	688	688	688
	County-Other	2,811	3,207	3,485	3,626	3,626	3,626	3,626
	HUDSPETH TOTAL	**3,344**	**3,815**	**4,146**	**4,314**	**4,314**	**4,314**	**4,314**
JEFF DAVIS	Fort Davis	1,050	1,554	1,717	1,897	1,897	1,897	1,897
	County-Other	1,157	1,235	1,249	1,249	1,249	1,249	1,249
	JEFF DAVIS TOTAL	**2,207**	**2,789**	**2,966**	**3,146**	**3,146**	**3,146**	**3,146**
PRESIDIO	Marfa	2,121	2,585	2,855	3,154	3,154	3,154	3,154
	Presidio	4,167	5,360	6,589	7,746	8,777	9,286	9,577
	County-Other	1,016	880	740	608	490	432	399
	PRESIDIO TOTAL	**7,304**	**8,825**	**10,184**	**11,508**	**12,421**	**12,872**	**13,130**
TERRELL	Sanderson	861	921	956	956	956	956	956
	County-Other	220	235	244	244	244	244	244
	TERRELL TOTAL	**1,081**	**1,156**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**
	REGION TOTAL	**705,399**	**855,466**	**1,018,479**	**1,161,232**	**1,283,725**	**1,405,966**	**1,527,713**

*Water User Groups are incorporated cities with a year-2000 population of 500 or more, and utilities that provided more than 280 acre-feet of water to its service area.
**El Paso County WCID-Westway has been incorporated into the City of El Paso.
***Horizon City and El Paso County Water Authority have merged into the Horizon Regional MUD.

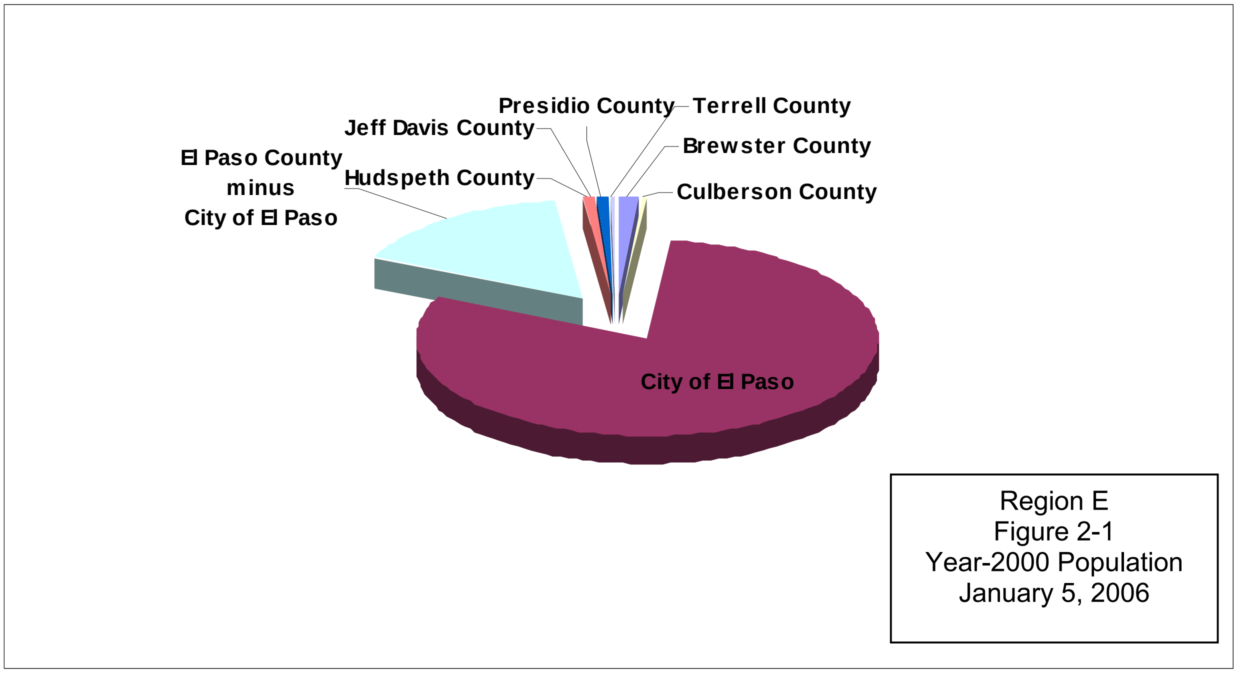

FIGURE 2- 1. YEAR-2000 POPULATION

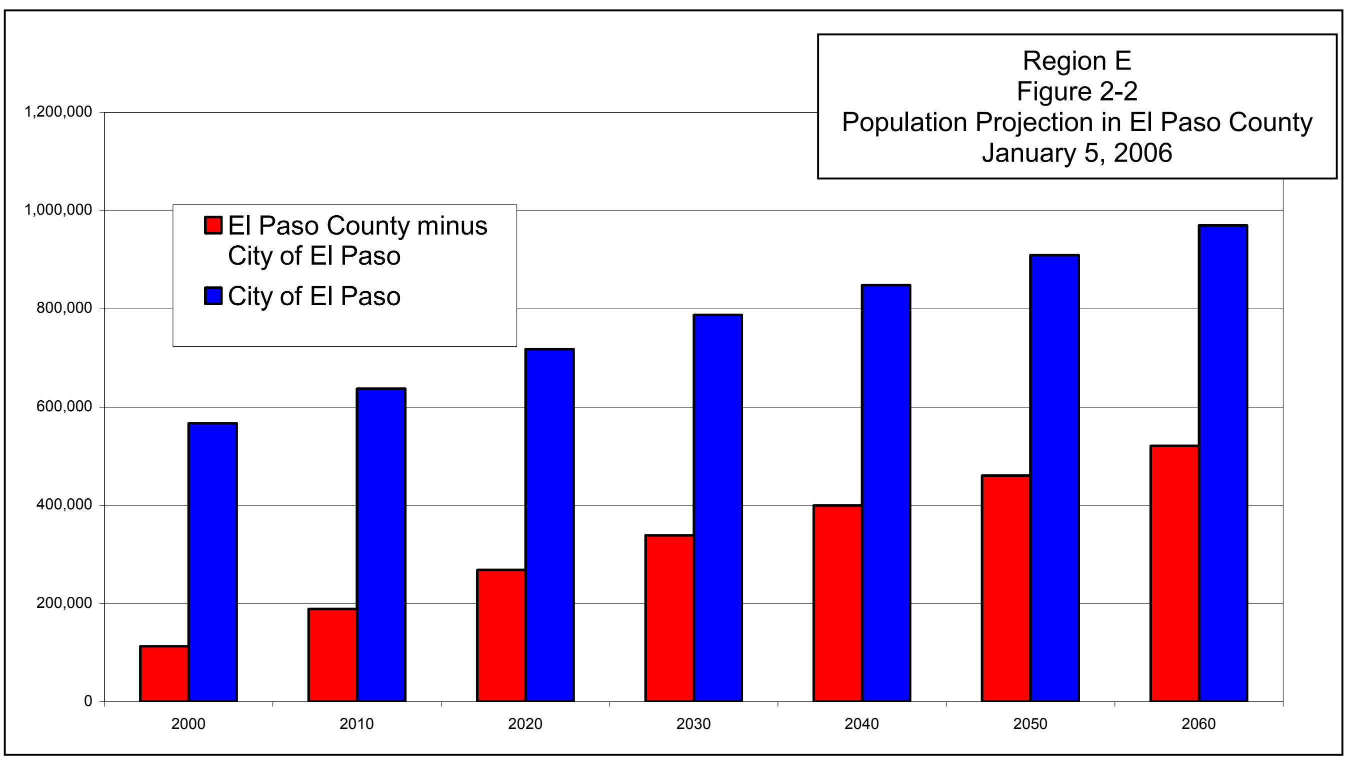

FIGURE 2- 2. POPULATION PROJECTION DISTRIBUTION IN EL PASO COUNTY

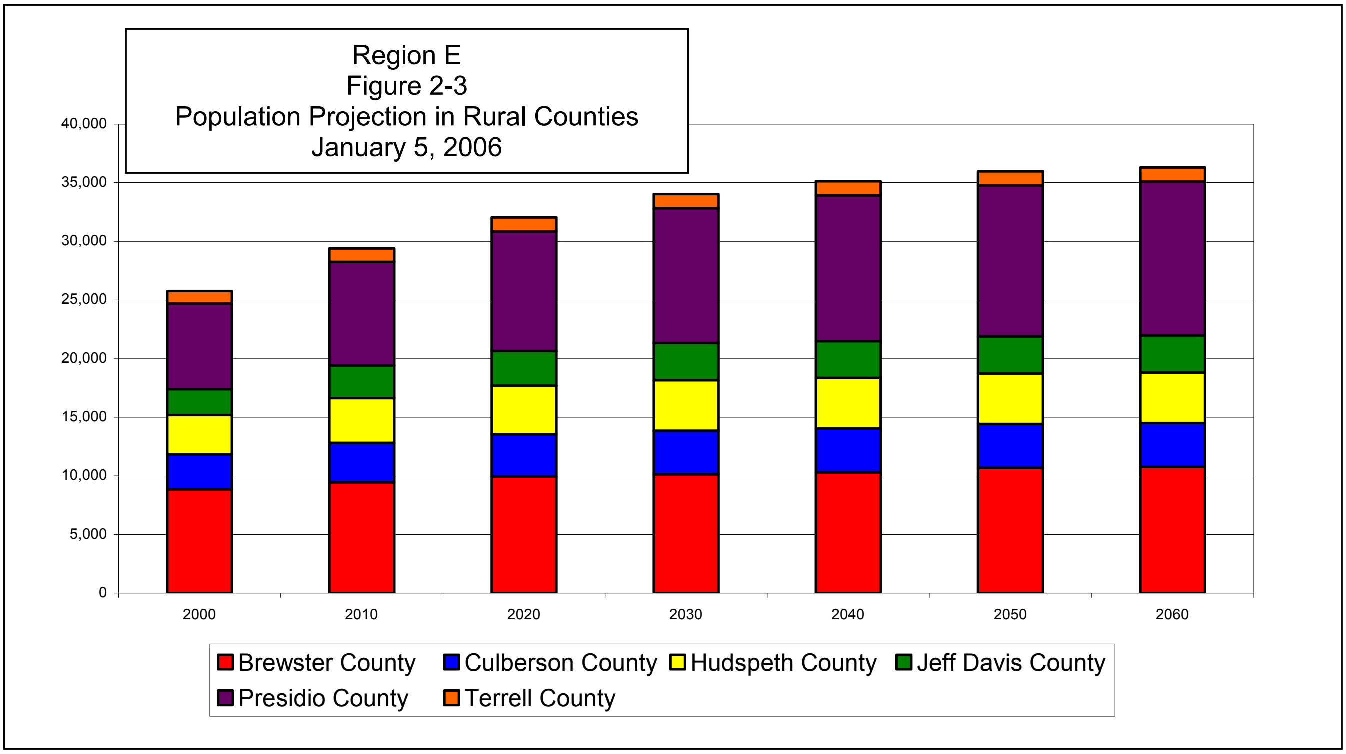

FIGURE 2- 3. POPULATION PROJECTION DISTRIBUTION IN RURAL COUNTIES

2.4 WATER DEMAND

A major component of water planning is the establishment of accurate water demand estimates for all water-use categories. Categories of water use include (1) municipal and rural domestic, (2) manufacturing, (3) irrigation, (4) steam electric, (5) livestock, and (6) mining. Table 2-2 lists the current and future projected regional water demands by county and water-use category. The percent distribution of year-2000 water demand in the Region by the six water-use categories is shown in Figure 2-4 and by county in Figure 2-5. Other water use categories that are not quantified in this plan but are addressed (Section 2.5) include environmental and recreational needs. An additional use that is not quantified but may be of significance is water that is used in road construction for both compaction and dust suppression.

Figure 2-6 illustrates current and future projected regional water demand estimates by water-use category, while Figure 2-7 illustrates water demand projections by county. From the year 2000 to 2060 the total water demand in the region is projected to increase from 665,793 acre-feet to 721,071 acre-feet.

The potential role of conservation is an important factor in projecting future water supply requirements. Water demands listed in the *2001 Far West Texas Regional Water Plan* included demand adjustments based on expected conservation practices. In this 2006 regional plan, conservation is only included in the municipal projections as a measure of expected savings based on requirements of the State plumbing code. All other conservation practices are discussed in terms of water supply strategies in Chapter 4 and as a component of drought management plans in Chapter 6.

The following sections present an overview of water supply needs for wholesale water providers and for each of the six designated water-use categories and include methods and assumptions used in the State's consensus water planning process. This information has been taken from the 2002 State Water Plan *(Water For Texas – 2002)* and Exhibit B – Guidelines for Regional Water Plan Development. The 2002 State Water Plan can be found on the TWDB web page (http://www.twdb.state.tx.us).

TABLE 2- 2. FAR WEST TEXAS WATER DEMAND PROJECTIONS (Acre-Feet/Year)

COUNTY	WATER USER GROUP	2000	2010	2020	2030	2040	2050	2060
BREWSTER	Alpine	1,672	1,791	1,888	1,917	1,928	2,014	2,034
	County-Other	455	451	448	441	432	431	432
	Manufacturing	3	4	4	4	4	4	4
	Irrigation	621	1,622	1,613	1,605	1,596	1,588	1,580
	Mining	696	576	554	546	539	532	523
	Livestock	707	707	707	707	707	707	707
	BREWSTER TOTAL	**4,154**	**5,151**	**5,214**	**5,220**	**5,206**	**5,276**	**5,280**
CULBERSON	Van Horn	758	839	890	907	905	901	901
	County-Other	68	74	78	78	77	76	76
	Manufacturing	0	0	0	0	0	0	0
	Irrigation	29,593	28,960	28,340	27,733	27,140	26,559	25,991
	Mining	1,380	1,514	1,560	1,577	1,594	1,610	1,632
	Livestock	344	344	344	344	344	344	344
	CULBERSON TOTAL	**32,143**	**31,731**	**31,212**	**30,639**	**30,060**	**29,490**	**28,944**
EL PASO	Anthony	621	719	826	924	1,004	1,089	1,182
	Clint	276	270	268	268	267	267	267
	City of El Paso (EPWU)*	116,775	127,996	140,698	151,719	161,402	171,836	183,205
	El Paso County WCID #4	1,121	1,583	2,124	2,587	2,992	3,389	3,813
	Fort Bliss	5,214	8,419	8,419	8,404	8,404	8,389	8,389
	Homestead MUD	420	614	841	1,030	1,195	1,370	1,544
	Horizon Regional MUD**	1,900	3,593	5,527	7,224	8,684	10,165	11,646
	Lower Valley Water District	490	1,121	1,726	2,282	2,725	3,199	3,672
	San Elizario	1,101	1,924	2,858	3,718	4,405	5,138	5,871
	Socorro	2,585	2,959	3,466	3,977	4,361	4,795	5,230
	El Paso County Tornillo WID	282	534	818	1,078	1,287	1,509	1,730
	Vinton	210	399	614	798	962	1,126	1,291
	County-Other	3,070	5,664	8,551	10,873	12,672	14,492	16,610
	Manufacturing	7,745	9,181	9,994	10,692	11,367	11,941	12,855
	Mining	169	157	153	151	149	147	146
	Steam Electric Power	2,962	3,131	6,937	8,111	9,541	11,284	13,410
	Irrigation	270,424	247,111	242,798	240,848	232,380	228,579	224,840
	Livestock	1,742	1,742	1,742	1,742	1,742	1,742	1,742
	EL PASO TOTAL	**417,107**	**417,117**	**438,360**	**456,426**	**465,539**	**480,457**	**497,443**
HUDSPETH	Sierra Blanca	110	123	130	134	132	131	131
	County-Other	264	287	297	301	288	284	284
	Manufacturing	2	2	2	2	2	2	2
	Irrigation	186,494	182,627	178,840	175,132	171,501	167,945	164,463
	Mining	1	1	1	1	1	1	1
	Livestock	613	613	613	613	613	613	613
	HUDSPETH TOTAL	**187,484**	**183,653**	**179,883**	**176,183**	**172,537**	**168,976**	**165,494**

COUNTY	WATER USER GROUP	2000	2010	2020	2030	2040	2050	2060
JEFF DAVIS	Fort Davis	251	366	398	433	427	425	425
	County-Other	157	162	159	155	151	150	150
	Manufacturing	0	0	0	0	0	0	0
	Irrigation	579	576	572	569	566	563	559
	Mining	0	0	0	0	0	0	0
	Livestock	508	508	508	508	508	508	508
	JEFF DAVIS TOTAL	**1,495**	**1,612**	**1,637**	**1,665**	**1,652**	**1,646**	**1,642**
PRESIDIO	Marfa	737	886	969	1,060	1,049	1,042	1,042
	Presidio	831	1,039	1,255	1,458	1,642	1,727	1,781
	County-Other	94	81	66	52	42	37	34
	Manufacturing	0	0	0	0	0	0	0
	Irrigation	20,475	20,068	19,670	19,279	18,896	18,521	18,154
	Mining	10	7	7	7	7	7	7
	Livestock	622	622	622	622	622	622	622
	PRESIDIO TOTAL	**22,769**	**22,703**	**22,589**	**22,478**	**22,258**	**21,956**	**21,640**
TERRELL	Sanderson	191	200	205	201	198	197	197
	County-Other	37	38	39	38	37	37	37
	Manufacturing	0	0	0	0	0	0	0
	Irrigation	80	78	77	75	73	72	70
	Mining	26	18	17	17	17	17	17
	Livestock	307	307	307	307	307	307	307
	TERRELL TOTAL	**641**	**641**	**645**	**638**	**632**	**630**	**628**
	REGION TOTAL	**665,793**	**662,608**	**679,540**	**693,249**	**697,884**	**708,431**	**721,071**

*El Paso County WCID-Westway has been incorporated into the City of El Paso.
** Horizon City and El Paso County Water Authority have been merged into Horizon Regional MUD.

While Table 2-2 lists TWDB approved water demand projections, Table 2-3 provides what the FWTWPG considers to be a more realistic outlook of future irrigation and livestock use in Jeff Davis and Presidio Counties. Although not presently in operation, existing irrigation wells in Jeff Davis and Presidio Counties could be placed back in use. Likewise, livestock numbers in Jeff Davis County suppressed by a number of years of drought conditions, will likely increase as weather and rangeland conditions improve.

TABLE 2- 3. REGIONAL PLANNING GROUP PERSPECTIVE ON PROJECTED IRRIGATION AND LIVESTOCK DEMANDS IN JEFF DAVIS AND PRESIDO COUNTIES (Acre-Feet/Year)

COUNTY	WATER USER GROUP	2000	2010	2020	2030	2040	2050	2060
JEFF DAVIS	Irrigation	3,184	3,119	3,057	2,995	2,935	2,875	2,816
	Livestock	547	547	547	547	547	547	547
PRESIDIO	Irrigation	25,678	25,156	24,646	24,145	23,655	23,175	22,705

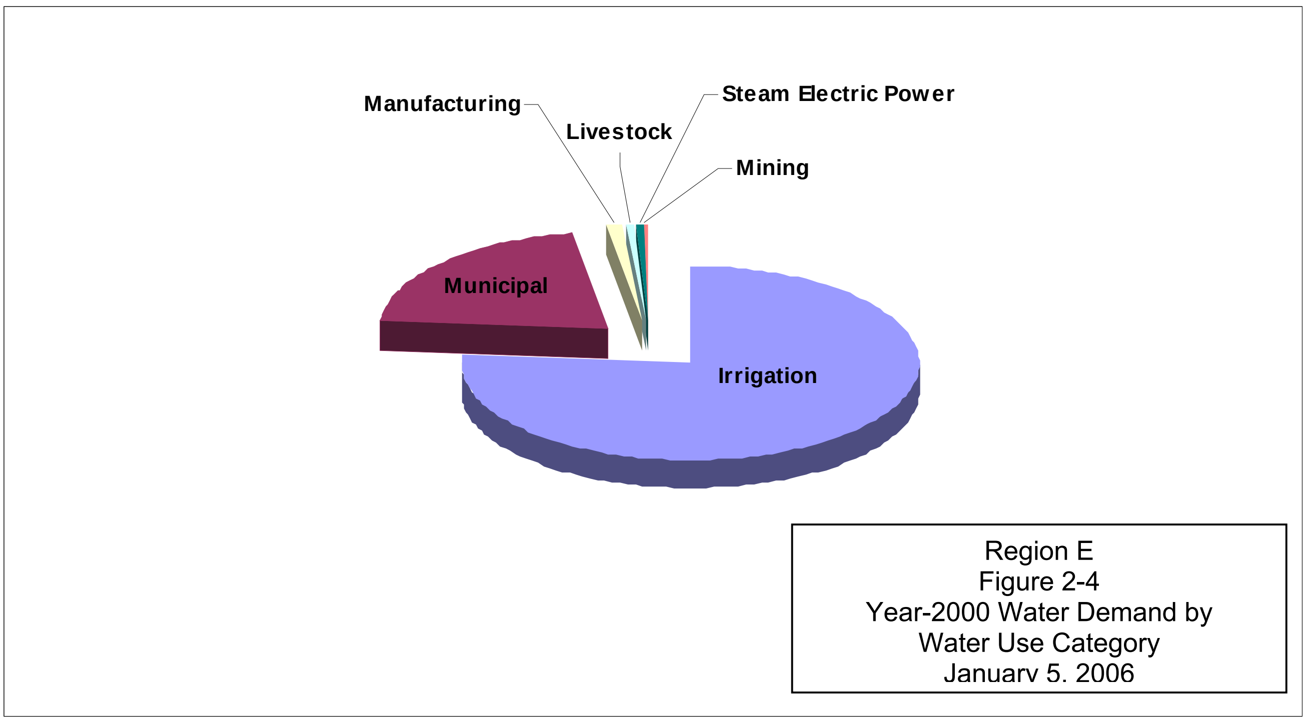

FIGURE 2- 4. YEAR-2000 WATER DEMAND BY WATER USE CATEGORY

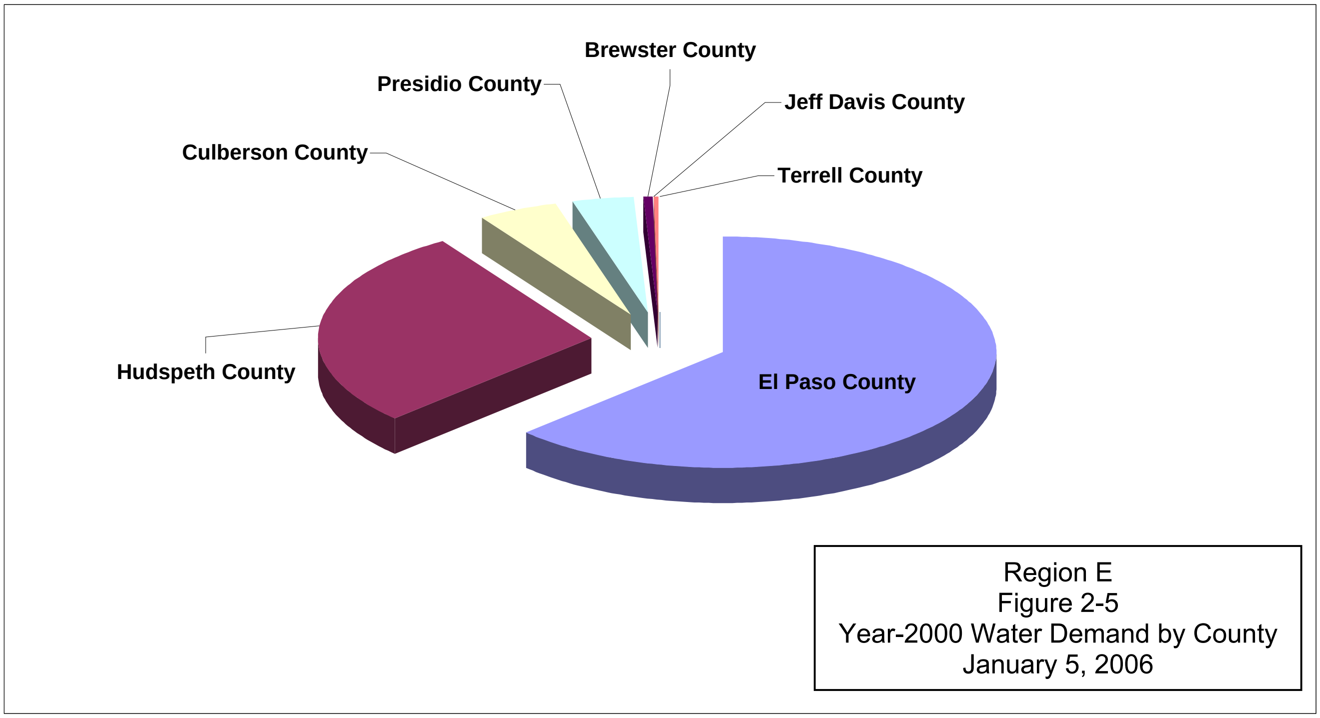

FIGURE 2- 5. YEAR-2000 WATER DEMAND BY COUNTY

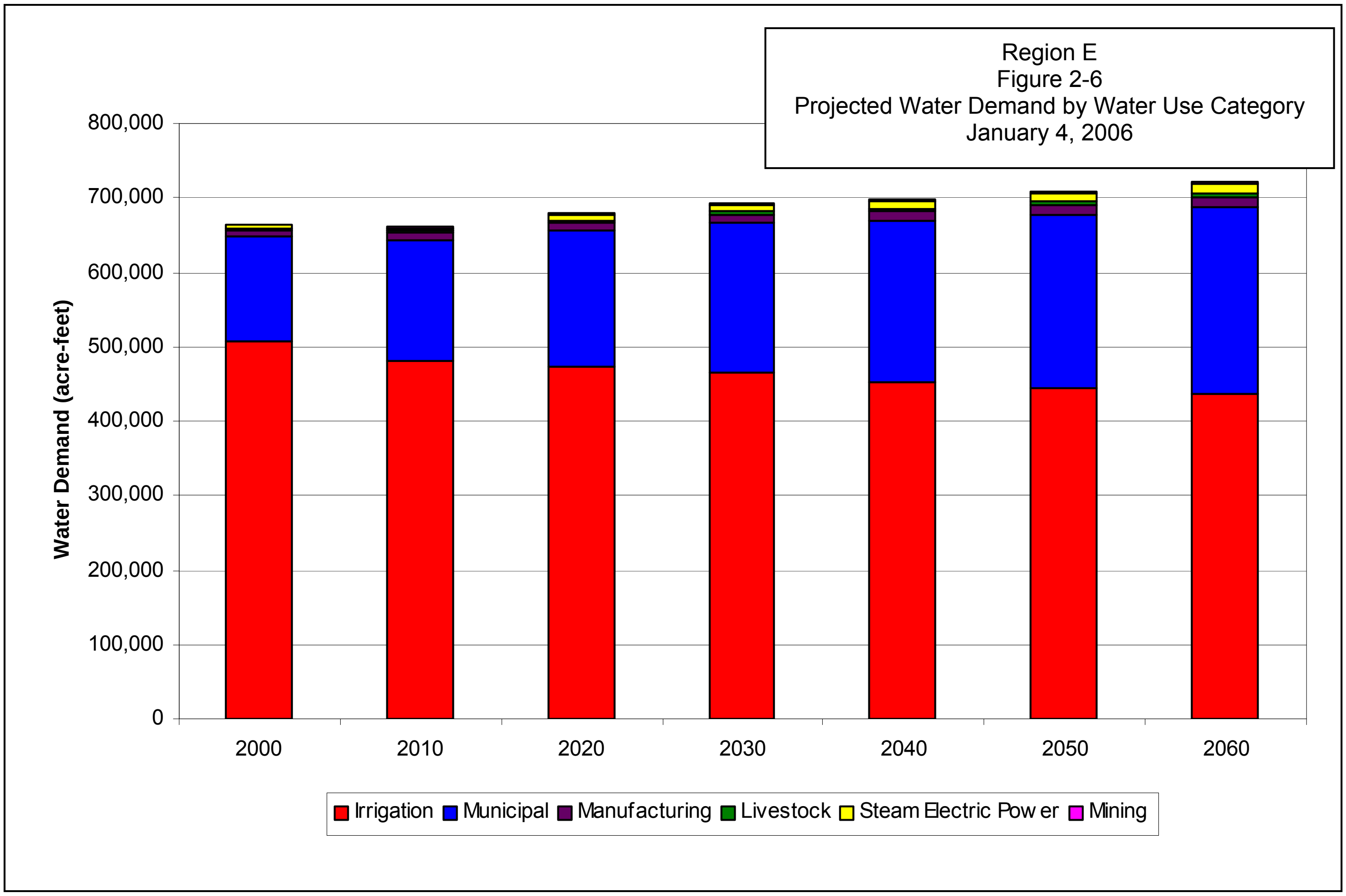

FIGURE 2- 6. PROJECTED WATER DEMAND BY WATER USE CATEGORY

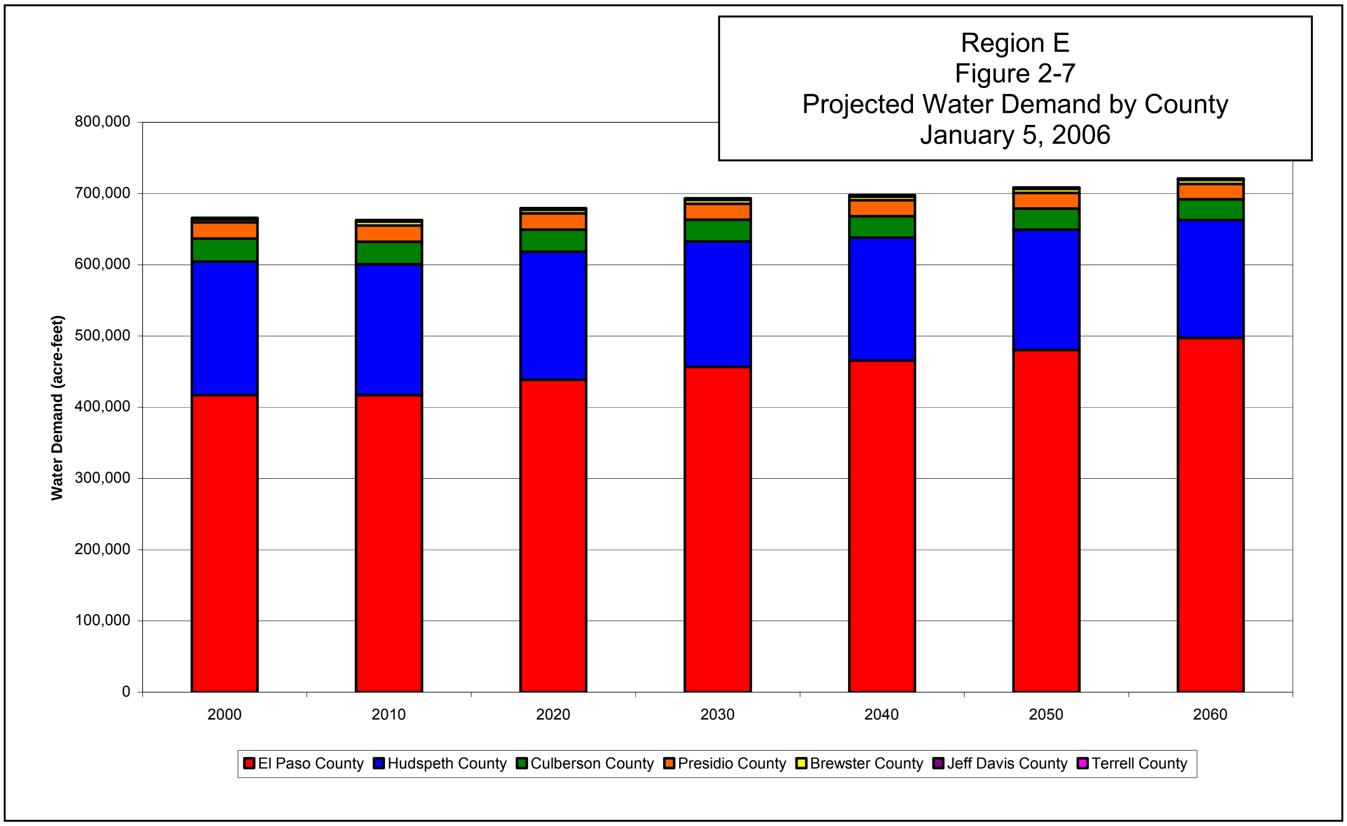

FIGURE 2- 7. PROJECTED WATER DEMAND BY COUNTY

2.4.1 WHOLESALE WATER PROVIDERS

A wholesale water provider is defined as any entity that had contracts to sell more than 1,000 acre-feet of water wholesale in any one year during the five years immediately preceding the adoption of the last regional water plan (2001), or that is expected to enter into contracts to sell more than 1,000 acre-feet of water per year wholesale during the period covered by this Plan (2001–2006). Table 2-4 lists projected water demands for wholesale water providers in Far West Texas and their customers.

TABLE 2- 4. WHOLESALE WATER PROVIDER WATER DEMAND (Acre-Feet/Year)
Contractual Obligation Indicated by ©

Wholesale Water Provider / Receiving Entities	2,000	2,010	2,020	2,030	2,040	2,050	2,060
El Paso County WID #1							
El Paso Water Utilities ©	7,855	7,855	7,855	7,855	7,855	7,855	7,855
El Paso Water Utilities							
City of El Paso	116,775	127,996	140,698	151,719	161,402	171,836	183,205
Fort Bliss ©	521	842	842	840	840	839	839
Homestead MUD ©	420	614	841	1,030	1,195	1,370	1,544
Lower Valley Water District ©	4,452	6,274	8,318	10,245	11,758	13,399	15,040
Vinton ©	210	399	614	798	962	1,126	1,291
Manufacturing	7,745	9,181	9,994	10,692	11,367	11,941	12,855
Mining	169	157	153	151	149	147	146
Steam Electric Power	2,962	3,131	6,937	8,111	9,541	11,284	13,410
Lower Valley Water District							
San Elizario ©	1,101	1,924	2,858	3,718	4,405	5,138	5,871
Socorro ©	2,585	2,959	3,466	3,977	4,361	4,795	5,230
Clint ©	276	270	268	268	267	267	267
County Other	490	1,121	1,726	2,282	2,725	3,199	3,672
El Paso County WCID #4							
(Fabens)	1,121	1,583	2,124	2,587	2,992	3,389	3,813
Horizon Regional MUD							
(Horizon City)	1,900	3,593	5,527	7,224	8,684	10,165	11,646

2.4.2 MUNICIPAL

The quantity of water used for municipal and rural domestic purposes is heavily dependent on population growth, climatic conditions, and water-conservation measures. For planning purposes, municipal water use comprises both residential and commercial. Commercial water use includes business establishments, public offices, and institutions. Residential and commercial uses are categorized together because they are similar types of uses: i.e., they both use water primarily for drinking, cleaning, sanitation, air conditioning, and landscape watering. Also included in this category is water applied to municipally owned golf courses. Water use within a city limit that is not included in the quantification of municipal demand is that used in manufacturing and industrial processes.

Municipal water demand is calculated for the communities and utilities designated in the population projections process and includes rural domestic use. Projected municipal water demand is based on the year-2000 per-capita water use, which is calculated with year-2000 population counts divided into reported water use for the same year. Per-capita water use in communities with significant non-residential water demands, such as for commercial customers, will appear abnormally high. The year-2000 per-capita water use is reduced slightly over time to simulate expected conservation savings due to state-mandated plumbing code implementation. The conservation adjusted per-capita water use is then applied to each of the decade population estimates to produce the projected water demand for each entity.

Rural communities (outside of El Paso County) are relatively small and are generally reliant on self-provided water supplies. Water demand within these communities is related directly to their population trends and is thus relatively stable or moderately increasing over the next 50 years. Projected water-demand growth for the numerous communities within El Paso County is significantly greater and thus will require a level of coordinated intercommunity planning.

Municipal Water Use Projection (in acre-feet/yr)

	2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Brewster	2,127	2,242	2,336	2,358	2,360	2,445	2,466
Culberson	826	913	968	985	982	977	977
El Paso	134,065	155,795	176,736	194,882	209,460	226,764	244,450
Hudspeth	374	410	427	435	420	415	415
Jeff Davis	408	528	557	588	578	575	575
Presidio	1,662	2,006	2,290	2,570	2,733	2,806	2,857
Terrell	228	238	244	239	235	234	234

A significant portion of the municipal water demand in Brewster, Jeff Davis, and Presidio Counties, is assigned to the County Other (Rural) category. This category includes small communities of less than 500 population, rural water utilities, and privately owned well use. Listed below are the active public water suppliers (restaurants and motels not included) in these counties that fall into the County Other category.

Brewster County

Big Bend National Park

Marathon WS&SC

Lajitas Resort

Study Butte Terlingua WS

Terlingua Ranch Development

Twin Peaks Mobile Home Park

Jeff Davis County

Camp Miter Peak

Chihuahuan Desert Research Institute

City of Valentine

Davis Mountains State Park (TPWD)

Fort Davis Estates

Fort Davis WSC

High Frontier

Prude Ranch

Skyline Drive (TPWD)

UT McDonald Observatory

Valentine ISD

Village Farms (Fort Davis)

Presidio County

Big Bend Ranch State Park (TPWD)

Candelaria WSC

Cibolo Creek Ranch

Fort Leaton SHP (TPWD)

Howard Water Supply

Redford School

Redford Water Supply

USAF TARS

Village Farms (Marfa)

2.4.3 MANUFACTURING

Manufacturing and industrial water use is quantified separately from municipal use even though the demand centers may be located within a city limits. Future manufacturing and industrial water use is largely dependent on technological changes in the production process, on improvements in water-efficient technology, and on the economic climate of the marketplace. 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 use of water for manufacturing purposes only occurs in Brewster, El Paso and Hudspeth Counties. Use in Brewster and Hudspeth Counties is minimal and is not anticipated to change significantly over time. Manufacturing water use in El Paso County, however, is expected to increase from 7,745 acre-feet in the year 2000 to 12,855 acre-feet by 2060. While a portion of this water is self-supplied, most will be purchased from various water supply entities, principally El Paso Water Utilities.

Manufacturing Water Use Projection (in acre-feet/yr)

	2000	2010	2020	2030	2040	2050	2060
Brewster	3	4	4	4	4	4	4
Culberson	0	0	0	0	0	0	0
El Paso	7,745	9,181	9,994	10,692	11,367	11,941	12,855
Hudspeth	2	2	2	2	2	2	2
Jeff Davis	0	0	0	0	0	0	0
Presidio	0	0	0	0	0	0	0
Terrell	0	0	0	0	0	0	0

2.4.4 IRRIGATION

A comprehensive irrigation survey was performed for the TWDB in 2000 that provided up-to-date crop and irrigation data. The acreage planted for each crop under irrigation, along with the water application rate for each crop, was estimated by the Natural Resource Conservation Service (NRCS) and computed to give total irrigation use for each county. Included in this projection is water applied to private (non-municipally owned) golf courses, greenhouse operations, and container-plant farms. Irrigation water demand includes estimates of surface water lost in the process of transportation to the field. In lieu of the above process, irrigation districts could provide more accurate estimates based on actual measured diversions or pumping withdrawals. Future irrigation use is then projected from this 2000 base year at a rate established for the same county irrigation projection in the previous regional water plan.

Statewide, irrigation water demands are expected to decline over time. More efficient canal delivery systems have improved water-use efficiencies of surface water irrigation. More efficient on-farm irrigation systems have also improved the efficiency of groundwater irrigation. Other factors that have contributed to decreased irrigation demands are declining groundwater supplies and the voluntary transfer of water rights historically used for irrigation to municipal uses.

Water used for agricultural irrigation in Far West Texas is significantly greater (76% of total) than all other water-use categories. On a regional basis, water used for the irrigation of crops is projected to decline slightly over the 50-year planning horizon. However, as any irrigator can attest, climate, water availability, and the market play key roles in how much water is actually applied on a year-by-year basis.

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. Irrigated farms along the Rio Grande corridor in El Paso and Hudspeth Counties are almost entirely dependent on water supplies derived from the River. When Rio Grande water is limited or not available, most farming temporarily ceases until water supplies once again become available. Irrigated farms in other areas within the region are dependent on groundwater supplies. Availability of these supplies depends on localized pumping, aquifer hydrologic characteristics, and energy cost.

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 evaporation. Proper application timing is also critical in avoiding over-watering. The lining of canals that transport water from its source to the fields reduces losses due to seepage. Drought tolerant crop selection is also important when faced with limited water supplies.

Some farmers across the Region are using slightly-saline water for irrigation. In order to maintain long-term soil productivity with saline waters, producers must over irrigate to maintain a leaching fraction that minimizes salt buildup in the crop root zone. In some areas, high levels of sodium have reduced soil infiltration rates. Producers often manage this problem through application of soil amendments (such as gypsum or organic residues) or through mechanical mixing of the soil.

Irrigation Water Use Projection (in acre-feet/yr)

	2000	2010	2020	2030	2040	2050	2060
Brewster	621	1,622	1,613	1,605	1,596	1,588	1,580
Culberson	29,593	28,960	28,340	27,733	27,140	26,559	25,991
El Paso	270,424	247,111	242,798	240,848	232,380	228,579	224,840
Hudspeth	186,494	182,627	178,840	175,132	171,501	167,945	164,463
Jeff Davis	3,184	3,119	3,057	2,995	2,935	2,875	2,816
Presidio	25,678	25,156	24,646	24,145	23,655	23,175	22,705
Terrell	80	78	77	75	73	72	70

2.4.5 STEAM-ELECTRIC

In determining current and future water use for steam-electric power generation, the TWDB relies on several types of information. Current water use is obtained for each plant from the TWDB's water use survey. Future water demand is estimated using a combination of available information, including published documents on planned additions to existing plants, existing water rights permits, specific company information, lignite-resource ownership, and other related sources. Individual plant design, thermodynamic operating characteristics, energy-conservation strategies, and technological improvements are also evaluated to determine how water use will change over time.

El Paso Electric located in El Paso County is the only facility within the Region that uses water in the form of steam to generate electricity. Anticipated local population growth, as well as increasing commercial and manufacturing power needs, means that the quantity of water needed to produce electricity will likewise increase. El Paso Electric currently purchases most of its water supply from El Paso Water Utilities.

Steam Electric Power Generation Water Use Projection (in acre-feet/yr)

	2000	2010	2020	2030	2040	2050	2060
Brewster	0	0	0	0	0	0	0
Culberson	0	0	0	0	0	0	0
El Paso	2,962	3,131	6,937	8,111	9,541	11,284	13,410
Hudspeth	0	0	0	0	0	0	0
Jeff Davis	0	0	0	0	0	0	0
Presidio	0	0	0	0	0	0	0
Terrell	0	0	0	0	0	0	0

2.4.6 LIVESTOCK

Texas is the nation's leading livestock producer, accounting for approximately 11 percent of the total United States production. Although livestock production is an important component of the Texas economy, the industry consumes a relatively small amount of water.

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 Cooperative Extension Service provides information on water-use rates, estimated in gallons per day per head, for each type of livestock: cattle, poultry, sheep and lambs, hogs and pigs, horses, and goats. The Texas Agricultural Statistics Service provides current and historical numbers of livestock by livestock type and county. Water-use rates are then multiplied by the number of livestock for each livestock type for each county.

For water-supply planning purposes, livestock water use is held constant throughout the 50-year planning period. However, reality dictates that during prolonged drought periods, when poor range conditions exist and/or during unfriendly market conditions, livestock herds are generally reduced thus resulting in significantly less water demand.

Livestock Water Use Projection (in acre-feet/yr)

	2000	2010	2020	2030	2040	2050	2060
Brewster	707	707	707	707	707	707	707
Culberson	344	344	344	344	344	344	344
El Paso	1,742	1,742	1,742	1,742	1,742	1,742	1,742
Hudspeth	613	613	613	613	613	613	613
Jeff Davis	547	547	547	547	547	547	547
Presidio	622	622	622	622	622	622	622
Terrell	307	307	307	307	307	307	307

2.4.7 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. 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. For each category of mineral products, the requirements for mining water were determined as a function of production. TWDB's 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 TWDB's 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.

Much of the water used in the mining industry in Far West Texas is related to its use in the extraction of gravel and road base materials. The largest single water use occurs in Culberson County where it is employed in the mining of talc mineral aggregates. Very little petroleum exploration is occurring in this Region.

Mining Water Use Projection (in acre-feet/yr)

	2000	2010	2020	2030	2040	2050	2060
Brewster	696	576	554	546	539	532	523
Culberson	1,380	1,514	1,560	1,577	1,594	1,610	1,632
El Paso	169	157	153	151	149	147	146
Hudspeth	1	1	1	1	1	1	1
Jeff Davis	0	0	0	0	0	0	0
Presidio	10	7	7	7	7	7	7
Terrell	26	18	17	17	17	17	17

2.5 ENVIRONMENTAL AND RECREATIONAL WATER NEEDS

Environmental and recreational water use in Far West Texas is not quantified but is recognized as being an important consideration as it relates to the natural community in which the residents of this Region share and appreciate. In Chapter 1, environmental and eco-recreational resources are identified and described. In the following paragraphs, the water resources needed to maintain these functions is discussed. Water-supply sources that serve environmental needs, along with identified major springs, are characterized in Chapter 3, and potential water-supply strategy consequences on the environment are considered in Chapter 4. Chapter 8 contains a discussion and recommendations pertaining to "Ecologically Unique Stream Segments."

In terms of combined area, Far West Texas contains most of the federal public land in Texas, and over half the land in the entire Texas State Park system. This conservation heritage has been preserved and protected "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations".

The presence of these protected public lands contributes greatly to the quality of life for area residents in a way that is not easily described in gallons, acre-feet or dollars and cents. It has been amply demonstrated that to attract 21st century enterprise that pays top salaries for skilled workers, quality of life is a critical issue. The spectacular natural and cultural heritage of the Region not only attracts many hundreds of thousands of temporary visitors per year to Far West Texas (more than 650,000 per year just to Guadalupe Mountains and Big Bend National Parks), it also helps to attract new residents and businesses to the Region. Providing sufficient water for recreation and habitat in Far West Texas is critical to long-term economic health.

Quantifying environmental and recreational needs is not always difficult. For the Rio Grande below Presidio, measured at the IBWC gage below Alamito Creek, a flow of 250 cubic feet per second is sufficient to support minimum needs. When flows fall below this point for any length of time, recreational, agricultural, and habitat values are seriously degraded.

Quantifying minimum flows at upland water sources that support wildlife and game through the year is impossible in terms of gallons and acre-feet, but is an observable fact that wildlife populations flux wildly over the years due to relative abundance or scarcity of rainfall and related spring productivity. It has also been observed that even major springs that historically have never run dry can disappear when local aquifers are pumped beyond sustainable levels. Even minor aquifer depletion can have a profound effect on wildlife habitat and recreational opportunities in affected local areas.

In terms of the regional planning process, discussion of environmental and recreational water needs has been largely considered a rural issue, and generally overlooked because of the perceived priority of other issues. However, every regional resident uses environmental and recreational water, be it for personal lawn and garden, a golf course, a swimming pool, or for canoeing the Rio Grande, hunting deer, or watching birds. In urban areas and small towns, environmental and recreational needs can constitute a third or more of total use during hot months. The FWTWPG recognizes the importance of supplying adequate environmental and recreational water fairly to all users, and the goal of better quantifying those needs in the next planning cycle.

All living organisms require water. The amount and quality of water required to maintain a viable population, whether it be plant or animal, is highly variable. While some individuals are capable of migrating long distances in search of water (birds, larger mammals, etc.), others are stationary (plants, fishes, etc.) and must rely on existing supplies. In both cases, endemic wildlife to this desert region of Texas has adapted to the harsh climatic conditions.

Because most available water-supply sources in Far West Texas are relatively small in areal extent and are generally separated by great distances, wildlife dependent on isolated sources exist at the mercy of that water supply. The loss of the supply source, even for a short time, may result in the loss or degradation of the resident species.

Natural and environmental resources are often overlooked when considering the consequences of prolonged drought conditions. As water supplies diminish during drought periods, the balance between both human and environmental water requirements becomes increasingly competitive. A goal of the Far West Texas Water Plan is to provide for the health, safety, and welfare of the human community, with as little detrimental effect to the environment as possible. To accomplish this goal, the evaluation of strategies to meet future water needs includes a distinct consideration of the impact that each implemented strategy might have on the environment.

Recreation are those activities that involve human interaction with the outdoors environment. Many of these activities are directly dependent on water resources such as fishing, swimming, and boating; while a healthy environment enhances many others, such as hiking and bird watching. Thus, it is recognized that the maintenance of the regional environmental community's water supply needs serves to enhance the lives of citizens of Far West Texas as well as the thousands of annual visitors to this Region.

In Chapter 4, each water management strategy contains an environmental impact assessment. A review of this chapter reveals that while some strategies may contain variable levels of negative impact, other strategies may likely have a positive effect. Negative environmental impacts are generally associated with the lowering of aquifer water levels due to increased groundwater withdrawals and its potential to cause springs to cease flowing. Also of concern is that lowered water levels could deplete supplies in shallow livestock wells that are often the only available source of water for some wildlife. The positive environmental aspect of the strategies is that during severe drought conditions when normal wildlife water supplies may naturally diminish, new supply sources might be developed such that wildlife could benefit.

CHAPTER 3

REGIONAL WATER SUPPLY SOURCES

3.1 INTRODUCTION

Whether it flows in rivers and streams or percolates through underground rock formations, water sustains life and thus is our most important natural resource. In the Chihuahuan Desert environment of Far West Texas, water supply availability takes on a more significant meaning than elsewhere in the State. The entire Far West Texas planning region is located within the Rio Grande Basin. With evaporation far exceeding rainfall, planning for the most efficient management of limited water supplies is essential.

Chapter 3 explores the current and future availability of all water supply resources in the Region including surface water, groundwater and reuse. The water demand and supply availability analysis developed in Chapters 2 and 3, respectively, form the basis for identifying in Chapter 4 the areas within Far West Texas that potentially could experience supply shortages in future years.

Water supply availability from each recognized source is estimated during *drought-of record* conditions. This allows each entity and water-use category to observe conditions when their supply source is at its most critical availability level. Specific assumptions used in estimating supply availability are listed below:

- With the exception of the controlled flows in the Rio Grande, very little surface water can be considered as a reliable source of supply in Far West Texas, especially in drought-of-record conditions. In this chapter, two primary surface water sources are considered, the Rio Grande and the Pecos River. Other ephemeral creeks and springs are recognized as important livestock supply, wildlife habitat, and recreational resources.
- The availability of water in the Rio Grande and Pecos River to meet existing permits is determined by using the TCEQ Rio Grande Water Availability Model (WAM) – Run 3.
- The availability of groundwater is based on acceptable levels of water level decline as simulated with Groundwater Availability Models (GAMs) or historical maximum pumpage estimates.

- Reuse of water is calculated for the City of El Paso based on anticipated build-out of their "purple pipe" project.

Water supplies available to meet recognized demands are reported in Tables 3-1, 3-2 and 3-3 and are reported in "acre-feet/year" (one acre-foot equals 325,851 gallons). Table 3-1 indicates the maximum amount of water supply that could be obtained from each unique supply source.

Table 3-2 lists water supplies that are available to cities and water-user categories, based on their current ability to obtain water from existing sources. Current infrastructure, legal limitations, and the physical availability of water from each source determine this availability. The amounts listed for cities and the "county other" category (representing small communities and rural households) are based on TCEQ estimates of infrastructure capabilities. Estimates for county categories of irrigation, mining and livestock are based on the largest annual amount estimated to have been used from 1990 to 2000. This period of time encompasses both dry years and current infrastructure (wells, pipelines, canals, etc.).

Table 3-3 lists water supplies available to each of the Wholesale Water Providers designated in Chapters 1 and 2. These supplies represent the total amount of water available to all the entities that each Wholesale Water Provider serves as shown in Table 3-2. Again, the available water supplies listed in all three tables are based on drought-of record conditions.

TABLE 3-1. WATER SUPPLY SOURCE AVAILABILITY (Acre-Feet/Year)

For surface water and groundwater, the largest amount of water that can be diverted or pumped from a given source without violating the most restrictive physical, regulatory, or policy conditions limiting withdrawals, under drought-of-record conditions. All sources are within the Rio Grande Basin.

Water Supply Source	County	2010	2020	2030	2040	2050	2060
Upper Rio Grande	El Paso	66,631	66,631	66,631	66,631	66,631	66,631
	Hudspeth	632	632	632	632	632	632
Upper Rio Grande Return Flows	El Paso	42,134	47,239	47,239	47,239	47,239	47,239
Upper Rio Grande Return Flows	Hudspeth	334	334	334	334	334	334
Lower Rio Grande	Brewster	8,082	8,082	8,082	8,082	8,082	8,082
	Hudspeth	518	518	518	518	518	518
	Presidio	10,853	10,853	10,853	10,853	10,853	10,853
	Terrell	152	152	152	152	152	152
Pecos River	Terrell	524	524	524	524	524	524
Direct Reuse	El Paso	7,387	10,531	13,676	16,820	19,964	23,109
Hueco Bolson	El Paso	110,000	110,000	110,000	110,000	110,000	110,000
	Hudspeth	16,000	16,000	16,000	16,000	16,000	16,000
Mesilla Bolson	El Paso	52,000	52,000	52,000	52,000	52,000	52,000
Edwards-Trinity (Plateau)	Brewster	300	300	300	300	300	300
	Culberson	55	55	55	55	55	55
	Jeff Davis	200	200	200	200	200	200
	Terrell	2,100	2,100	2,100	2,100	2,100	2,100
Bone Spring - Victorio Peak[(a)]	Hudspeth	63,000	63,000	63,000	63,000	63,000	63,000
Capitan Reef (Diablo Farms)	Brewster	50	50	50	50	50	50
	Culberson	20,000	20,000	20,000	20,000	20,000	20,000
	Hudspeth	5,100	5,100	5,100	5,100	5,100	5,100

TABLE 3-1. WATER SUPPLY SOURCE AVAILABILITY (Acre-Feet/Year)

For surface water and groundwater, the largest amount of water that can be diverted or pumped from a given source without violating the most restrictive physical, regulatory, or policy conditions limiting withdrawals, under drought-of-record conditions. All sources are within the Rio Grande Basin.

Water Supply Source	County	2010	2020	2030	2040	2050	2060
Igneous	Brewster	5,000	5,000	5,000	5,000	5,000	5,000
	Culberson	100	100	100	100	100	100
	Jeff Davis	2,000	2,000	2,000	2,000	2,000	2,000
	Presidio	6,500	6,500	6,500	6,500	6,500	6,500
Marathon	Brewster	200	200	200	200	200	200
Rustler	Culberson	1,000	1,000	1,000	1,000	1,000	1,000
West Texas Bolson Red Light Draw	Hudspeth	50	50	50	50	50	50
West Texas Bolson (Eagle Flat)	Hudspeth	50	50	50	50	50	50
West Texas Bolson (Green River Valley)	Hudspeth	75	75	75	75	75	75
	Jeff Davis	75	75	75	75	75	75
	Presidio	75	75	75	75	75	75
West Texas Bolson (Presidio-Redford)	Presidio	6,000	6,000	6,000	6,000	6,000	6,000
West Texas Bolson (Salt Basin)	Culberson	38,000	38,000	38,000	38,000	38,000	38,000
	Jeff Davis	8,000	8,000	8,000	8,000	8,000	8,000
	Presidio	10,000	10,000	10,000	10,000	10,000	10,000
Other Aquifers (Cretaceous Limestones)	Brewster	2,200	2,200	2,200	2,200	2,200	2,200
Other Aquifers (Diablo Plateau)[(b)]	Hudspeth	1,000	1,000	1,000	1,000	1,000	1,000
Other Aquifers (Balmorhea Alluvium)	Jeff Davis	274	274	274	274	274	274
Other Aquifers	Presidio	300	300	300	300	300	300
Other Aquifers (Rio Grande Alluvium)	El Paso	80,066	80,066	80,066	80,066	80,066	80,066

(a) Bone Spring-Victorio Peak aquifer is the portion of the Diablo Plateau that lies within the HCUWCD#1 management

(b) Other Aquifer (Diablo Plateau) is the portion of the Diablo Plateau that lies outside the HCUWCD#1 management b

TABLE 3-2. WATER USER GROUP WATER SUPPLY CAPACITY (Acre-Feet/Year)

Water supply capacity based on current infrastructure, existing contracts, and source supply availability under drought-of-record conditions.

County	Water User Group	Supply Source Name	Infrastructure Capacity per Source	Total Infrastructure Capacity 2010	2020	2030	2040	2050	2060
BREWSTER	ALPINE	Igneous (Brewster County)	3,843	4,864	4,864	4,864	4,864	4,864	4,864
		Igneous (Jeff Davis County)	1,021						
	COUNTY OTHER	Edwards-Trinity (Plateau)	23	455	455	455	455	455	455
		Igneous	273						
		Marathon	68						
		Other Aquifer (Cretaceous Limestones)	91						
	MANUFACTURING	Igneous	4	4	4	4	4	4	4
	MINING	Igneous	348	696	696	696	696	696	696
		Other Aquifer (Cretaceous Limestones)	348						
	IRRIGATION	Other Aquifer (Cretaceous Limestones)	1,330	8,790	8,790	8,790	8,790	8,790	8,790
		Lower Rio Grande	7,460						
	LIVESTOCK	Edwards-Trinity (Plateau)	239	798	798	798	798	798	798
		Igneous	240						
		Marathon	80						
		Other Aquifer (Cretaceous Limestones)	239						
CULBERSON	VAN HORN	West Texas Bolson (Salt Basin)	2,084	2,084	2,084	2,084	2,084	2,084	2,084
	COUNTY OTHER	West Texas Bolson (Salt Basin)	62	78	78	78	78	78	78
		Edwards-Trinity (Plateau)	8						
		Rustler	8						
	MINING	West Texas Bolson (Salt Basin)	1,312	2,161	2,161	2,161	2,161	2,161	2,161
		Rustler	849						
	IRRIGATION	West Texas Bolson (Salt Basin)	29,593	34,593	34,593	34,593	34,593	34,593	34,593
		Capitan Reef	5,000						
	LIVESTOCK	West Texas Bolson (Salt Basin)	299	466	466	466	466	466	466
		Edwards-Trinity (Plateau)	47						
		Rustler	120						

TABLE 3-2. WATER USER GROUP WATER SUPPLY CAPACITY (Acre-Feet/Year)

Water supply capacity based on current infrastructure, existing contracts, and source supply availability under drought-of-record conditions.

County	Water User Group	Supply Source Name	Infrastructure Capacity per Source	Total Infrastructure Capacity					
				2010	2020	2030	2040	2050	2060
EL PASO	ANTHONY	Hueco - Mesilla Bolson	3,065	3,065	3,065	3,065	3,065	3,065	3,065
	CLINT	Hueco - Mesilla Bolson	276	276	276	276	276	276	276
		Rio Grande	0						
	CITY OF EL PASO (EPWU)	Rio Grande	7,855	116,775	116,775	116,775	116,775	116,775	116,775
		Direct Reuse	2,040						
		Hueco - Mesilla Bolson	106,880						
	EL PASO WCID#4	Hueco - Mesilla Bolson	4,445	4,445	4,445	4,445	4,445	4,445	4,445
	FORT BLISS	Hueco - Mesilla Bolson	217	21,694	21,694	21,694	21,694	21,694	21,694
		Rio Grande	218						
		Hueco - Mesilla Bolson	21,259						
	HOMESTEAD MUD	Hueco - Mesilla Bolson	210	420	420	420	420	420	420
		Rio Grande	210						
	HORIZON REGIONAL MUD	Hueco - Mesilla Bolson	9,500	9,500	9,500	9,500	9,500	9,500	9,500
	LOWER VALLEY WATER DISTRICT	Hueco - Mesilla Bolson	245	490	490	490	490	490	490
		Rio Grande	245						
	SAN ELIZARIO	Hueco - Mesilla Bolson	550	1,101	1,101	1,101	1,101	1,101	1,101
		Rio Grande	551						
	SOCORRO	Hueco - Mesilla Bolson	1,292	2,585	2,585	2,585	2,585	2,585	2,585
		Rio Grande	1,293						
	EL PASO COUNTY TORNILLO WID	Hueco - Mesilla Bolson	1,225	1,225	1,225	1,225	1,225	1,225	1,225
	VINTON	Hueco - Mesilla Bolson	105	210	210	210	210	210	210
		Rio Grande	105						
	COUNTY OTHER	Hueco - Mesilla Bolson	3,070	3,070	3,070	3,070	3,070	3,070	3,070
	MANUFACTURING	Hueco - Mesilla Bolson	7,745	7,745	7,745	7,745	7,745	7,745	7,745
		Rio Grande	0						
	MINING	Hueco - Mesilla Bolson	103	169	169	169	169	169	169
		Other aquifer (Rio Grande Alluvium)	66						
	STEAM ELECTRIC POWER	Direct Reuse	2,960	2,962	2,962	2,962	2,962	2,962	2,962
		Hueco - Mesilla Bolson	2						
	IRRIGATION	Other aquifer (Rio Grande Alluvium)	80,000	173,751	173,751	173,751	173,751	173,751	173,751
		Rio Grande	56,154						
		Indirect Reuse (return flow)	37,597						
	LIVESTOCK	Hueco - Mesilla Bolson	1,742	1,742	1,742	1,742	1,742	1,742	1,742

TABLE 3-2. WATER USER GROUP WATER SUPPLY CAPACITY (Acre-Feet/Year)

Water supply capacity based on current infrastructure, existing contracts, and source supply availability under drought-of-record conditions.

County	Water User Group	Supply Source Name	Infrastructure Capacity per Source	Total Infrastructure Capacity					
				2010	2020	2030	2040	2050	2060
	SIERRA BLANCA	West Texas Bolson (Salt Basin)	351	351	351	351	351	351	351
	COUNTY OTHER	Hueco Bolson	241	412	412	412	412	412	412
		Bone Spring -Victorio Peak	126						
		Other Aquifer	45						
	MANUFACTURING	Other Aquifer	10	10	10	10	10	10	10
	MINING	Other Aquifer	2	2	2	2	2	2	2
	IRRIGATION	Bone Spring -Victorio Peak	63,000	84,150	84,150	84,150	84,150	84,150	84,150
		Capitan Reef	5,000						
		Other Aquifer (Rio Grande Alluvium)	15,000						
		Upper Rio Grande	632						
		Lower Rio Grande	518						
	LIVESTOCK	Hueco Bolson	88	626	626	626	626	626	626
		Bone Spring -Victorio Peak	31						
		Other Aquifer	438						
		Capitan Reef	12						
		West Texas Bolson (Red Light Draw, Eagle Flat and Green River Valley)	57						
JEFF DAVIS	FORT DAVIS	Igneous	912	912	912	912	912	912	912
	COUNTY OTHER	Igneous	151	162	162	162	162	162	162
		West Texas Bolson (Salt Basin)	8						
		Edwards-Trinity (Plateau)	3						
	IRRIGATION	Igneous	735	3,307	3,307	3,307	3,307	3,307	3,307
		West Texas Bolson (Salt Basin)	2,572						
	LIVESTOCK	Igneous	84	563	563	563	563	563	563
		West Texas Bolson (Salt Basin)	85						
		Edwards-Trinity (Plateau)	141						
		Other Aquifers (Balmorhea Alluvium)	253						

TABLE 3-2. WATER USER GROUP WATER SUPPLY CAPACITY (Acre-Feet/Year)

Water supply capacity based on current infrastructure, existing contracts, and source supply availability under drought-of-record conditions.

County	Water User Group	Supply Source Name	Infrastructure Capacity per Source	Total Infrastructure Capacity					
				2010	2020	2030	2040	2050	2060
PRESIDIO	MARFA	Igneous	4,839	4,839	4,839	4,839	4,839	4,839	4,839
	PRESIDIO	West Texas Bolson (Presidio-Redford)	3,419	3,419	3,419	3,419	3,419	3,419	3,419
	COUNTY OTHER	Other Aquifer	2	94	94	94	94	94	94
		West Texas Bolson (Presidio-Redford)	56						
		Igneous	36						
	MINING	West Texas Bolson (Presidio-Redford)	10	10	10	10	10	10	10
	IRRIGATION	Igneous	1,318	16,522	16,522	16,522	16,522	16,522	16,522
		West Texas Bolson (Presidio-Redford)	2,149						
		West Texas Bolson (Salt Basin)	2,202						
		Lower Rio Grande	10,853						
	LIVESTOCK	Igneous	142	646	646	646	646	646	646
		West Texas Bolson (Presidio-Redford)	110						
		West Texas Bolson (Salt Basin)	142						
		Other Aquifer	252						
TERRELL	SANDERSON	Edwards-Trinity (Plateau)	1,081	1,081	1,081	1,081	1,081	1,081	1,081
	COUNTY OTHER	Edwards-Trinity (Plateau)	39	39	39	39	39	39	39
	MINING	Edwards-Trinity (Plateau)	42	42	42	42	42	42	42
	IRRIGATION	Edwards-Trinity (Plateau)	494	646	646	646	646	646	646
		Lower Rio Grande	152						
	LIVESTOCK	Edwards-Trinity (Plateau)	411	411	411	411	411	411	411

TABLE 3- 3. WATER SUPPLIES AVAILABLE TO EACH WHOLESALE WATER PROVIDER

Wholesale Water Provider	2010	2020	2030	2040	2050	2060
El Paso County WID #1	173,751	173,751	173,751	173,751	173,751	173,751
El Paso Water Utilities	116,775	116,775	116,775	116,775	116,775	116,775
Lower Valley Water District	490	490	490	490	490	490
El Paso County WCID #4	4,445	4,445	4,445	4,445	4,445	4,445
Horizon Regional MUD	9,500	9,500	9,500	9,500	9,500	9,500

3.2 RIO GRANDE

Waters of the Rio Grande (Mexico's Rio Bravo) originate in the San Luis Valley, the principal drainage basin of the San Juan Mountains in southwestern Colorado, and in the mountain ranges of northern New Mexico. The river flows southward through New Mexico, and then forms the international boundary between the Mexican States of Chihuahua, Coahuila, Nuevo Leon, Tamaulipas, and the State of Texas. The Rio Grande's total length is approximately 1,896 miles, with approximately 1,248 miles make up the international boundary between Texas and Mexico.

The water supply available from the Upper Rio Grande is affected by climatic conditions in Colorado and northern New Mexico. Although dams have been built on the River in New Mexico to provide a degree of control, floods and droughts still take their toll in the region. Most of the Rio Grande's flow above Fort Quitman is diverted at the Mesilla Dam in New Mexico to support irrigation in Dona Ana County, New Mexico and at the American Dam in Texas to supply irrigation and municipal demand in Texas. Water is also diverted at the International Dam for delivery through the Acequia Madre to supply irrigation demand in Mexico as stipulated by Treaty. Downstream from El Paso, most of the flow consists of irrigation return flow, and small amounts of treated and larger amounts of untreated municipal wastewater.

The flow from below Fort Quitman to Presidio is often intermittent and is referred to as the "Forgotten River". The River becomes a permanent stream again at the point where the Mexican river, the Rio Conchos, enters upstream of Presidio. From Presidio downstream through the Big Bend until it reaches the Amistad Reservoir, the Rio Grande often lacks sufficient flow to adequately support minimum recreational, environmental, or agricultural needs; and during dry periods, may fall significantly short of supplying such needs.

Under drought conditions in the upper catchment basin, flows in the Rio Grande are significantly reduced and are allotted by the United States Bureau of Reclamation (USBR) in accordance with a prearranged schedule. The lowest total release from Caballo Dam was 206,081 acre-feet in 1964. The lowest diversion by EPCWID#1 is estimated to be 72,746 acre-feet in 1964, which is not sufficient to meet the needs of water users in the El Paso area. Low releases and diversions significantly affect downstream water users who are highly dependent on a steady source of river water. In addition, such low diversions result in a degradation of the River's water and environmental quality.

American Heritage River Initiative - The Rio Grande, from El Paso to Laredo, is one of only 14 rivers in the United States, and the only river in Texas, to receive the American Heritage River designation. Established in 1997, the American Heritage River Initiative recognizes rivers, or segments of rivers, that have played a significant role in the history and culture of the region it traverses. The initiative gives federal support to voluntary community-led work that benefits riverfront communities. Some of the possible benefits of being designated an American Heritage River are increased opportunities in commerce and trade, recreational improvements along the River, incorporation of wildlife habitats, and cultural stimulation. The American Heritage River Initiative does not conflict with matters of state and local government jurisdiction, such as water rights, land-use planning and water-quality standards. Also, the initiative does not impair the authority of each state to allocate quantities of water within its jurisdiction.

<u>Rio Grande Wild and Scenic River</u> - In 1978, Congress designated a 196-mile reach of the Rio Grande, from the Coahuila-Chihuahua State line, near Mariscal Canyon, to the Terrell-Val Verde County line, a “Wild and Scenic River”. This segment of the river is recommended by the Far West Texas Water Planning Group (FWTWPG) as an “Ecologically Unique River Segment” and is discussed in further detail in Chapter 8.

3.2.1 Rio Grande Treaties and Compact

Water demand related to irrigation use and population growth has affected the River since the 1800s. Water appropriations and shortages have spawned lawsuits, as well as the involvement of the federal government in the management of the River. The following sections describe efforts by state and national governments to address many of the complex issues associated with the Rio Grande.

<u>1906 International Treaty</u> - Under the 1906 International Treaty, the United States is obligated to deliver 60,000 acre-ft of water annually from the Rio Grande to Mexico, except in the cases of extraordinary drought or serious accident to the irrigation system in the United States. The 60,000 acre-ft must be delivered, at no cost to Mexico and in accordance with a monthly distribution schedule from February through November, in the bed of the Rio Grande at the headworks of the Acequia Madre (International Dam). The International Boundary and Water Commission (IBWC)/Comisión International de Límites y Aguas (CILA) is the designated binational agency that makes the yearly delivery of international waters to Mexico. The U.S. Bureau of Reclamation (USBR) calculates the allocations in coordination with the IBWC.

<u>Rio Grande Compact</u> - The Rio Grande Compact is a tri-state agreement, approved by the U.S. Congress and ratified by the states of Colorado, New Mexico and Texas. The Rio Grande Compact Commission administers the Compact. The Commission is comprised of a Commissioner from each of the states and a nonvoting chairman appointed by the President of the United States. The Compact addresses only surface-water apportionment between the three states.

The Compact encompasses the waters of the Rio Grande from the southern Colorado headwaters to above Fort Quitman, Texas and distributes them between Colorado, New Mexico and Texas. It sets out a schedule of the water-delivery obligation of Colorado at the Colorado/New Mexico state line and the obligation of New Mexico to deliver water to Texas via Rio Grande Project reservoirs at Elephant Butte and Caballo. Releases from the reservoirs are measured downstream of Caballo Reservoir.

1944 International Treaty - This 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. The 1944 Treaty also stipulates that one-third of the flow of the Rio Conchos in Mexico is allotted to the United States. The Rio Conchos is by far the largest tributary of the Rio Grande. The treaty requires that 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-ft. The IBWC is responsible for implementing the treaties between the United States and Mexico. In recent years, the required minimum flow has not been met, however, as of the printing of this plan, Mexico has repaid its entire water debt.

3.2.2 Rio Grande Project

The Rio Grande Project is an irrigation storage and flood control federal reclamation project administered by the USBR. Elephant Butte and Caballo Reservoirs in New Mexico and the diversion dams at the headings of the main canals make up the Project's primary facilities. The Project delivers water to the Elephant Butte Irrigation District (EBID) and the El Paso County Water Improvement District No. 1 (EPCWID#1). The EBID encompasses all the project lands in New Mexico south of the Caballo Reservoir, while the EPCWID#1 encompasses the project lands in El Paso County, Texas. The Districts deliver water to farmlands in New Mexico and Texas. Since 1941, EPCWID#1 has delivered water to the City of El Paso for municipal and industrial use through contracts among the District, the City and the USBR. The City of El Paso also owns farmland with first class water rights, which it uses for municipal purposes. The Project also delivers water to Mexico in accordance with the Treaty of 1906. In 1979 and 1980, the two Districts took over the operation and maintenance responsibilities of most of the respective irrigation works within the boundaries of each entity. Legal titles to the rights-of-way of irrigation canals and drains were transferred from the United States to the Districts in January 1996.

Project Water Allocation - Deliveries of Rio Grande Project water is based on irrigation requirements authorized for the Project and are agreed on by the two irrigation districts and the USBR. The annual allotment of Rio Grande Project water downstream of the Caballo Reservoir is determined by the USBR based on the amount of usable water in storage. Through data obtained from the measurement of snow pack and river gauging stations along the upper reaches of the Rio Grande, the USBR determines the projected inflow to Elephant Butte Reservoir. The USBR measures storage available in the Elephant Butte and Caballo Reservoirs and projects volumes available for allocation as a 30-year moving average.

Total releases from Project storage during a full-allotment year average approximately 764,000 acre-feet. Total diversions, however, average approximately 932,000 acre-feet per year. Total average diversions exceed average total releases by 168,000 acre-feet. The difference between the two is attributable to irrigation and municipal return flows, operations spills from upstream users, and rainfall runoff. Total diversion allocations are 495,000 acre-feet to EBID, 376,000 acre-feet to EPCWID#1, and 60,000 acre-feet to Mexico during years of full supply.

Currently, the City of El Paso's right to use water from the Project arises from its ownership of 2,000 acres of land with rights to use water, approximately 5,542 acres of 50- and 75-year term City of El Paso Irrigation Water Assignments (Leases) for rights to use water from urbanized land parcels, and approximately 3,088 acres of Lower Valley Water District (LVWD) Leases. The rights to use water from the LVWD Leases are transferred to the City of El Paso on an annual basis in exchange for a wholesale supply of water from the City. EPWU receives an annual allocation for water leased and land ownership categories based on the yearly allocation and the provisions of the respective 1941, 1962, 1989, and

2001 contracts. During a full allocation year, EPWU has rights to divert 65,000 acre-feet of Rio Grande Project water from all contract sources. The conversion of rights to use water from agricultural to municipal and industrial use must be contracted with the EPCWID#1 and the USBR. El Paso has also finalized an agreement with EPCWID#1 to acquire additional raw water based on EPCWID#1's operation of new shallow wells intended for drought relief. The 2001 Third Party Implementing Contract with EPCWID#1 converts to municipal and industrial use Project water saved from canal lining, operational efficiencies, and other miscellaneous water sources. The City has negotiated and agreed in principal on the terms of a Third Party Implementing Contract that would allow it to contract for the conversion of rights to use water directly from farmers through the use of short-term "Forbearance Contracts."

3.2.3 Rio Grande Watermaster

A binational commission determines the allocation of Rio Grande water below Ft. Quitman. The TCEQ Rio Grande Watermaster administers the allocation of Texas' share of international waters. Two reservoirs located in the middle of the Lower Rio Grande, Amistad and Falcon, store the water allocated by the Watermaster. The Watermaster oversees Texas' share of water in the Lower Rio Grande and its Texas tributaries from Fort Quitman to Amistad Dam, excluding the drainage basins of the Pecos and Devils Rivers.

3.2.4 Rio Grande Water Quality

The quality of water in the segment of the Rio Grande that flows through Far West Texas varies significantly from specific location and season of the year. Of prime consideration is that there is little natural flow in the river. The TNRCC's (predecessor name of TCEQ) inventory of water quality in the state (TNRCC, 1996) cites drainage area and a wide range of geologic and climatic conditions in Far West Texas as factors responsible for water-quality conditions in the Rio Grande. Heavy metals and pesticides have been identified along the course of the Rio Grande. Elevated fecal coliform and nutrient levels occur in the river downstream of border cities, primarily because of untreated wastewater from Mexico. A more detailed discussion on Rio Grande water quality is provided in Chapter 5.

3.2.5 Long-Term Reliability of the Rio Grande

The long-term reliability of Rio Grande water is sporadic. Aside from the legal mechanisms governing allocation of the water from Elephant Butte Reservoir and the allocation of water between the two nations of Mexico and the United States, the meteorologic and hydrologic reality is that the El Paso area is supplied by the Rio Grande, which has its headwaters in a climatic regime totally apart from the climatic regime of Far West Texas. If a drought occurs in Colorado, then the El Paso area is essentially thrown into a drought-like scenario. Drought prediction modeling, although attempted by climatologists worldwide, is still in its infancy and therefore the likelihood of a sure knowledge of long-term availability of water in the Rio Grande headwaters is slim.

3.2.6 Rio Grande Channelization

In 1933, the United States and Mexico signed a Convention entitled, "Rectification of the Rio Grande", in which the two countries agreed to provide flood protection to urban, suburban and agricultural lands and stabilize the international boundary line. Construction work authorized by this Convention addressed channel aggrading due to the flat gradient and low velocities of the Rio Grande and the new channels that tended to form on lower ground during flood flows. The rectified channel between its upper end at Cordova Island, near El Paso, to its lower end reduced the original river channel length from 155.2 miles to 85.6 miles and increased the gradient from about two feet per mile to 3.2 feet per mile. The Rectification Project also included the construction of three toll-free bridges, Caballo Dam and Riverside Dam and Heading. Construction commenced in March 1934 and was completed in 1938. In June of 1987, Riverside Dam failed. El Paso County Water District constructed a temporary rock cofferdam immediately downstream of Riverside Dam as a temporary means of diverting irrigation water through Riverside Heading, with the stipulation that the temporary dam would be removed once the American Canal Extension, scheduled for completion in February 1999, was constructed.

Recent events include the completion of the American Canal Extension, a currently ongoing Biological Assessment of the Rectification Project (resulting from a Memorandum of Understanding between IBWC and the Southwest Environmental Center), and IBWC's commitment to prepare an Environmental Impact Statement of the Rectification Project in fiscal year 2001.

The other important joint project with Mexico, the Rio Grande Boundary Preservation Project, carries out the provisions of Article IV of the 1970 "Treaty to Resolve Pending Boundary Differences and Maintain the Rio Grande and Colorado River as the International Boundary". The project covers the Rio Grande's 194-mile reach between Fort Quitman and Haciendita, Texas and addresses sedimentation as well as the phenomenon of salt cedars choking the channel. In some places the channel is nearly obliterated, and lands on both sides of the river are subject to periodic flooding from flash floods of tributary arroyos. The final Environmental Impact Statement for the Boundary Preservation Project was completed in 1978. In the United States, the Boundary Preservation Project was constructed in reaches based on contracts issued and inspected by the IBWC's United States Section.

Construction was completed for Reach I but was interrupted for other reaches by an extended period of flooding in 1981. Subsequent work done by IBWC's United States Section was tied to the Mexican Section's schedule; February of 1986 marked the end of U.S. Section construction work anywhere within the Boundary Preservation Project.

Funding to continue maintenance of the completed channel work has not been received since 1985; consequently, sediment plugs on the large tributary arroyos and high flows in the river have caused overtopping of the banks with the result that the channel has deviated from its original alignment. It is this deviation from channel alignment that concerns IBWC and which is properly termed "re-channelization".

IBWC's perspective is that re-channelization of the Rio Grande is a treaty requirement, and that re-channelization offers some water salvage potential when combined with removal of salt cedar (since salt cedar, in addition to choking the channel, is also a known phreatophyte). IBWC has proposed a feasibility study and notes that the Army Corps of Engineers has authority to fund such studies under the federal Water Resources Development Act of 1986.

The FWTWPG acknowledges the importance of the re-channelization issue and awaits the outcome of the decision regarding federal funding for the feasibility study. Such a study, if funded, will likely be completed during the next regional water planning cycle and the study results will then be incorporated into the Far West Texas Water Plan.

3.2.7 Forgotten River Segment Study

Reduced flows below Fort Quitman have resulted in a long stretch of the Rio Grande (locally known as the "Forgotten River") with no defined channel, and the riparian vegetation in that area has become a tamarisk thicket. The high flows and periodic floods necessary to maintain the river channels have been reduced significantly over the past several decades.

In August 2004, at the request of TCEQ, the Albuquerque Division of the Corps of Engineers conducted a reconnaissance level investigation of the Forgotten River. Based on that investigation, the Corps recommended that further watershed management studies be pursued. The Section 905(b) analysis was approved in March 2005. The total cost of the study is estimated to be $ 400,000, with half being supplied by the State of Texas. Half of the State's contribution will be cash, and half will be in-kind services. The TWDB supplied the State's cash match, through TCEQ. Cooperating entities include the University of Texas Center for Research in Water Resources, the University of Texas Center for Space Research, the Texas Department of Agriculture, and Environmental Defense. For study purposes, the area of the Forgotten River reach is considered to extend approximately 150 miles from Fort Quitman to Presidio.

The study will take a preliminary look at how to accomplish the following goals and will identify possible approaches and projects, some of which might be carried out by the Corps and other agencies.

- Improve riverine ecosystem function
- Stabilize river geomorphology
- Reduce nutrient loading to improve water quality

- Increase bio-diversity of the riverine ecosystem
- Improve international boundary delineation
- Reduce the loss of lands for agriculture and ranching within the study area

Major tasks and activities for the study include:

- Define and evaluate existing conditions in the Forgotten River Reach of the Rio Grande Basin study area. This will be accomplished through hydrologic studies, limited geomorphologic studies, remote sensing to delineate salt cedar encroachment, and environmental studies, including potential for revegetation with native trees and grasses. The results of these efforts will be used to characterize the basin and will provide the baseline data for any potential ecosystem restoration. Other work will consist of analysis of existing data, preliminary identification of constraints, and public involvement. The use of GIS mapping and analysis will be an important tool in these work activities, subject to the availability of information and required level of effort.

- Attempt to identify and prioritize viable projects that address environmental restoration and water quality improvements, along with flood damage reduction measures and recreation enhancements in the study area. Measures will include those that may enhance overall water quality or reduce water quality impacts. These projects will be developed to a conceptual level of detail so that preliminary cost estimates can be determined in order to establish priorities. Potential projects will also be evaluated as to their eligibility for Federal involvement.

3.3 PECOS RIVER

The Pecos River is the largest Texas river basin that flows into the Rio Grande. Originating in New Mexico, the Pecos flows southerly into Texas, and discharges into the channel of the Rio Grande near Langtry in Val Verde County. The River forms the easternmost border of Far West Texas along the northeast corner of Terrell County. Flows of the Pecos River are controlled by releases from the Red Bluff Reservoir near the Texas – New Mexico state line. Storage in the reservoir is affected by the delivery of water from New Mexico. According to data of the IBWC, the Pecos River contributes an average of 11 percent of the annual streamflow into the Rio Grande near Amistad Reservoir. The Pecos also contributes more than 29 percent of the annual salt loading into the reservoir.

3.3.1 Pecos River Compact

The Pecos River Compact provides for the apportionment and diversion of the Pecos River waters. The interstate administrative agency known as the Pecos River Compact Commission administers the Compact. This Compact repeatedly refers to the "1947 Condition," which is a Pecos River Basin situation defined in the Compact Commission's Report of the Engineering Advisory Committee. The term "unappropriated flood waters" includes Pecos River waters originating above the Red Bluff Dam located in Texas at the New Mexico/Texas border. The impoundment will not deplete the water usable by the storage and diversion facilities under the 1947 condition. If not impounded, the water will flow past Girvin, Texas.

The terms of the Pecos River Compact can be summarized by the following four points:

- New Mexico cannot decrease the Pecos flow at the New Mexico/Texas border to a point less than that of the 1947 condition. (When determining the quantity of Texas water for the 1947 condition, waters of the Delaware River are apportioned to Texas.)
- Of the beneficial consumptive use of water salvaged in New Mexico on the River, Texas shall receive 43 percent and New Mexico 57 percent.
- Any water salvaged by beneficial use, but which is not beneficially consumed, shall be apportioned to New Mexico. Any water salvaged in Texas shall go to Texas.

- Beneficial consumptive use of unappropriated floodwaters shall go equally to Texas and to New Mexico.

The Pecos River Compact allows Texas and New Mexico to build additional reservoir capacity to replace unusable reservoir capacity, for the utilization of salvaged water and unappropriated floodwaters as apportioned by the Compact and for making more efficient use of water. Each state shall work with agencies to solve the salinity problem in the Pecos, and each may construct and operate facilities to prevent flood damage.

The two states were involved in a lawsuit that was decided in March 1988. The decree required New Mexico to abide by the terms of the Pecos River Compact. It also resulted in the appointment of a Pecos Rivermaster.

3.3.2 Water Allocation and Water Rights

Waters delivered to Texas are stored in Red Bluff Reservoir and are allocated by a master irrigation control district to seven other irrigation districts downstream. Each district apportions the waters to individual farmers. The irrigation districts are located in Loving, Ward, Reeves and Pecos Counties, which lie in Far West Texas' neighboring Senate Bill-1 region, Region F.

Within the reach of the Pecos that borders Far West Texas, the TCEQ water-rights master file lists only two water rights on unnamed tributaries of the Pecos River. These water-rights holders, both located in Terrell County, are authorized to divert 44.6 and 0.6 acre-ft of water per year for irrigation purposes.

3.3.3 Significant Pecos River Basin Tributaries

Phantom Creek - Phantom Creek originates from groundwater discharging at Phantom Spring in Jeff Davis County. The creek flows northeastward into Reeves County, where it gains additional flow from San Solomon, Giffin, Saragosa, East Sandia and West Sandia Springs. Phantom Creek is an important source of water for irrigation in southern Reeves County. The U.S. Bureau of Reclamation manages the spring property and holds two water rights for the annual diversion of as much as 18,900 acre-feet of water for irrigation.

According to a study performed by the TWDB in 2003, flow in Phantom Spring has experienced significant decline over the past several drought years, declining from more than 10 cubic feet per second (cfs) during the 1930s to less than 1 cfs during the most recent drought period. Recently on several occasions, Phantom Spring has actually ceased flowing and a pump has been installed into the spring pool to support surface species residing at the spring outfall.

Independence Creek – Independence Creek, a large spring-fed creek in northern Terrell County, is the most important of the few remaining freshwater tributaries to the lower Pecos River. Caroline Spring produces 3,000 to 5,000 gallons per minute and comprises about 25 percent of the creek's flow. Independence Creek's contribution increases the Pecos River water volume by 42 percent at the confluence and reduces the total suspended solids by 50 percent, thus improving both water quantity and quality (Nature Conservancy of Texas descriptive flier).

Independence Creek hosts a variety of bird and fish species, some of which are extremely rare. For the Proserpine shiner, Rio Grande darter, headwater catfish, and several other native fishes, Independence Creek is an important refuge during stressful Pecos River conditions. Following periods of low-water quality and occasional algae blooms on the Pecos River, fish populations in the clear waters of the creek help to repopulate the River after a fish kill. The Nature Conservancy of Texas manages a significant portion of Independence Creek, including Caroline Spring, as a natural preserve.

3.3.4 Pecos River Basin Assessment Program

The Pecos River is the lifeblood of many communities within its reaches, and serves

as a major water source for irrigation, recreational uses, and recharge for underlying aquifers. However, the flows of the once great Pecos River have dwindled to a mere trickle due to natural and man-induced causes. Because water quality and streamflows have declined, the aquatic community of the Pecos River has been drastically altered. To address these river issues, the Pecos River Basin Assessment Program has been initiated by the various facilities of Texas A&M University (http://pecosbasin.tamu.edu/). The project is funded by the Texas Soil and Water Conservation Board through the U.S. Environmental Protection Agency-Clean Water Act Grant. Components of the project include:

- A basin assessment with regards to stream channel morphology, riparian vegetation, land use, salinity mapping, water inflows and outflows, aquatic habitats, historic perspectives and economic modeling. (Texas Agricultural Experiment Station)
- Educational programs working with various state and local agencies to assemble a series of publications and organize and conduct a series of educational meetings targeted at landowners, stakeholders and policymakers in the Basin. (Texas Cooperative Extension)
- Monitoring programs consisting of data collection, analysis, and water use studies intended to estimate the effect of salt concentration and fate of water salvaged through saltcedar control in the Pecos River Watershed.

3.4 GROUNDWATER

Other than irrigation use and a portion of City of El Paso municipal use from the Rio Grande, almost all other water use in Far West Texas is supplied from groundwater sources. Although not as large in areal extent as some aquifers in the State, i.e., the Ogallala and the Carrizo-Wilcox, individual aquifers in Far West Texas are more numerous (14) than in any of the other planning regions (Figure 3-1).

Aquifers in the Region can be categorized into two basic types, bedrock and bolson. Bedrock aquifers are those where groundwater flows through permeable fractures in hard-rock formations (limestone, dolomite, volcanic basalt, etc.). Aquifers of this type include the Bone Spring-Victorio Peak, Capitan Reef, Edwards-Trinity, Rustler, Marathon, and Davis Mountains Igneous. Bolson aquifers occur in thick silt, sand, and gravel deposits that fill valleys between the numerous mountain ranges. Bolson aquifers in the Region include the Hueco, Mesilla, and the various individual aquifers that comprise the West Texas Bolson aquifer group. Water quality characteristics of these aquifers are discussed in Chapter 5.

The evaluation of groundwater availability is based on previous geohydrologic studies, groundwater data including historical use contained in state and federal databases, and groundwater availability models (GAMs). Regardless of the specific method used to calculate groundwater supply availability, all analyses include the consideration of four basic components: (1) recharge to the aquifer, (2) recoverable storage capacity within the aquifer, (3) lateral movement into and out of the aquifer, and (4) withdrawals from the aquifer.

Recharge is a term that encompasses all of the sources by which an aquifer is replenished with water. This includes precipitation, infiltration of water from streams, and irrigation return flow. The arid to semi-arid climate of Far West Texas is a significant limiting factor in the amount of precipitation that can be converted to recharge. Throughout the Region, evaporation typically exceeds precipitation by as much as 70 inches per year. Because most of the rainfall occurs during the hottest months of the year, most of what reaches the ground is lost very quickly to evaporation. In addition to high evaporative losses, a significant amount of moisture is exhausted by desert plants, which have developed highly efficient mechanisms of extracting moisture from soils. Recharge rates vary significantly throughout the Region with fractured bedrock formations at higher elevations receiving the greater amounts and bolson floors receiving the least.

Recoverable storage capacity refers to the quantity of water contained within void spaces in the aquifer formation that can be extracted by pumping. Storage is thus a function of the porosity of the saturated portion of the formation. The term "Specific Yield" refers to the percentage of water that will drain, under the force of gravity, from the pore spaces of an aquifer.

Lateral movement includes groundwater that moves laterally into or out of a specific aquifer from or into adjacent water-bearing formations, and is sometimes referred to as lateral recharge. Lateral movement is a critical calculation in the determination of groundwater availability in the aquifers such as the Bone Spring-Victorio Peak.

Aquifer withdrawals primarily occur as pumpage, but also include natural spring flow. Water-level declines occur in aquifers where pumping withdrawals outpace recharge.

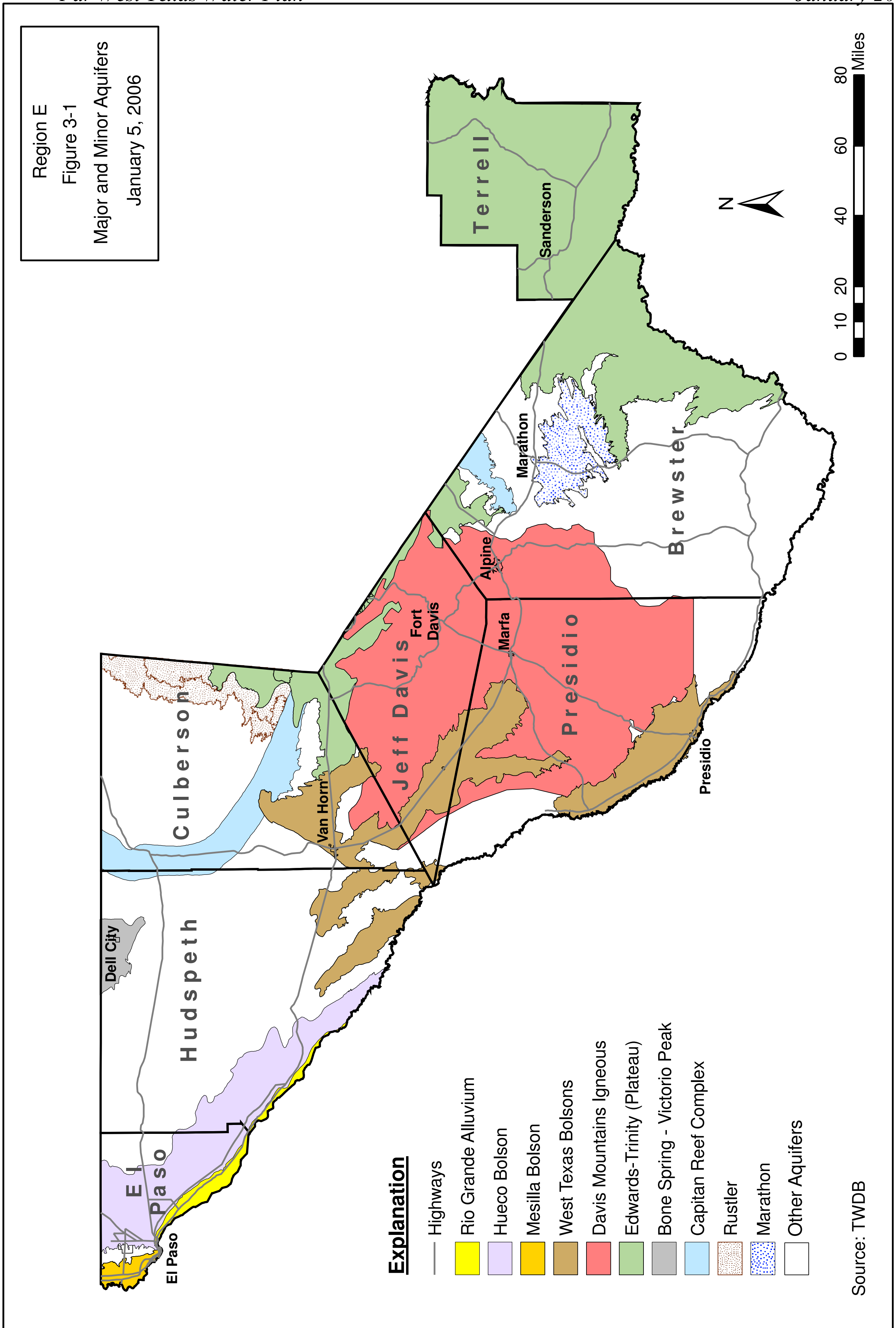

FIGURE 3-1. MAJOR AND MINOR AQUIFERS OF FAR WEST TEXAS

LBG-GUYTON ASSOCIATES

3.4.1 Hueco Bolson and Rio Grande Alluvium

The Hueco Bolson aquifer is a major source of groundwater for cities in El Paso and Hudspeth Counties, as well as Ciudad Juarez, Mexico. The Hueco Bolson extends southeastward from the Franklin Mountains in El Paso County to the southern end of the Quitman Mountains in Hudspeth County. The eastern boundary of the bolson is established by the Diablo Plateau in El Paso and Hudspeth Counties and the Malone and Quitman Mountains in Hudspeth County. Northward, the Hueco extends into New Mexico where it is hydrologically connected to the Tularosa Basin aquifer. The Hueco Bolson also extends southward into the Mexican State of Chihuahua, where it is bounded by a series of mountain ranges that trend toward the southeast from Ciudad Juarez to near the southernmost point of the Quitman Mountains in Texas.

The Hueco Bolson consists of deposits of basin fill with a maximum thickness of approximately 10,000 feet along its western edge. The upper part of the basin fill consists of silt, sand and gravel. The lowermost deposits are made up largely of clay and silt. Only portions of the upper several hundred feet of the bolson fill are known to contain fresh to slightly saline water. A wedge of fresh water increases to a maximum depth at or near the western edge of the aquifer. There is no fresh water on the eastern edge of the aquifer. Where Hueco Bolson sediments directly underlie Rio Grande alluvial sediments, the two units are hydrologically connected. Recent data analysis and computer modeling indicate that the Hueco Bolson aquifer can continue to be sustainably developed well beyond previous estimates.

3.4.2 Mesilla Bolson Aquifer

The Mesilla Bolson aquifer is located west of the Franklin Mountains and is part of a larger bolson that extends from southern New Mexico to northern Mexico. The bolson deposits consist of approximately 2,000 feet of clay, silt, sand, and gravel. Three water-bearing zones have been identified based on water levels and quality. The shallow zone includes the overlying Rio Grande Alluvium. The City of El Paso maintains a municipal well field in this aquifer near Canutillo.

3.4.3 West Texas Bolsons

3.4.3.1 Salt Basin Aquifer

The Salt Basin is the largest of the West Texas Bolson aquifers extending from the New Mexico state line on the western side of the Guadalupe Mountains southward to near Marfa in northern Presidio County. The basin is subdivided into four distinct but hydrologically connected areas referred to as "flats" that contain significant quantities of groundwater that is being produced for both municipal and irrigation use. These sub-aquifers include from south to north Ryan, Lobo, Wild Horse, and Michigan Flats.

Ryan Flat is the southernmost extension of the Salt Basin. The bolson watershed covers an area of 1,410 mi^2, and the storage area is 525 mi^2. The largest part of the storage area (360 mi^2) is in Presidio County, and a smaller area (165 mi^2) extends northward into Jeff Davis County. The bolson is the source of municipal supply for the Town of Valentine (Jeff Davis County). It is also the source of domestic water, stock water for ranches and a source of irrigation water for farms.

Well completion information and pumping records from the Antelope Valley Ranch owned by EPWU indicates that a zone of saturated, permeable, fractured volcanic rocks from 1,000 to as much as 3,000 feet thick underlies the bolson fill in Ryan Flat.

Lobo Flat lies to the north of Ryan Flat. The basin is bounded by mountains along its western and eastern margins, and is hydrogeologically connected with Wild Horse Flat to the north-northwest. The bolson watershed covers an area of 350 mi^2, with a groundwater storage area of 130 mi^2. The largest part of the storage area (75 mi^2) is in Culberson County, and a smaller part (55 mi^2) lies within Jeff Davis County. The bolson is not a source of municipal supply for any town in Jeff Davis County or Culberson County. It is, however, a source of domestic water and stock water for ranches and is also a significant source of irrigation water.

<u>Wild Horse Flat and Michigan Flat</u> lie to the north and northeast, respectively, of Lobo Valley. Lobo Valley is hydrogeologically integrated with the southernmost part of Wild Horse Flat. Mountains bound the Wild Horse-Michigan Flat area along its western, eastern and southeastern margins. The basins extend toward the north, where they are bordered by the Salt Flat Graben.

The Wild Horse-Michigan Flat watershed covers an area of approximately 1,000 mi^2 (Gates and others, 1980). The storage area is estimated to be 375 mi^2. The Wild Horse Flat area of the basin is a source of municipal supply for the Towns of Van Horn (Culberson County) and Sierra Blanca (Hudspeth County). The Wild Horse-Michigan Flat aquifer is a major source of domestic and stock water for ranches and of irrigation water for farms in the valley.

3.4.3.2 Presidio-Redford Bolson

In Texas, the Presidio-Redford Bolson extends along the Rio Grande from Candelaria to outcrops of volcanic rocks 6 to 10 miles southeast of Presidio. The Redford extension of the bolson continues along the Rio Grande for another 12 miles. The bolson is bounded along the northeast by the Chinati Mountains and along the southeast by the Cienega Mountains, the Black Hills, and the Bofecillos Mountains. The southwestern boundary of the bolson in Texas is the Rio Grande. The drainage area in Texas is estimated to be 1,100 mi^2 (Gates and others, 1980). This is an area of approximately 480 mi^2. Based on studies by Gates and others (1980) and Gabaldon (1991), saturated thickness is conservatively estimated to be 500 feet beneath this area. The Presidio-Redford Bolson is the source of municipal supply water for the Town of Presidio. It is also the source of domestic water, irrigation water and stock water for ranches and farms.

3.4.3.3 Green River Valley

The Green River Valley Bolson lies in parts of Hudspeth, Jeff Davis and Presidio Counties. It is bordered by the Eagle Mountains on the west, the Van Horn Mountains on the east, and the Rio Grande on the south. The Green River Valley watershed covers an area of 160 mi^2 (Gates and others, 1980), the storage area, however, is only 40 mi^2. Green River

Valley is the smallest of the West Texas Bolsons and is a source of water only for ranches in the basin. A few abandoned wells give witness to a past history of irrigation.

3.4.3.4 Red Light Draw

Red Light Draw, located in Hudspeth County, is situated between the Eagle Mountains along the north-northeast and the Quitman Mountains along the southwest. The Rio Grande is the southern border of the basin. The drainage area of the Red Light Draw watershed is estimated to be 370 mi^2 (Gates and others, 1980) and an aquifer area of 185 mi^2. The Red Light Bolson is a source of water only for ranches in the basin, and at its southern end for a research station operated by the University of Texas at El Paso.

3.4.3.5 Eagle Flat

The Eagle Flat Bolson, located in Hudspeth County, is situated between the Eagle Mountains along the south-southwest, the Diablo Plateau along the north, and the Carrizo and Van Horn Mountains along the east. The drainage area of the bolson watershed is estimated to be 560 mi^2 (Gates and others, 1980), and the basin fill covers an area of 156 mi^2. Only the southeastern part of the basin is regarded as having potential for the development of groundwater resources (Gates and others, 1980; Darling and others, 1994; Darling, 1997). The Eagle Flat Bolson is not a source of supply for municipalities in Hudspeth County. The unincorporated Town of Sierra Blanca, located in the western region of the basin, gets water from a well field operated by the Town of Van Horn in Wild Horse Flat.

3.4.4 Bone Spring-Victorio Peak Aquifer

The Bone Spring-Victorio Peak aquifer underlies the Dell Valley area of northeastern Hudspeth County (Figure 3-1). Dell Valley lies between the Salt Flat Basin and the Guadalupe Mountains on the east and the Diablo Plateau on the west. The aquifer, which extends northward into the Crow Flats area of New Mexico, is used primarily for irrigation, but is also the public water supply source for Dell City (Ashworth, 1994).

The aquifer consists of carbonate rocks (limestone and dolomite) of early Permian age. Groundwater in the aquifer occurs under water-table conditions in interconnected solution cavities of variable size and dimension that formed along joints, fractures and bedding planes. Water-bearing zones have been encountered in wells as deep as 2,000 feet. The productivity of a well completed in the aquifer is dependent on the number and size of cavities penetrated by the well bore. Well yields are reported to range from 150 gpm to as much as 4,000 gpm. The depth to groundwater within the irrigated region of Dell Valley ranges from approximately 35 feet along the eastern side of the valley to 325 feet on the west.

There are four principal components of recharge to the Bone Spring-Victorio Peak aquifer (Ashworth, 1994):

- Precipitation that falls over watersheds that drain toward Dell Valley infiltrates rapidly along fractures and solution features such as sinkholes;
- The Sacramento River, which drains the Sacramento Mountains of New Mexico, discharges large volumes of water to the subsurface in the lowlands that border the mountain catchments;
- Lateral inflow of groundwater from areas to the north and the west; and
- Return flow from irrigation in Dell Valley.

During the irrigation season, the flow of groundwater is highly influenced by pumping wells, which create cones of depression in the water table. The cones of depression may induce the flow of highly saline water from the Salt Flats toward the pumping wells by reversing the flow of groundwater along the eastern side of the valley. However, chemical analyses of wells along the eastern border of the valley have not indicated a significant influx of saline water.

3.4.5 Igneous Aquifer

The Davis Mountains Igneous aquifer system comprises all contiguous Tertiary igneous (volcanic) formations underlying the Davis Mountains and adjacent areas primarily in Brewster, Jeff Davis and Presidio Counties. Most of the aquifer's areal extent is underlain by a thickness ranging from 1,000 to 4,000 feet; however, most wells are less than 1,000 feet in depth. The aquifer is not a single homogeneous aquifer but rather a system of complex water-bearing formations that are in varying degrees of hydrologic communication.

Over 40 separately named volcanic units have been identified, each of which are highly variable in nature. Water quality of the aquifer is relatively good and generally meets safe drinking water standards. Alpine, Marfa and Fort Davis, along with a growing rural population, derive their municipal supplies from this aquifer.

3.4.6 Edward-Trinity (Plateau) Aquifer

The Edwards-Trinity (Plateau) aquifer in Far West Texas is the westernmost extension of a vast groundwater system that underlies the Edwards Plateau east of the Pecos River and the Stockton Plateau west of the River. The aquifer is exposed over an area of 4,690 mi^2 in Terrell (2,350 mi^2), Brewster (1,460 mi^2), Jeff Davis (530 mi^2) and Culberson (350 mi^2) Counties. It is the source of municipal water for the City of Sanderson (Terrell County); a source of domestic water in Brewster, Culberson, and Terrell Counties; a source of irrigation water in Brewster and Terrell Counties; a source of stock water in all four counties; and a source of water for oil and gas operations in Terrell County.

The aquifer consists of saturated sediments of the Cretaceous age Trinity Group formations and the overlying carbonate rocks (limestone and dolomite) of the Comanche Peak, Edwards, and Georgetown formations. Groundwater occurs under water-table conditions in the four Far West Texas counties.

The hydrogeology of the Edwards-Trinity (Plateau) aquifer in Far West Texas is not understood as well as in areas to the east, where the aquifer is a major source of supply for the municipal, industrial and agricultural sectors of the economy.

3.4.7 Capitan Reef Aquifer

The Capitan Reef formed along the margins of the Delaware Basin, a Late Paleozoic sea. In Texas, the reef formed along the western and eastern edges of the basin in arcuate strips 10 to 14 miles wide. The reef is exposed in the Guadalupe and Apache Mountains of Culberson County and in the Glass Mountains of Brewster County. In other areas, the reef is found only in the subsurface. It extends northward into New Mexico, where it is a source of fresh water for the City of Carlsbad. The aquifer is not a source of municipal supply for cities in Texas. Most of the groundwater pumped from the aquifer in Far West Texas is used for irrigation in Culberson and Hudspeth Counties.

The Capitan Reef aquifer is composed of up to 2,000 feet of massive to cavernous dolomite and limestone, bedded limestone and reef talus. In many areas of Culberson and Hudspeth Counties, the yields of wells are commonly more than 1,000 gpm. Further to the south, in the Apache Mountains of Culberson County, well yields appear to be in the range of 400 gpm. There is no reported production data for the Glass Mountains portion of the Capitan Reef.

3.4.8 Marathon Aquifer

The Marathon aquifer is located entirely within the north-central area of Brewster County. It is the source of municipal supply for the Town of Marathon, and of domestic and stock water for ranches in the area.

The Marathon area is underlain by complexly faulted and folded Paleozoic rocks having a total thickness of 21,000 feet. Figure 3-1 delineates the 390-mi^2 area in which the rocks that make up the Marathon aquifer are exposed in Brewster County. Existing water wells have penetrated up to 900 feet of the aquifer, however most wells are significantly shallower. Groundwater occurs under unconfined conditions in crevices, joints and cavities. The most significant water-bearing formation of the aquifer is the Marathon Limestone (early Ordovician age). Artesian conditions are common in areas where the Paleozoic rocks are buried beneath younger formations. The depth to groundwater is generally less than 150 feet, and depths less than 50 feet are not uncommon. Most wells are generally less than 250 feet deep (DeCook, 1961; TWDB, 1997).

3.4.9 Rustler Aquifer

The Rustler aquifer is located in eastern Culberson County, where it is exposed in a southwest-trending belt that begins at the northeast corner of the county. The aquifer dips toward the east, and is found in the subsurface in easternmost Culberson County and Jeff Davis County. Approximately 803 mi^2 of land in Far West Texas are underlain by the Rustler aquifer. The Rustler aquifer is a source of water for irrigation and livestock. High concentrations of dissolved solids render the formation unsuitable as a source of municipal and domestic supply. The Rustler aquifer consists mainly of dolomite, limestone, and gypsum of the Rustler Formation (Permian age). Groundwater is produced primarily from solution channels, caverns and collapsed breccia zones. The aquifer is under water-table conditions in the outcrop recharge zone in eastern Culberson County and is under artesian conditions elsewhere (TWDB, 1997).

3.4.10 Rio Grande Alluvium

The Rio Grande Alluvium forms the flood plain of the Rio Grande in El Paso and Hudspeth Counties. Averaging approximately 200 feet in thicknesses, the alluvial aquifer is hydrologically connected to the underlying Hueco Bolson. Groundwater contained within the shallow alluvial sediments generally has high concentrations of dissolved solids (typically greater than 2,000 mg/l), and thus is not a source of drinking water. However, it is a source of irrigation water in El Paso and Hudspeth Counties whenever flow in the Rio Grande is insufficient to support agricultural operations. These irrigation wells are capable of annually producing approximately 80,000 acre-feet in El Paso County and 15,000 acre-feet in Hudspeth County from the Rio Grande Alluvium.

3.4.11 Other Groundwater Resources

Also shown in Figure 3-1 are large areas of Far West Texas that are depicted as not underlain by major or minor aquifers. The map, however, should not be interpreted as an indication that such areas are devoid of groundwater, but rather as a reflection of the current level of understanding of the extent of known groundwater resources in the region.

In southern Brewster County, the small communities of Study Butte and Terlingua, as well as the Lajitas Golf Resort, obtain groundwater from underlying **Cretaceous formations**. Wells recently drilled to supply water for the Lajitas golf courses have demonstrated that groundwater of likely significant quantity is present in this aquifer system. However, very little data has been collected pertaining to this aquifer. The Lajitas' wells are relatively deep, the temperature of the water is warm, and the water contains elevated radioactivity. The FWTWPG recommends that this aquifer be studied in more detail.

The rock formations that make up the subsurface of the **Diablo Plateau** of central and northern Hudspeth County may have large volumes of groundwater in storage. The Plateau, however, has not been sufficiently evaluated by hydrogeologists to warrant definite conclusions regarding its status as a potential source of groundwater at this time. Relatively few exploration wells have been drilled on the Plateau. Consequently, factors such as hydrostratigraphy and important hydraulic parameters (e.g., porosity, hydraulic conductivity and transmissivity) are largely unknown.

3.4.12 Groundwater Conditions in Municipal Well Fields

Brewster County

City of Alpine

The City of Alpine owns 20 municipal supply wells in two principal well fields (the Musquiz and Sunny Glen well fields). Water levels have remained relatively stable in the vicinity of the well fields, and there are no reported major water quality problems. The Musquiz field produces approximately 66 percent of the city's municipal water, but the Sunny Glen field is regarded as having greater storage capacity. Recently, several wells within the Sunny Glen field were deepened, and yields are reported to have increased from less than 100 gpm to as much as 500 gpm.

Community of Marathon

The Marathon Water and Sewer Service Corporation provides water to the community from two wells screened in the Marathon aquifer. Water levels have remained stable in the vicinity of the community, and there are no reported major water quality problems. There are no other sources of groundwater in the vicinity of the community.

Communities of Terlingua and Study Butte

The Study Butte Water Supply Corporation (WSC) has developed two wells into the Cretaceous Santa Elena Limestone. The capacity of either well is sufficient to supply daily needs. Water levels have remained relatively stable, but little is known about how high production wells into the same formation 10 miles away might affect local static water levels. Radiological activity in the untreated water consists mainly of Radon gas and radium 226, which are present in levels barely above detection limits. Radon levels are drastically reduced by mechanically assisted gassing, and the particulate R226 can be filtered out in such a quantity as to leave both an excellent product water and to pose no problems for disposal. This water system has one of the most sophisticated rural public water treatment facilities in West Texas, combining reverse osmosis desalination and other more traditional technologies to produce a product of superior taste and quality.

Resort of Lajitas

The Resort of Lajitas has drilled several large bore wells into deep Cretaceous formations of varying water quality. Depending on location, wells have demonstrated artesian characteristics, with completed static level as much as 700 feet above the level where the formation was entered. The water is chemically similar to that found 10 miles away by the Terlingua Study Butte WSC, and poses similar treatment problems. Lajitas Resort also uses a modest surface right on the Rio Grande to provide for is overall water needs. The majority of water produced by the Lajitas Resort water system is for golf course and turf irrigation from a combination of sources; a state-of-the-art electro-dialysis desalination provides high quality product for municipal use by residents, employees, and resort guests. No change in aquifer levels has been reported since the onset of high volume pumping in 2000, but little reliable data is available for either recharge rates or total pumping volumes.

Culberson County

Town of Van Horn

Municipal supply for the Town of Van Horn is derived from five city-owned wells in the Wild Horse Flat aquifer. Water levels in the vicinity of Van Horn have remained stable. Other than fluoride concentrations that have been reported to range from 2.3 to 3.1 mg/l, all other dissolved constituents are within their respective drinking-water standards. The current well field has significant expansion capability if additional production is needed to meet increased demand. The city is currently replacing all water meters in order to better monitor water use.

El Paso County

City of El Paso and Vicinity

The production of groundwater from well fields in the vicinity of El Paso and in Ciudad Juarez has created a large cone of depression in the potentiometric surface beneath each city. Average declines in wells in the upper portion of the Lower Valley in El Paso are in excess of 100 ft. These declines, in combination with deteriorating water quality, have prompted the City to discontinue pumping from certain wells. Elsewhere, average water-level declines are generally in the range of 60 to 80 ft. Recent water-level data indicate a slight rise of water levels in the valley. This is probably traceable to lower pumpage in some areas. The total decrease in the potentiometric surface beneath Ciudad Juarez has been significant enough to cause the cone beneath Ciudad Juarez to migrate north of the Rio Grande. The lowering of the potentiometric surface not only has reversed the predevelopment hydraulic gradient in the westernmost regions of the Hueco Bolson, but also is a factor underlying the deterioration of water quality in part of the El Paso area.

The concentrations of chloride and other dissolved ions have increased in many of the municipal wells of both cities. In El Paso County, for example, the TDS in production wells has risen to more than 1,000 mg/l. In recent years, El Paso Water Utilities has taken approximately 30 wells out of service due to elevated levels of chloride and TDS. In many cases, the greatest increases in TDS are associated with wells that have had large, sustained drawdowns, but similar changes have also been observed in some wells from which much less pumping has occurred. To continue the use of some of the more brackish quality wells, El Paso Water Utilities has installed skid-mounted desalination equipment.

Hudspeth County

Community of Sierra Blanca

Water provided to the Community of Sierra Blanca by the Hudspeth County Water Control and Improvement District #1 is purchased from the Town of Van Horn. The Van Horn well field is composed of two wells located in the Wild Horse Flat aquifer in southern Culberson County. Water levels in the well field have remained constant, and water quality has not been reported to be a problem for the Community. The Wild Horse well field has substantial room for expansion if an additional well is needed to meet demand. Since 1970, Sierra Blanca has drilled as many as five wells in Hudspeth County in unsuccessful attempts to develop local sources of groundwater.

City of Dell City

Dell City relies on three wells completed in the Bone Spring-Victorio Peak aquifer for municipal water. Groundwater from the aquifer is brackish and must be desalinated. The Bone Spring-Victorio Peak aquifer is capable of supporting production from additional municipal supply wells if needed.

Communities of Fort Hancock and McNary

Fort Hancock and McNary have relied on groundwater provided by one well owned by the Fort Hancock WCID and on 11 wells owned by the Esperanza FWSD#1. All production is from the Rio Grande Alluvium aquifer. Water levels fall in response to extended drought conditions in the region, but the owner of the Esperanza FWSD #1 reports that water levels usually recover quickly after periods of rainfall. Water quality is a problem in the area, as TDS ranges from approximately 1,000 mg/l to as much as 2,500 mg/l. Other dissolved solids in excess of drinking water standards are fluoride and manganese. The possibilities for expansion are limited by the occurrence of saline groundwater in both the Rio Grande Alluvium and the Hueco Bolson aquifer.

Jeff Davis County

Community of Fort Davis

The Fort Davis Water Supply Corporation (FDWSC) provides water to the Community of Fort Davis and the surrounding area from three wells completed in the Davis Mountains Igneous aquifer. One of the wells is used only as a backup. Water levels in the vicinity of the wells have remained stable; and other than elevated fluoride, there are no reported problems with water quality. The FDWSC has also looked at other areas in the vicinity of Fort Davis for future well development.

Town of Valentine

The Town of Valentine relies on one municipal water supply well completed in the Ryan Flat aquifer. A second well owned by the Valentine Independent School District provides water to the school and to a small number of residences occupied by teachers. Water levels in the vicinity of Valentine have remained stable, and there are no reported problems with water quality. Under consideration is a proposal to drill a second municipal water supply well. The Ryan Flat aquifer appears to have ample capacity to support additional well development for the Town of Valentine.

Presidio County

<u>City of Marfa</u>

The City of Marfa depends on three city-owned wells for all of its municipal water needs. Two of the wells are capable of producing as much as 1,100 gpm, and the third well yields an additional 450 gpm. The Tertiary volcanics of the Igneous aquifer are the source of groundwater. Other than fluoride, which has been reported at concentrations ranging from 2.5 to 3 mg/l, all other dissolved solids are below their respective drinking-water standards, and TDS are typically less than 400 mg/l. The well field has significant expansion capacity if other wells are needed to meet additional demand.

<u>City of Presidio</u>

The City of Presidio derives all of its municipal water from three wells completed in the thick basin fill deposits of the Presidio Bolson aquifer. Two wells are located within the city limits, and the third well is located approximately 7 miles to the southeast of town. Water levels have remained stable in the vicinity of the wells; and other than fluoride concentrations from 2 to 3 mg/l, all other dissolved solids are within their respective drinking-water standards. There is ample expansion capacity in the vicinity of the city, and the city expects that additional wells will be needed to satisfy increased demand.

Terrell County

<u>Community of Sanderson</u>

The Community of Sanderson owns 18 public supply wells that produce groundwater from the Edwards-Trinity (Plateau) aquifer. Ten of the wells provide most of the community's water needs, and the Water Department plans to drill an additional well in the near future to replace the two lowest producing wells. Water levels have remained stable; and water quality is not reported to be a problem for the community.

3.4.13 Groundwater Exports

Jeff Davis is the only county from which water is exported to other areas outside of its borders. As shown by the table below, the City of Alpine pumps approximately 985 acre-ft per year from five wells in the Musquiz well field in southern Jeff Davis County. All other exports go to Reeves County. In 1998, the City of Balmorhea and the Madera Valley WSC extracted about 95 acre-ft and 101 acre-ft respectively, from the Balmorhea Alluvium, and the USBR has rights for diversions of up to 18,900 acre-ft from Phantom Creek for irrigation use in Reeves County.

Received By	Receiving County	Source	Amount (Acre-ft/Yr)	Remarks
City of Alpine	Brewster	Igneous Aquifer	983	Pumpage from five wells in Musquiz well field
City of Balmorhea	Reeves	Balmorhea Alluvium	126	Pumpage from one well
Madera Valley WSC	Reeves	Balmorhea Alluvium	74	Pumpage from two wells
U.S. Bureau of Reclamation	Reeves	Phantom Creek	18,900	Permitted diversion for irrigation

3.5 REUSE

El Paso has nearly 40 miles of reclaimed water lines (purple pipeline) in place in all areas of the City. Reclaimed water serves the landscape irrigation demand of golf courses, parks, schools, and cemeteries, and also provides water supplies for steam electric plants and industries within the City. The supply from the direct reuse program is expected to increase from 5,000 acre-ft per year in 2000 to over 23,000 acre-ft per year by 2060.

CHAPTER 4

WATER MANAGEMENT STRATEGIES

4.1 INTRODUCTION

Chapter 4 contains a comparison of projected water demands for each municipality and non-municipal water user group from Chapter 2, and water supplies available to meet those demands from Chapter 3. Water supply strategy recommendations are then made for those water use groups that have water supply deficits based on the comparison between demand and supply. In the development of water management strategies, existing water rights, water contracts, and option agreements are recognized and fully protected. A socioeconomic impact of unmet water needs in Far West Texas analysis prepared by the Texas Water Development Board is provided in Appendix 4A.

4.2 WATER SUPPLY AND DEMAND COMPARISON

Table 4-1 compares available water user group supplies (Table 3-2) with their corresponding future projected demands (Table 2-2). Water supply deficits are identified where the demand exceeds the supply. Water supply deficits are identified for a number of municipalities, manufacturing use, and steam power electric generation in El Paso County, and for irrigation supply use in El Paso, Hudspeth, and Presidio Counties. Sections 4.4 and 4.5 provide recommended strategies to meet these identified deficits.

4.3 STRATEGY EVALUATION PROCEDURE

A specific process was used in the selection and evaluation of strategies and is summarized in the flow chart illustrated in Figure 4-1. The process started with a consideration of potentially feasible strategies to meet the needs of each entity or category with a supply deficit. From this list, the Far West Texas Water Planning Group (FWTWPG) selected specific strategies for further feasibility and impact analysis.

The strategy evaluation procedure is designed to provide a side-by-side comparison such that all the strategies can be assessed based on the same factors. Table 4-2 lists strategies considered and provides a comparison of the evaluated factors. Specific factors considered were:

- Quantity of water supply generated
- Water quality considerations
- Reliability
- Cost (total capital cost, annual cost, and cost per acre-foot) (see Table 4-3)
- Environmental impacts (see Table 4-4)
- Impacts to agricultural resources
- Impact to natural resources
- Recreational impacts

To adequately consider the unique challenges faced by municipal and industrial water users in El Paso County, an integrated approach was used to establish a feasible strategy capable of identifying sufficient future supplies to meet the needs of El Paso Water Utilities (EPWU), the largest wholesale water provider in the county. Six separate approaches were considered that combined various potential surface water and groundwater sources at variable supply rates and times of implementation. The FWTWPG compared the six integrated strategies and selected the strategy termed the *"Balanced Approach with Moderate Increase in Surface Water"* (Section 4.4). A detailed report containing all six strategies and titled Integrated Water Management Strategies for the City and County of El Paso is provided under a separate cover. The content of this report is not necessarily endorsed by the FWTWPG as being a part of the Far West Texas Water Plan, but rather is a working document used by the Group to reach consensus on an adopted integrated strategy.

Other non-integrated municipal strategies are discussed in Section 4.5. The evaluation of irrigation strategies for El Paso, Hudspeth, and Presidio Counties differs slightly in that these strategies represent recommended best management practices. These strategies are discussed in detail in Section 4.6 and are summarized in Table 4-5. Included in Appendix 4B are other projects for future consideration. Strategies or project proposals for which the FWTWPG received insufficient data are not included in this plan.

TABLE 4-1. WATER SUPPLY CAPACITY AND WATER DEMAND COMPARISON DURING DROUGHT-OF-RECORD CONDITIONS (Acre-Feet/Year)(Shaded areas designate shortages)

County/ Water Use Category	Supply / Demand	2010	2020	2030	2040	2050	2060
Brewster County							
Alpine	S	4,864	4,864	4,864	4,864	4,864	4,864
	D	1,791	1,888	1,917	1,928	2,014	2,034
		3,073	**2,976**	**2,947**	**2,936**	**2,850**	**2,830**
County- Other	S	455	455	455	455	455	455
	D	451	448	441	432	431	432
		4	**7**	**14**	**23**	**24**	**23**
Manufacturing	S	4	4	4	4	4	4
	D	4	4	4	4	4	4
		0	**0**	**0**	**0**	**0**	**0**
Mining	S	696	696	696	696	696	696
	D	576	554	546	539	532	523
		120	**142**	**150**	**157**	**164**	**173**
Irrigation	S	8,790	8,790	8,790	8,790	8,790	8,790
	D	1,622	1,613	1,605	1,596	1,588	1,580
		7,168	**7,177**	**7,185**	**7,194**	**7,202**	**7,210**
Livestock	S	798	798	798	798	798	798
	D	707	707	707	707	707	707
		91	**91**	**91**	**91**	**91**	**91**
Culberson County							
Van Horn	S	2,084	2,084	2,084	2,084	2,084	2,084
	D	839	890	907	905	901	901
		1,245	**1,194**	**1,177**	**1,179**	**1,183**	**1,183**
County- Other	S	78	78	78	78	78	78
	D	74	78	78	77	76	76
		4	**0**	**0**	**1**	**2**	**2**
Mining	S	2,161	2,161	2,161	2,161	2,161	2,161
	D	1,514	1,560	1,577	1,594	1,610	1,632
		647	**601**	**584**	**567**	**551**	**529**
Irrigation	S	34,593	34,593	34,593	34,593	34,593	34,593
	D	28,960	28,340	27,733	27,140	26,559	25,991
		5,633	**6,253**	**6,860**	**7,453**	**8,034**	**8,602**
Livestock	S	466	466	466	466	466	466
	D	344	344	344	344	344	344
		122	**122**	**122**	**122**	**122**	**122**

County/ Water Use Category	Supply / Demand	2010	2020	2030	2040	2050	2060
El Paso County							
Anthony	S	3,065	3,065	3,065	3,065	3,065	3,065
	D	719	826	924	1,004	1,089	1,182
		2,346	**2,239**	**2,141**	**2,061**	**1,976**	**1,883**
Clint	S	276	276	276	276	276	276
	D	270	268	268	267	267	267
		6	**8**	**8**	**9**	**9**	**9**
City of El Paso (EPWU)	S	116,775	116,775	116,775	116,775	116,775	116,775
	D	127,996	140,698	151,719	161,402	171,836	183,205
		-11,221	**-23,923**	**-34,944**	**-44,627**	**-55,061**	**-66,430**
El Paso WCID #4	S	4,445	4,445	4,445	4,445	4,445	4,445
	D	1,583	2,124	2,587	2,992	3,389	3,813
		2,862	**2,321**	**1,858**	**1,453**	**1,056**	**632**
Fort Bliss	S	21,694	21,694	21,694	21,694	21,694	21,694
	D	8,419	8,419	8,404	8,404	8,389	8,389
		13,275	**13,275**	**13,290**	**13,290**	**13,305**	**13,305**
Homestead MUD	S	420	420	420	420	420	420
	D	614	841	1,030	1,195	1,370	1,544
		-194	**-421**	**-610**	**-775**	**-950**	**-1,124**
Horizon Regional MUD	S	9,500	9,500	9,500	9,500	9,500	9,500
	D	3,593	5,527	7,224	8,684	10,165	11,646
		5,907	**3,973**	**2,276**	**816**	**-665**	**-2,146**
Lower Valley Water District	S	490	490	490	490	490	490
	D	1,121	1,726	2,282	2,725	3,199	3,672
		-631	**-1,236**	**-1,792**	**-2,235**	**-2,709**	**-3,182**
San Elizario	S	1,101	1,101	1,101	1,101	1,101	1,101
	D	1,924	2,858	3,718	4,405	5,138	5,871
		-823	**-1,757**	**-2,617**	**-3,304**	**-4,037**	**-4,770**
Socorro	S	2,585	2,585	2,585	2,585	2,585	2,585
	D	2,959	3,466	3,977	4,361	4,795	5,230
		-374	**-881**	**-1,392**	**-1,776**	**-2,210**	**-2,645**
El Paso County Tornillo WID	S	1,225	1,225	1,225	1,225	1,225	1,225
	D	534	818	1,078	1,287	1,509	1,730
		691	**407**	**147**	**-62**	**-284**	**-505**
Vinton	S	210	210	210	210	210	210
	D	399	614	798	962	1,126	1,291
		-189	**-404**	**-588**	**-752**	**-916**	**-1,081**
County- Other	S	3,070	3,070	3,070	3,070	3,070	3,070
	D	5,664	8,551	10,873	12,672	14,492	16,610
		-2,594	**-5,481**	**-7,803**	**-9,602**	**-11,422**	**-13,540**
Manufacturing	S	7,745	7,745	7,745	7,745	7,745	7,745
	D	9,181	9,994	10,692	11,367	11,941	12,855
		-1,436	**-2,249**	**-2,947**	**-3,622**	**-4,196**	**-5,110**
Mining	S	169	169	169	169	169	169
	D	157	153	151	149	147	146
		12	**16**	**18**	**20**	**22**	**23**
Steam Electric Power	S	2,962	2,962	2,962	2,962	2,962	2,962
	D	3,131	6,937	8,111	9,541	11,284	13,410
		-169	**-3,975**	**-5,149**	**-6,579**	**-8,322**	**-10,448**
Irrigation	S	173,751	173,751	173,751	173,751	173,751	173,751
	D	247,111	242,798	240,848	232,380	228,579	224,840
		-73,360	**-69,047**	**-67,097**	**-58,629**	**-54,828**	**-51,089**
Livestock	S	1,742	1,742	1,742	1,742	1,742	1,742
	D	1,742	1,742	1,742	1,742	1,742	1,742
		0	**0**	**0**	**0**	**0**	**0**

County/ Water Use Category	Supply / Demand	2010	2020	2030	2040	2050	2060
Hudspeth County							
Sierra Blanca	S	351	351	351	351	351	351
	D	123	130	134	132	131	131
		228	**221**	**217**	**219**	**220**	**220**
County- Other	S	412	412	412	412	412	412
	D	287	297	301	288	284	284
		125	**115**	**111**	**124**	**128**	**128**
Manufacturing	S	10	10	10	10	10	10
	D	2	2	2	2	2	2
		8	**8**	**8**	**8**	**8**	**8**
Mining	S	2	2	2	2	2	2
	D	1	1	1	1	1	1
		1	**1**	**1**	**1**	**1**	**1**
Irrigation	S	84,150	84,150	84,150	84,150	84,150	84,150
	D	182,627	178,840	175,132	171,501	167,945	164,463
		-98,477	**-94,690**	**-90,982**	**-87,351**	**-83,795**	**-80,313**
Livestock	S	626	626	626	626	626	626
	D	613	613	613	613	613	613
		13	**13**	**13**	**13**	**13**	**13**
Jeff Davis County							
Fort Davis	S	912	912	912	912	912	912
	D	366	398	433	427	425	425
		546	**514**	**479**	**485**	**487**	**487**
County- Other	S	162	162	162	162	162	162
	D	162	159	155	151	150	150
		0	**3**	**7**	**11**	**12**	**12**
Irrigation	S	3,307	3,307	3,307	3,307	3,307	3,307
	D	576	572	569	566	563	559
		2,731	**2,735**	**2,738**	**2,741**	**2,744**	**2,748**
Livestock	S	563	563	563	563	563	563
	D	508	508	508	508	508	508
		55	**55**	**55**	**55**	**55**	**55**
Presidio County							
Marfa	S	4,839	4,839	4,839	4,839	4,839	4,839
	D	886	969	1,060	1,049	1,042	1,042
		3,953	**3,870**	**3,779**	**3,790**	**3,797**	**3,797**
Presidio	S	3,419	3,419	3,419	3,419	3,419	3,419
	D	1,039	1,255	1,458	1,642	1,727	1,781
		2,380	**2,164**	**1,961**	**1,777**	**1,692**	**1,638**
County- Other	S	94	94	94	94	94	94
	D	81	66	52	42	37	34
		13	**28**	**42**	**52**	**57**	**60**
Mining	S	10	10	10	10	10	10
	D	7	7	7	7	7	7
		3	**3**	**3**	**3**	**3**	**3**
Irrigation	S	16,522	16,522	16,522	16,522	16,522	16,522
	D	20,068	19,670	19,279	18,896	18,521	18,154
		-3,546	**-3,148**	**-2,757**	**-2,374**	**-1,999**	**-1,632**
Livestock	S	646	646	646	646	646	646
	D	622	622	622	622	622	622
		24	**24**	**24**	**24**	**24**	**24**

County/ Water Use Category	Supply / Demand	2010	2020	2030	2040	2050	2060
Terrell County							
Sanderson	S	1,081	1,081	1,081	1,081	1,081	1,081
	D	200	205	201	198	197	197
		881	**876**	**880**	**883**	**884**	**884**
County- Other	S	39	39	39	39	39	39
	D	38	39	38	37	37	37
		1	**0**	**1**	**2**	**2**	**2**
Mining	S	42	42	42	42	42	42
	D	18	17	17	17	17	17
		24	**25**	**25**	**25**	**25**	**25**
Irrigation	S	646	646	646	646	646	646
	D	78	77	75	73	72	70
		568	**569**	**571**	**573**	**574**	**576**
Livestock	S	411	411	411	411	411	411
	D	307	307	307	307	307	307
		104	**104**	**104**	**104**	**104**	**104**

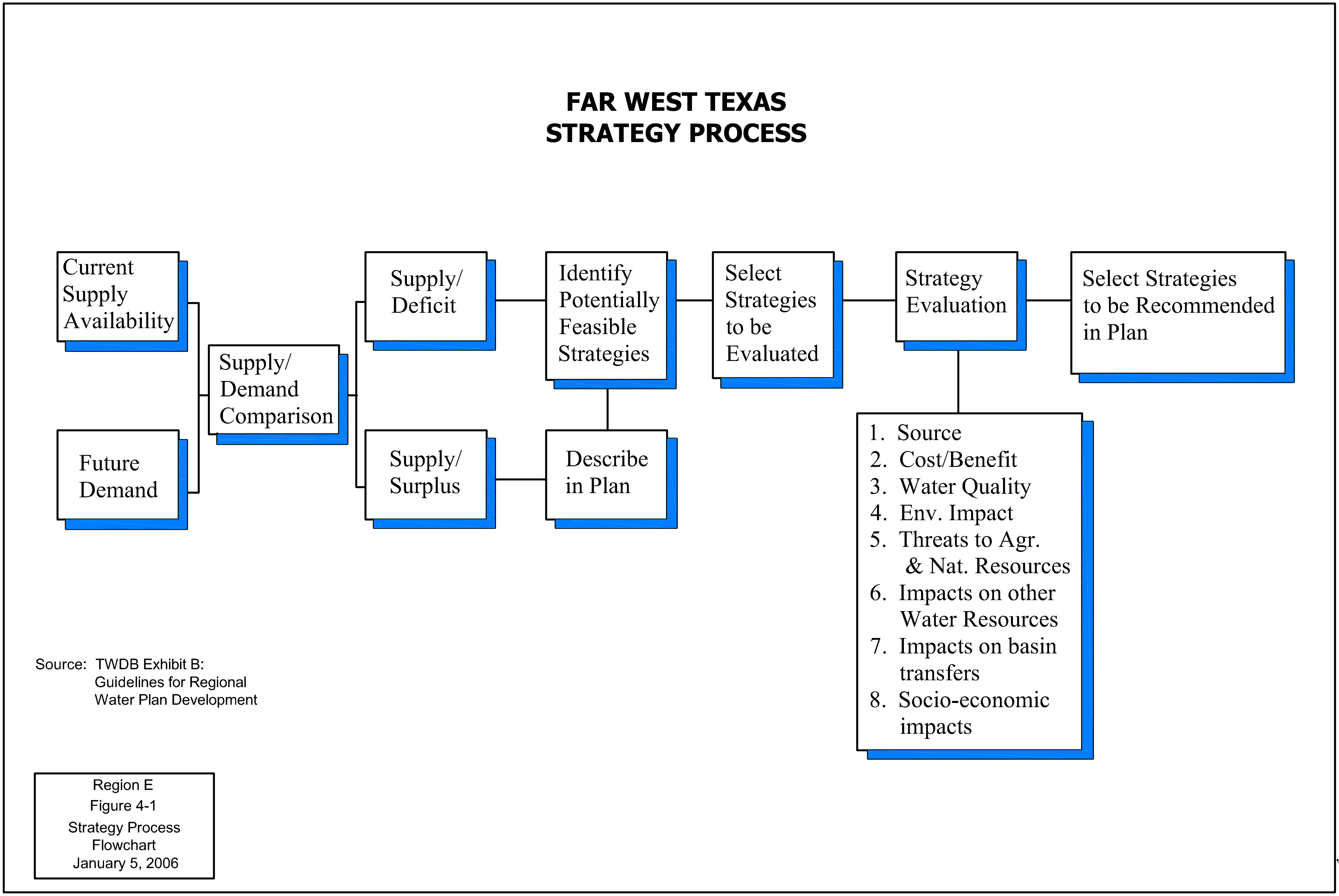

FIGURE 4-1. STRATEGY PROCESS FLOW CHART

LBG-GUYTON ASSOCIATES

TABLE 4-2. SUMMARY OF WATER MANAGEMENT STRATEGY EVALUATIONS

(All strategies are in the Rio Grande Basin)

Water User Group	County Used	Strategy	Strategy ID	Source	Supply Deficit (Acre-Feet/Year)						Total Capital Cost (Table 4-3)	Quality *	Reliability**	Average Environmental Factors (Table 4-4)	Strategy Impacts***		
					2010	2020	2030	2040	2050	2060					Water Resources (1-5)	Agricultural Resources (1-5)	Natural Resources (1-5)
City of El Paso	El Paso	IWMS - Direct Reuse	E-1	Treated EPWU blended sources	2,387	5,531	8,676	11,820	14,964	18,109	$45,842,000	2	1	1.5	1	2	2
City of El Paso	El Paso	IWMS - Conservation	E-2	NA	29,359	29,148	26,279	24,100	22,837	23,437	NA	NA	NA	2	NA	NA	NA
City of El Paso	El Paso	IWMS - Conjunctive use with additional surface water	E-3	Upper Rio Grande		10,000	15,000	20,000	20,000	20,000	$103,494,000	2	2	2	2	3	2
City of El Paso	El Paso	IWMS - Import from Diablo Farms	E-4	Capitan Reef Aquifer				10,000	10,000	10,000	$23,113,000	1	1	2.25	3	3	2
City of El Paso	El Paso	IWMS - Import from Dell Valley	E-5	Bone Spring-Victorio Peak Aquifer			16,000	16,000	33,000	50,000	$502,743,000	2	1	2.25	2	4	2
Homestead MUD	El Paso	Purchase water from EPWU	E-6	EPWU blended sources	194	421	610	775	950	1,124	$0	1	2	2	2	2	2
Horizon Regional MUD	El Paso	Additional 2 wells	E-7	Hueco Bolson Aquifer					665	2,146	$1,000,000	1	1	2.25	3	2	2
Lower Valley WD	El Paso	Purchase water from EPWU	E-8	EPWU blended sources	631	1,236	1,792	2,235	2,709	3,182	$0	1	2	2	2	2	2
San Elizario	El Paso	Purchase water from LVWD	E-9	EPWU blended sources	823	1,757	2,617	3,304	4,037	4,770	$0	1	2	2	2	2	2
Socorro	El Paso	Purchase water from LVWD	E-10	EPWU blended sources	374	881	1,392	1,776	2,210	2,645	$0	1	2	2	2	2	2
El Paso County Tornillo WID	El Paso	Additional 1 well	E-11	Hueco Bolson Aquifer				62	284	505	$500,000	1	1	2.25	3	2	2
Vinton	El Paso	Purchase water from EPWU	E-12	EPWU blended sources	189	404	588	752	916	1,081	$0	1	2	2	2	2	2
County Other	El Paso	Additional Small-MUD wells	E-13	Hueco & Mesilla Bolson Aquifers	2,075	4,385	6,242	7,682	9,138	10,832	$6,750,000	1	1	2.25	3	2	2
County Other	El Paso	Additional domestic wells	E-14	Hueco & Mesilla Bolson Aquifers	519	1,096	1,561	1,920	2,284	2,708	$5,416,000	1	1	2.25	3	2	2
Manufacturing	El Paso	Purchase water from EPWU	E-15	EPWU blended sources	1,436	2,249	2,947	3,622	4,196	5,110	$0	1	2	2	2	2	2
Steam Electric Power	El Paso	Purchase water from EPWU	E-16	EPWU blended sources	169	3,975	5,149	6,579	8,322	10,448	$0	1	2	2	2	2	2
Irrigation	El Paso	Irrigation water use management	E-17	NA													
		Land management systems	E-18	NA													
		On-farm water delivery systems	E-19	NA													
		Water District delivery systems	E-20	NA													
		Miscellaneous systems	E-21	NA													
Irrigation	Hudspeth	Irrigation water use management	E-22	NA													
		Land management systems	E-23	NA													
		On-farm water delivery systems	E-24	NA							**Table 4-5**						
		Water District delivery systems	E-25	NA													
		Miscellaneous systems	E-26	NA													
Irrigation	Presidio	Irrigation water use management	E-27	NA													
		Land management systems	E-28	NA													
		On-farm water delivery systems	E-29	NA													
		Water District delivery systems	E-30	NA													
		Miscellaneous systems	E-31	NA													

* Quality range: 1= Meets safe drinking-water standards; 2=Must be treated or mixed to meet safe drinking-water standards.
** Reliability range: 1=Sustainable; 2=Interruptible during droughts; 3=Non-sustainable.
*** Strategy impact range: 1=positive; 2=no new; 3=minimal negative; 4=moderate negative; 5=significant negative.

TABLE 4-3. SUMMARY OF WATER MANAGEMENT STRATEGY COST
(Cost in US Dollars)

Water User Group	County Used	Strategy	Supply Deficit (Acre-Feet/Year)						Total Capital Cost	O&M Cost/Year						Cost per Acre-Foot/Year					
			2010	2020	2030	2040	2050	2060		2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
City of El Paso	El Paso	IWMS - Reuse	2,387	5,531	8,676	11,820	14,964	18,109	$45,842,000	$3,999,500	$3,999,500	$5,504,250	$4,660,000	$4,660,000	$4,043,000	$442	$442	$405	$257	$257	$223
City of El Paso	El Paso	IWMS - Conservation	29,359	29,148	26,279	24,100	22,837	23,437	NA	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$136	$137	$152	$166	$175	$171
City of El Paso	El Paso	IWMS - Conjunctive use with additional surface water		10,000	15,000	20,000	20,000	20,000	$103,494,000		$13,174,000	$13,174,000	$13,174,000	$5,655,000	$5,655,000		$659	$659	$659	$283	$283
City of El Paso	El Paso	IWMS - Import from Diablo Farms				10,000	10,000	10,000	$23,113,000				$3,533,000	$3,533,000	$3,533,000				$353	$353	$353
City of El Paso	El Paso	IWMS - Import from Dell Valley			16,000	16,000	33,000	50,000	$502,743,000			$31,517,000	$31,517,000	$44,370,000	$31,424,000			$1,970	$1,970	$1,345	$628
Homestead MUD****	El Paso	Purchase water from EPWU	194	421	610	775	950	1,124	$0	$0	$0	$0	$0	$0	$0	$378	$378	$378	$378	$378	$378
Horizon Regional MUD *	El Paso	Additional 2 wells					665	2,146	$1,000,000					$5,000	$10,000					$8	$5
Lower Valley WD****	El Paso	Purchase water from EPWU	631	1,236	1,792	2,235	2,709	3,182	$0	$0	$0	$0	$0	$0	$0	$333	$333	$333	$333	$333	$333
San Elizario****	El Paso	Purchase water from LVWD	823	1,757	2,617	3,304	4,037	4,770	$0	$0	$0	$0	$0	$0	$0	$333	$333	$333	$333	$333	$333
Socorro****	El Paso	Purchase water from LVWD	374	881	1,392	1,776	2,210	2,645	$0	$0	$0	$0	$0	$0	$0	$333	$333	$333	$333	$333	$333
El Paso County Tornillo WID *	El Paso	Additional 1 well				62	284	505	$500,000				$5,000	$5,000	$5,000				$81	$18	$10
Vinton****	El Paso	Purchase water from EPWU	189	404	588	752	916	1,081	$0	$0	$0	$0	$0	$0	$0	$776	$776	$776	$776	$776	$776
County Other**	El Paso	Additional Small-MUD wells	2,075	4,385	6,242	7,682	9,138	10,832	$6,750,000	$13,000	$27,500	$39,000	$48,000	$57,000	$67,500	$6	$6	$6	$6	$6	$6
County Other***	El Paso	Additional domestic wells	519	1,096	1,561	1,920	2,284	2,708	$5,416,000	$13,000	$27,400	$39,000	$48,000	$57,100	$67,700	$25	$25	$25	$25	$25	$25
Manufacturing****	El Paso	Purchase water from EPWU	1,436	2,249	2,947	3,622	4,196	5,110	$0	$0	$0	$0	$0	$0	$0	$1,174	$1,174	$1,174	$1,174	$1,174	$1,174
Steam Electric Power****	El Paso	Purchase water from EPWU	169	3,975	5,149	6,579	8,322	10,448	$0	$0	$0	$0	$0	$0	$0	$474	$474	$474	$474	$474	$474
Irrigation	El Paso	Agricultural irrigation BMPs																			
Irrigation	Hudspeth	Agricultural irrigation BMPs	See Table 4-5																		
Irrigation	Presidio	Agricultural irrigation BMPs																			

IWMS = Integrated Water Management Strategy

* Municipal water well cost:
Capital cost per well = $500,000
Annual O&M = $5,000
Well yield = 700gpm
Cost per ac-ft assumes no additional distribution cost

**Small MUD water well cost:
Capital cost per well = $50,000
Annual O&M = $500
Well yield = 200gpm
Cost per ac-ft assumes no additional distribution cost

***Domestic water well cost:
Capital cost per well = $8,000
Annual O&M = $100
Well yield = 20gpm
Cost per ac-ft assumes no additional distribution cost

**** EPWU contract sales price per acre-foot
O&M included in contracted price

TABLE 4-4. SUMMARY OF ENVIRONMENTAL ASSESSMENTS

Water User Group	County	Basin	Strategy	**Total Number of Rare, Threatened & Endangered Species in County (species impacted is undetermined)	Environmental Impact Factors *						Acreage Impacted
					Envir. Water Needs	Habitat	Cultural Resources	Envir. Water Quality	Bays & Estuaries	Overall Envir. Impact	
					(1-5)	(1-5)	(1-5)	(1-5)	NA	(1-5)	
City of El Paso	El Paso	Rio Grande	IWMS - Reuse	45	1	1	2	2		1.5	Undetermined area remporarly impacted by pipeline construction. Landscape irrigation creates greener space.
City of El Paso	El Paso	Rio Grande	IWMS - Conservation	45	2	2	2	2		2	Creates less stress on existing water sourses.
City of El Paso	El Paso	Rio Grande	IWMS - Conjunctive use with additional surface water	45	2	2	2	2		2	Will require additional treatment plant facility (20 acres). 5,000 acres impacted by change in use from agricultural to municipal suply use.
City of El Paso	El Paso	Rio Grande	IWMS - Import from Diablo Farms	45	2	3	2	2		2.25	81 acres temporarly impacted by right-of-way. 28,000 acres converted from agricultural to municipal supply use. Land use changed from cultivated to rangeland.
City of El Paso	El Paso	Rio Grande	IWMS - Import from Dell Valley	45	2	3	2	2		2.25	460 acres impacted by right-of-way. 24,000 acres converted from agricultural to municipal supply use. Will require desal plant and disposal facility.
Homestead MUD	El Paso	Rio Grande	Purchase water from EPWU	45	2	2	2	2		2	Causes no change in existing conditions.
Horizon Regional MUD	El Paso	Rio Grande	Additional wells	45	2	3	2	2		2.25	Temporary land disturbance during drilling of wells.
Lower Valley WD	El Paso	Rio Grande	Purchase water from EPWU	45	2	2	2	2		2	Causes no change in existing conditions.
San Elizario	El Paso	Rio Grande	Purchase water from LVWD	45	2	2	2	2		2	Causes no change in existing conditions.
Socorro	El Paso	Rio Grande	Purchase water from LVWD	45	2	2	2	2		2	Causes no change in existing conditions.
El Paso County Tornillo WID	El Paso	Rio Grande	Additional wells	45	2	3	2	2		2.25	Temporary land disturbance during drilling of wells.
Vinton	El Paso	Rio Grande	Purchase water from EPWU	45	2	2	2	2		2	Causes no change in existing conditions.
County Other	El Paso	Rio Grande	Additional wells	45	2	3	2	2		2.25	Temporary land disturbance during drilling of wells.
Manufacturing	El Paso	Rio Grande	Purchase water from EPWU	45	2	2	2	2		2	Causes no change in existing conditions.
Steam Electric Power	El Paso	Rio Grande	Purchase water from EPWU	45	2	2	2	2		2	Causes no change in existing conditions.
Irrigation	El Paso	Rio Grande	Agricultural irrigation BMPs	45	2	2	2	2		2	Causes no change in existing conditions.
Irrigation	El Paso	Rio Grande	Regulating reservoirs	45	1	1	5	1		2	1,000 acre reservoir. Wetland created.
Irrigation	Hudspeth	Rio Grande	Agricultural irrigation BMPs	52	2	2	2	2		2	Causes no change in existing conditions.
Irrigation	Hudspeth	Rio Grande	Regulating reservoirs	52	1	1	5	1		2	1,000 acre reservoir. Wetland created.
Irrigation	Presidio	Rio Grande	Agricultural irrigation BMPs	74	2	2	2	2		2	Causes no change in existing conditions.

*** Strategy impact range: 1=positive; 2=no new; 3=minimal negative; 4=moderate negative; 5=significant negative**

**** Texas Parks & Wildlife Department's Natural Diversity Database of rare, threatened, and endangered species.**

TABLE 4-5. IRRIGATION STRATEGIES SUMMARY

Strategies Considered to Meet Irrigation Needs for El Paso, Hudspeth, and Presidio Counties

Source: TWDB Report 362 - Water Conservation Best Management Practices (BMP) Guide for Agriculture

Strategy		Water Savings	Cost Considerations
Irrigation water use management	Irrigation scheduling	Estimated savings of 0.3 to 0.5 acre-feet per acre.	Primarily labor cost.
	Volumetric measurement of irrigation water use	Does not directly conserve water.	$600 to $1,000 per meter.
	Crop residue management and conservation tillage	Estimated savings of 0.75 to 1.0 acre-foot per acre.	Primarily labor cost.
	On farm irrigation audit	Does not directly conserve water.	Primarily labor cost.
Land management systems	Land leveling	Undetermined	$50 to $400 per acre.
On-farm water delivery systems	Ditch lining	80% of original seepage.	EPDM liner $0.85, urethane liner $1.43, concrete liner $2.50 to $3.50 per square foot.
	Ditch replacement with pipe	Similar to above.	$5.00 per foot plus site preparation and installation labor.
	Low pressure center pivot sprinkler	70% to 95% application efficiency.	$300 to $500 per acre.
	Drip/micro-irrigation system	Highly variable. Prefered method for high value crops.	$800 to $1,200 per acre plus maintenance cost.
	Gated and flexible pipe	Estimated by amount of original seepage loss.	PVC gated pipe $2.00 to $2.50 , flexible pipe $0.15 to $0.25 per foot plus installation.
	Surge flow irrigation	Estimated savings of 10% to 40%.	$800 to $2,000 per surge valve. Cost savings of $20 to $25 per acre-foot.
	Linear move sprinkler	70% to 95% application efficiency.	$300 to $700 per acre.
	Automation and telemetry	Undetermined savings are a result of more timely irrigation application.	$1,500 to $3,500 per center pivot sprinkler, plus $3,000 to $5,000 for soil moisture equipment and weather data.
Water district delivery systems	Ditch lining	80% of original seepage.	EPDM liner $0.85, urethane liner $1.43, concrete liner $2.50 to $3.50 per square foot.
	Ditch replacement with pipe	Similar to above.	24in PVC $15 to $21, concrete pipe undetermined, plus site preparation and installation.
	Automation and telemetry	Undetermined savings are a result of more timely irrigation application.	$150,000 to $250,000 for SCADA system with 20 flow measurement and control sites.
Miscellaneous systems	Tailwater reuse	0.5 to 1.5 acre-feet per acre.	Small storage reservoir $800 to $2,000 per acre-foot plus $15 per foot installed pipe.
	Regulating reservoirs	Undetermined savings are a result of more timely irrigation application.	$2,000 to $3,000 per acre-foot for a small on-farm reservoir. $600 to $2,000 per acre-foot for large reservoirs constructed by an irrigation district.

4.4 EL PASO COUNTY INTEGRATED STRATEGY

Water resource management opportunities and challenges faced by municipal and industrial users in the City and County of El Paso are unique in Texas in that local surface water and local groundwater are managed conjunctively. The typical approach to strategy development does not address the necessity of linking between individual strategies when conjunctive management is practiced.

The El Paso County Integrated Strategy evolved from an analysis of six integrated water development strategies, each of which could meet future non-agricultural water demands in the City and County of El Paso. The analysis includes a discussion of the technical feasibility, cost, environmental – agricultural – natural resource impacts, socioeconomic impact, and water quality. The six strategies are termed “integrated” because they represent combinations of individual sources due to the unique nature of water management in El Paso. Taken separately, each source could be evaluated and analyzed. However, combining all sources into an integrated strategy provides an opportunity to evaluate the interrelationship of the individual components and provides a regional context to the plan. Water conservation and increased reuse was considered as part of all six strategies. The comparison of all six integrated strategies concluded with a preferred strategy to be implemented in El Paso County.

The non-agricultural demand in El Paso County is projected be 270,861 acre-feet per year by 2060. Current supplies are composed of a conjunctive use of water from the Rio Grande and local groundwater and a water reclamation program. Under the conjunctive use approach, pumping from groundwater is increased when the surface water availability is reduced. These sources currently provide 150,000 acre-feet per year.

The preferred strategy adopted to meet the needs of water supply is composed of the following elements:

- Increased conservation
- Increased reclaimed water use

- Increased use from the Rio Grande (developed conjunctively with local groundwater)
- Importation of groundwater from the Capitan Reef aquifer (Culberson and Hudspeth Counties)
- Importation of groundwater from the Bone Spring-Victorio Peak aquifer in the Dell City area (Hudspeth County)

The importation of groundwater from the West Texas Bolson aquifers in the vicinity of Van Horn and Valentine (Culberson, Jeff Davis and Presidio Counties) was evaluated under other integrated strategies, but it is not part of the preferred strategy.

4.4.1 CONSERVATION

Reduction of municipal water consumption may be achieved with the implementation of conservation programs that reduce per capita usage and prevent water waste. EPWU has been implementing an aggressive water conservation program for the last 13 years with actions such as adoption of a rate structure that penalizes high consumption, restrictions on residential watering, rebate programs for replacing appliances and bathroom fixtures for low consumption units, plumbing fixtures to reduce leaks, native landscaping programs to reduce landscape irrigation, public education, and enforcement.

This conservation program has reduced the per capita demand from 200 gpcd in 1990 to 155 gpcd in 2002. Consumption during 2003 and 2004 was 149 gpcd and 139 gpcd respectively. The lower consumption over the past two years occurred because the region was under drought restrictions in 2003, and in 2004, EPWU had a rate increase along with the incentives programs. The summer of 2004 was also cooler and wetter than normal, which may have further lowered demand.

The conservation goal for El Paso County is 140 gpcd, which would be the lowest large city per capita use in Texas. Table 4-6 shows the population and non-agricultural demand for El Paso County developed by the Texas Water Development Board. Non-agricultural demand includes mining, manufacturing, and steam electric power generation uses. TWDB demand projections already include some conservation due to the application of the plumbing code. Table 4-6 shows that the projected per capita use would be reduced from 177 gpcd in 2010 to 157 gpcd in 2060 without any additional conservation other than the amount assumed by the TWDB. The conservation goal of 140 gpcd will further reduce the projected demands in El Paso County by 23,437 acre-feet per year in 2060.

TABLE 4- 6. PROJECTED CONSERVATION AND REUSE SAVINGS

	2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Supplied by EPWU							
Population	617,100	714,375	823,104	918,534	1,000,838	1,083,142	1,165,446
TWDB Demand (AF/yr)	133,015	148,594	168,397	183,586	197,214	211,942	228,330
Reuse (AF/yr)	5,000	7,387	10,531	13,676	16,820	19,964	23,109
Net Demand (AF/yr)	128,015	141,207	157,866	169,910	180,394	191,978	205,221
Net Per Capita Use (gpcd)	185	177	171	165	161	158	157
Per Capita Goal (gpcd)	N/A	140	140	140	140	140	140
Savings Due to Conservation (gpcd)	0	37	31	25	21	18	17
Savings Due to Additional Conservation EPWU (AF/yr)	*0*	*29,207*	*28,845*	*25,825*	*23,495*	*22,082*	*22,516*
Savings for Remainder of County (AF/yr)							
Savings Due to Conservation Fort Bliss (AF/yr)	*0*	*152*	*303*	*454*	*605*	*755*	*921*
TOTAL CONSERVATION SAVINGS (AF/yr)	**0**	**29,359**	**29,148**	**26,279**	**24,100**	**22,837**	**23,437**

4.4.2 Reuse

A portion of the wastewater effluent from the Northwest, Haskell, Bustamante, and Fred Hervey Plants is currently being redirected into a water distribution system (Purple Pipeline) for users of the reclaimed water. Reclaimed water serves the demand of golf courses, parks, schools, steam electric plants, and industries. Currently EPWU is operating three reuse projects that currently provide near 5,000 acre-feet per year. The recommended integrated strategy proposes to expand the reuse supply to 23,109 acre-feet per year (average of 20 mgd) by 2060. This expansion would require capital investment to modify or expand wastewater treatment plants and to expand the distribution of the Purple Pipeline. The recommended increased reuse under the preferred strategy is shown in Table 4-6.

The current water quality of the treated effluent makes more a reuse project more feasible. The Fred Hervey WWTP is able to produce effluent that meets drinking water quality standards. It currently serves irrigation of ball fields, playgrounds and landscape. Although the effluent has high water quality, reuse for domestic supply may not be feasible due to concerns about the public acceptance of using reclaimed water to serve residential customers. Other WWTPs produce effluent with TDS levels above the drinking water quality standard, but the effluent is acceptable for uses such as irrigation of golf courses or parks. Reuse would have high reliability as water from direct reuse is available all year-round with acceptable quality.

4.4.3 Needs and Strategy for Additional Supply

Table 4-7 shows the resulting projected new water supply needs after factoring out conservation and reuse. These new needs will be met with the implementation of the preferred integrated strategy.

TABLE 4- 7. PROJECTED NEEDS FOR NEW SUPPLIES AFTER CONSERVATION AND RECLAIMED WATER REUSE

	2010	2020	2030	2040	2050	2060
Projected non-agricultural demands	168,264	193,820	213,836	231,417	250,136	270,861
Conservation and Reclaimed water						
Additional reclaimed water	2,387	5,531	8,676	11,820	14,964	18,109
Conservation	29,359	29,148	26,279	24,100	22,837	23,437
Total conservation and new reclaimed water	*31,746*	*34,679*	*34,955*	*35,920*	*37,801*	*41,546*
Demand after conservation and reclaimed water	136,518	159,141	178,881	195,497	212,335	229,315
Total current supplies	150,000	150,000	150,000	150,000	150,000	150,000
Total needs for new supplies	0	9,141	28,881	45,497	62,335	79,315
Rounded needs	**0**	**10,000**	**29,000**	**46,000**	**63,000**	**80,000**

It can be seen that the total needs for new supply are 80,000 acre-feet per year by 2060. The preferred integrated strategy increases the use of water from the Rio Grande by 20,000 acre-feet per year. The Hueco and Mesilla Bolson aquifers would be used to supplement water from the Rio Grande during times of drought. Importation of groundwater from the Dell City area and Capitan Reef aquifer would be 50,000 and 10,000 acre-feet per year respectively, for a total supply of 80,000 acre-feet per year in 2060.

This recommended integrated strategy achieves a sustainable use of groundwater sources. For purposes of this plan, the term "sustainable" refers to the predetermined maximum rate of withdrawal, based on existing data, that would likely make the source be economically available at least during the planning horizon and that would not produce significant water quality deterioration.

The strategy uses water from the Rio Grande and the Hueco and Mesilla Bolson aquifers at a level considered sustainable from the groundwater management standpoint. Pumping from the Capitan Reef aquifer is maintained in the lower end of the recharge range, which would secure continuous availability into the future without water quality deterioration. Groundwater imported from the Dell City area would be at a sustainable rate as permitted by the Hudspeth County Underground Water Conservation District #1. The strategy is summarized in Table 4-8 and Figure 4-2.

TABLE 4- 8. DEVELOPMENT OF NEW SOURCES UNDER THE PREFERRED INTEGRATED STRATEGY

	2010	2020	2030	2040	2050	2060
Rio Grande (conjunctively with Hueco and Mesilla Bolson)	0	10,000	15,000	20,000	20,000	20,000
Capitan Reef Aquifer	0	0	0	10,000	10,000	10,000
Dell City Area Aquifer	0	0	15,000	16,000	33,000	50,000
West Texas Bolsons	0	0	0	0	0	0
Total	**0**	**10,000**	**30,000**	**46,000**	**63,000**	**80,000**

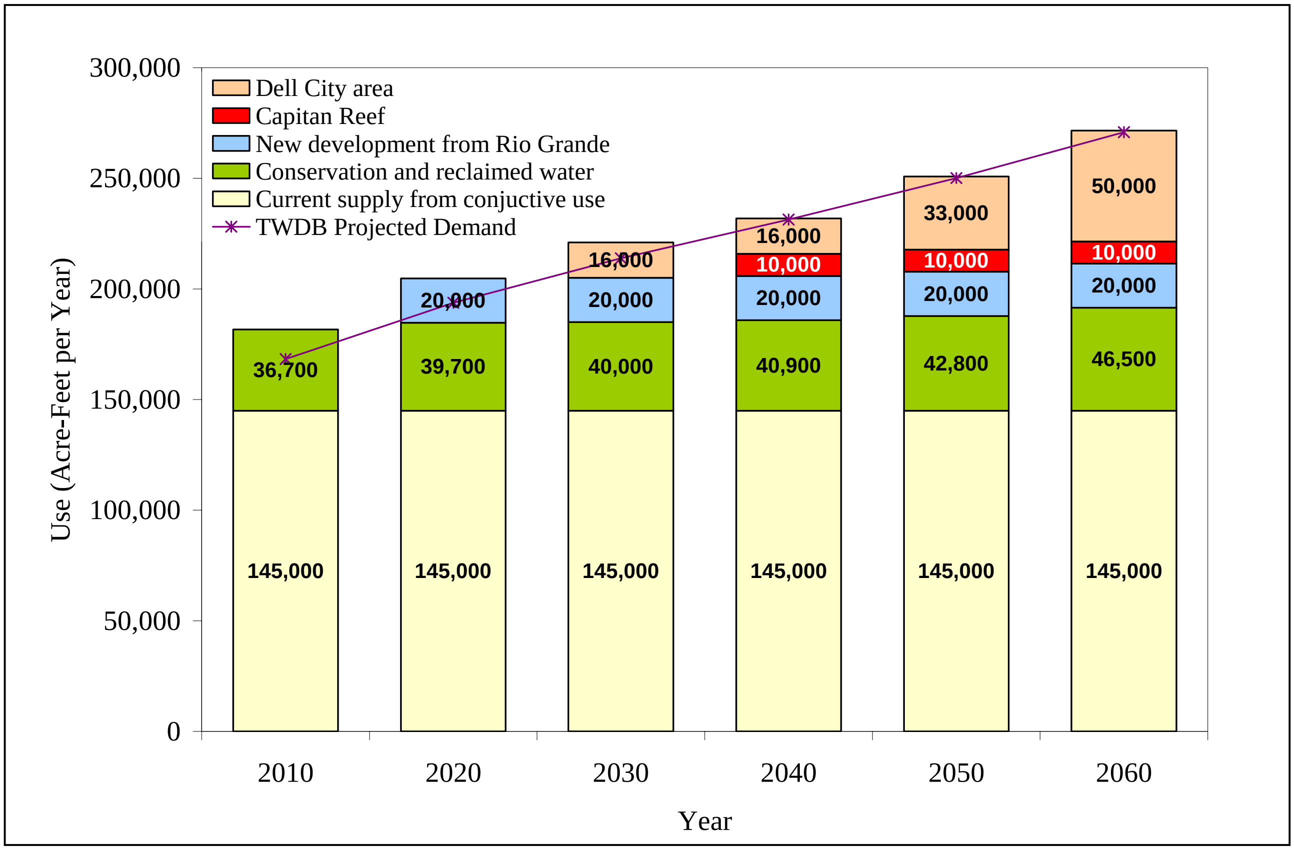

FIGURE 4- 2. DISTRIBUTION OF ALL SOURCES TO MEET PROJECTED DEMANDS

4.4.4 Conjunctive Use of Rio Grande and Local Groundwater

EPWU currently obtains water from the Rio Grande in accordance with a series of contracts with EPCWID#1, the U.S. Bureau of Reclamation, and the Lower Valley Water District that allow the conversion of water allocated for irrigation of lands owned or leased by EPWU into municipal supply. The County and City of El Paso may increase the annual diversion from surface water by converting additional water allocated to irrigated lands in El Paso County that would be urbanized or retired from irrigation. Agriculture lands that become urbanized or that are purchased by water providers are still entitled to water from the Rio Grande regardless of their use. EPWU may purchase or lease irrigated lands in tracts inside the area of the Rio Grande Project, retire them from irrigation, and use the water for municipal supply.

The conversion of water for municipal supply requires contracts or agreements with the U.S. Bureau of Reclamation, EPCWID#1, and local farmers. Alternatively, the conversion could be done by forbearance agreements in which EPWU would enter into a contract that allows short-tem sale of water for municipal purposes from irrigated lands under terms to be defined. These agreements should include an allowance to EPCWID#1 to offset any impact on the efficiency of the irrigation water delivery system.

The allotment for irrigated lands is expressed in acre-feet of water per acre of land, which is determined based upon drought conditions. The historical allotments have fluctuated between 0.33 and 4.0 acre-feet per acre. Surface water availability is highly variable from year to year, and water would be available only during the irrigation season. EPWU currently receives nearly 60,000 acre-feet per year in a full allotment year (greater than 3.024 acre-feet per acre) and nearly 10,000 acre-feet per year during drought conditions (allotment less than 0.5 acre-feet per acre). Analysis with historical hydrologic data from 1940 to 2003 show that the maximum available for EPWU (60,000 acre-feet per year) of water would be available in 27 percent of the years and that the minimum allocation (10,000 acre-feet per year) would be available in 8 percent of the years. Therefore, surface water is not a reliable stand-alone source.

As a result, and as is the current practice, groundwater pumping in the Hueco and Mesilla would have to increase to replace surface water during droughts and in the winter. Therefore, as part of any strategy that considers an increased use of water from the Rio Grande, it would be necessary to not only build additional surface water treatment capacity, but also construct additional wells to produce sufficient groundwater in drought years.

The current supply from the conjunctive use of local groundwater and surface water is considered sustainable. However, a significant increase in groundwater pumping is likely to result in an unsustainable groundwater management (i.e. declining groundwater levels and declining groundwater storage). Large increases to pumping for the Hueco and Mesilla Bolsons would undoubtedly require desalination due to the large volumes of brackish groundwater in both the Hueco and Mesilla. It is estimated that the proposed increase of 20,000 acre-feet per year under the conjunctive use concept would not cause any significant water quality deterioration on groundwater, and the management of the aquifers would still be sustainable.

4.4.5 CAPITAN REEF AQUIFER (DIABLO FARMS)

The Capitan Reef aquifer is recognized as a minor aquifer by the TWDB. The majority of the aquifer is located in Culberson, Hudspeth, Jeff Davis, Pecos, Reeves, Ward, and Winkler counties. In 2003 and 2004, EPWU purchased about 28,000 acres of land (Diablo Farms) overlying the Capitan Reef Aquifer straddling the Hudspeth and Culberson County lines in an area adjacent to the Salt Basin southeast of Dell City. Recharge estimates for this portion of the Capitan Reef range from 10,000 to 20,000 acre-feet per year. TDS concentrations in the area range from 850 to 1,500 mg/L, although all the operating wells on Diablo Farms (one of the properties recently acquired by EPWU) have TDS values below 1,000 mg/L. However, it is expected that significant increases in historical pumping amounts would result in movement of poorer quality groundwater into the area.

EPWU has completed preliminary evaluations of groundwater availability in the area, and has concluded that pumping less than 10,000 acre-feet per year would require no desalination. Pumping between 10,000 and 25,000 acre-feet per year would not produce mining of the aquifer, but the groundwater would likely have to be desalinated over time. These estimates are preliminary, and are subject to confirmation after additional monitoring and tests. Ideally, any development would be completed in phases such that responses to pumping in terms of groundwater level changes and groundwater quality changes could be used to refine and modify future phases. Importation of 10,000 acre-feet per year from the Capitan Reef is proposed by 2031.

4.4.6 BONE SPRING-VICTORIO PEAK AQUIFER (DELL CITY AREA)

Dell City is located approximately 75 miles east of El Paso, near the New Mexico-Texas border. The Bone Spring-Victorio Peak aquifer covers 130 square miles in Texas near Dell City. The Hudspeth County Underground Water Conservation District No.1 (HCUWCD) regulates groundwater pumping in this area. The key elements of the HCUWCD management plan and rules are the explicit management of groundwater on a sustainable basis, and the use of a historic period to grant permits to users. Sustainable pumping is defined as 63,000 acre-feet per year in the management plan.

The rules of the District outline a permitting system that will result in limitations that are designed to achieve the sustainable pumping goals of the management plan. Holders of permits pump groundwater based on a "Water Allocation", which is expressed in terms of acre-feet per acre. The amount of the allocation is adjusted every two years based on the groundwater elevation in a monitoring well. There are three types of permits:

- Validation Permits are granted for existing and historical uses.
- Operating Permits are granted for pumping where no Validation Permit exists.
- Transfer Permits are granted for uses outside the District boundaries, and require either a Validation Permit or an Operating Permit prior to issuance.

For validation permits for irrigation, the following "Water Allocation" limits are then applied based on the groundwater level in the well:

- If the groundwater elevation is greater than 3,570 feet above mean sea level, the Water Allocation is 4 acre-feet/acre.
- If the groundwater elevation is between 3,565 and 3,570 feet, the District Board, by resolution, may establish a Water Allocation on a pro-rata basis between 4.0 and 3 acre-feet/acre.
- If the groundwater elevation is below 3,560 feet, the Water Allocation is 3 acre-feet/acre.

The rules are silent as to the Water Allocation for irrigation validation permits if the groundwater elevation is between 3,560 and 3,565 feet. Operating permits, which are granted when there is no historical existing use, are allocated only if the groundwater elevation is above 3,580 feet. The amount depends on the amount of water available for allocation between all operating permit holders.

Transfer of water is limited to the consumptive use portion of the validation or operating permit. Under the current rules, the consumptive use under a full allocation (4 acre-feet/acre) is 2.8 acre-feet/acre. If the water allocation were reduced to 3 acre-feet/acre, consumptive use would be 2.1 acre-feet/acre. Therefore, to transfer the 50,000 acre-feet per year proposed under the preferred strategy, about 17,900 acres of land with validation permits would be needed under a full allocation scenario, and about 23,800 acres of land with validation permits would be required under a reduced allocation.

Concentrations of iron, chloride, nitrate, sulfate, and aluminum exceed water quality standards for municipal supply. Total dissolved solids in the area range from 1,810 to 3,900 mg/l. Desalination would be required before distribution for municipal use.

The proposed importation of 50,000 acre-feet per year would be developed in three equal phases of 16,600 acre-feet per year each developed in 2021, 2041, and 2051.

4.4.7 ENVIRONMENTAL IMPACTS

Conjunctive Use of Rio Grande and Local Groundwater

Additional use from the Rio Grande would have no major environmental impact on streamflow regime or flow frequencies, as water is available through a conversion of exiting diversion. Additional local groundwater use from the Hueco and Mesilla Bolson aquifers would use existing infrastructure where possible and minimize new environmental impact. New groundwater wells are proposed to replace existing wells with declining production and to provide additional capacity.

Capitan Reef Aquifer

The drilling of new wells and trenching of pipeline routes will disturb a small percentage of the land surface, thus causing a minor amount of environmental impact. The pipeline may be routed to avoid environmentally sensitive areas. The conversion of cultivated land associated with the well field to native rangeland may benefit some species, however; the loss of a food source (grain crops, etc.) may be detrimental to other species.

Bone Spring-Victorio Peak Aquifer (Dell City Area)

As with the Capitan Reef aquifer above, the drilling of new wells and trenching of pipeline routes will disturb a small percentage of the land surface, thus causing a minor amount of environmental impact. A pipeline route connecting the source back to El Paso is expected to impact approximately 460 acres of right-of-way. The pipeline may be routed to avoid environmentally sensitive areas. The conversion of cultivated land to native rangeland that is associated with new well fields may benefit some species, however; the loss of a food source (grain crops, etc.) may be detrimental to other species.

A greater level of impact may be associated with the disposal of concentrate water resulting from the desalination process. Alternatives for disposal of desalination concentrate include deep well injection and the use of evaporation beds. Injection wells if constructed properly have minimal impact other than construction disturbances. Evaporation beds will disturb the acreage required for disposal with the potential of groundwater contamination if not properly lined. The high level of mineral concentration in the ponded water may also have a detrimental impact on attracted birds.

4.4.8 IMPACT TO RURAL AND AGRICULTURAL ACTIVITIES

Conjunctive Use of Rio Grande and Local Groundwater

Additional 20,000 acre-feet per year from the Rio Grande would be obtained after the retirement of about 5,000 acres of land from irrigation. This represents a reduction of agricultural activities in El Paso County. Two factors drive this conversion: expected population growth in El Paso County and economics. As more people live in El Paso County, some cropland necessarily will be converted to urban use. In addition, as population grows the cropland adjacent to urbanized area will become more valuable than the crops produced on the land or the rights of the Rio Grande Project water associated with the land. At that point, many agricultural producers will make the decision to convert their property to residential, commercial or some purpose other than irrigated agriculture. This conversion is primarily the result of urbanization, not the implementation of this water management strategy. Conversion would be voluntary by lease, sale, or forbearance agreements.

Capitan Reef Aquifer

EPWU owns land above the Capitan Reef aquifer and, until the construction phase is started, the land will continue to be used for agricultural purposes. The eventual discontinuation of irrigated farming on this property will impact only a minor number of agricultural jobs. Workers needed to operate and maintain the well field would replace these agricultural jobs.

Bone Spring-Victorio Peak Aquifer (Dell City Area)

The integrated strategy would utilize the water rights for 24,000 acres of land in Hudspeth County, which would reduce irrigation activities near Dell City. The transfer to El Paso County is near 80 percent of the maximum groundwater pumping limit. Conversion of water rights to transfer water to El Paso County would be voluntary. Some land may become unsuitable for agriculture after extensive irrigation with brackish water due to accumulation of salt in the soil, and would be retired from irrigation regardless of how much water is exported to El Paso County. It is expected that irrigators will find it economically beneficial to transfer or sell their land or water rights.

4.4.9 IMPACT ON NATURAL RESOURCES

Conjunctive Use of Rio Grande and Local Groundwater

There would be a gradual increase of pumping of the Hueco and Mesilla Bolson aquifers, reaching a maximum level by 2040. Some deterioration in water quality is possible, but water could be used without desalination. The proposed level of pumping would continue to be considered nearly sustainable.

Capitan Reef

A pumping rate of 10,000 acre-feet per year is at the lower end of the range of estimated annual recharge to the Capitan Reef aquifer, and therefore the aquifer water level will be maintained at a sustainable level without the occurrence of aquifer mining. Little or no water quality deterioration is anticipated.

Dell City Area

Aquifer withdrawals from the Bone Spring-Victorio Peak aquifer at the proposed pumping rates for this strategy are at a sustainable level based on the current rules of the Hudspeth County Underground Water Conservation District No.1. Municipal transfer pumping would replace an equal amount of agricultural pumping, and therefore, no net increase of pumping would occur.

4.4.10 INTEGRATED STRATEGY COST

Conservation

The cost for the conservation program is expected to be $4,000,000 per year. Most of the expenses will be dedicated to rebates for turf replacements and for the installation of low flow toilets, high-efficiency washing machines, and low flow showerheads. Conservation costs also cover education campaigns. Typical rebates are $100 for low-flow toilet, $200 for washing machines, and $1 per square foot of turf replaced by native landscape.

Reuse

Estimated capital cost of the reclaimed water is $45,842,000, with unit cost per acre-foot ranging from $304 to $442. By 2060, the amount of reuse supply would be 18,109 acre-feet per year at a cost of $223 per acre-foot. Capital and annual cost of reuse by decade is shown in Table 4-9.

TABLE 4- 9. CAPITAL COST OF THE REUSE STRATEGY

Year	Capital Investment Items	Average Reuse in Decade (ac-ft/yr)	Capital Cost	Total Debt Service	O&M	Total Annual Costs	$/ac-ft
2010	WWTP Improvements. Expand Purple Pipeline. Avg. 8 mgd	9,055	$ 30,598,000	$ 2,223,000	$ 1,776,500	$ 3,999,500	$ 442
2030	WWTP Improvements. Expand Purple Pipeline. Avg. 4 mgd	13,582	$ 8,492,000	$ 2,840,000	$ 887,750	$ 5,504,250	$ 405
2040	Expand Purple Pipeline. Avg. 4 mgd	18,109	$ 6,752,000	$ 1,108,000	$ 887,750	$ 4,660,000	$ 257
			$ 45,842,000		$ 3,552,000		

Other Sources of the Integrated Strategy

The capital cost of the other sources of the integrated strategy is $629,350,000. The cost for each phase is shown in Table 4-10. The unit costs for this strategy range from $508 to $1,241 per acre-foot, averaging $835. The discounted present value cost through 2060 is $656,792,000. The capital cost is the lowest of all six alternatives considered during the evaluation of several strategies. A detailed cost analysis for this and other proposed strategies is found under the report *Integrated Water Management Strategies for the City and County of El Paso.*

TABLE 4- 10. CAPITAL COST OF THE PREFERRED INTEGRATED STRATEGY

Year	Capital Investment Item(s)	Supply	Capital Cost	Debt Service	New O&M	Annual Costs	$/AF
2015	New surface water conjunctive with groundwater 20,000 af/yr	20,000	$ 103,494,000	$ 7,519,000	$ 5,655,000	$ 13,174,000	$ 659
2021	Dell City Area. Phase I 16,000 af/yr	36,000	$ 330,983,000	$ 24,046,000	$ 7,471,000	$ 44,691,000	$ 1,241
2031	Capitan Reef 10,000 af/yr	46,000	$ 23,113,000	$ 1,679,000	$ 1,854,000	$ 48,224,000	$ 1,048
2041	Dell City Phase II. 17,000 af/yr	63,000	$ 92,728,000	$ 6,737,000	$ 6,116,000	$ 61,077,000	$ 969
2051	Dell City Phase III. 17,000 af/yr	80,000	$ 79,032,000	$ 5,742,000	$ 5,358,000	$ 40,612,000	$ 508
	TOTAL		**$ 629,350,000**		**$ 26,454,000**		

4.4.11 Water Source Reliability

Under the concept of conjunctive use, pumping from the Hueco and Mesilla Bolsons is increased to supplement the surface water that is not available during lower flows. As a result, groundwater use also fluctuates. The integrated strategy proposes an increased conjunctive use. However, the long-term average pumping will not cause significant depletions of the groundwater sources or significant deterioration of groundwater quality in the long term. At the recommended conjunctive use level of this strategy, the Hueco and Mesilla Bolsons will be available when needed to supplement surface water. It is expected that other sources (Capitan Reef and Bone Spring-Victorio Peak aquifers) will be available throughout the planning horizon with little change in water quality. Therefore, the overall reliability of the integrated strategy is very high.

4.5 NON-IWMS EL PASO COUNTY MUNICIPAL STRATEGIES

4.5.1 Horizon Regional MUD

Horizon Regional MUD provides water for the greater Horizon community. Brackish groundwater is supplied from four wells in the Hueco Bolson aquifer and is desalinated through a 1.5 MGD plant. Table 4-1 shows that Horizon Regional MUD will require additional infrastructure to produce the needed supply in the decade beginning in the year 2050. The recommended strategy is to drill and complete an additional 700-gpm well in 2050 and add an additional well in 2060.

<u>Cost:</u> As shown in Table 4-2, the capital cost of each well is $500,000 with O&M annual cost of $5,000. The cost does not presently include the possible need to upgrade the desalination facility in the future.

<u>Quality and Reliability:</u> The groundwater source will continue to be brackish and will be converted to fresh quality through the desalination facility. There is a significant quantity of brackish quality water in the aquifer; therefore, the source is considered reliable.

<u>Impacts:</u> Temporary land disturbance will occur during the drilling of the wells and the trenching of additional pipeline routes. This will result in temporary minor environmental impacts during the construction period. There are no anticipated new impacts to water, agriculture or natural resources.

4.5.2 El Paso County Tornillo WID

El Paso County Tornillo WID provides water for the Community of Tornillo and surrounding neighborhoods. The District is anticipated to have a supply deficit beginning in the 2040-decade. An additional 700-gpm well provide sufficient water to meet this need.

<u>Cost:</u> As shown in Table 4-2, the capital cost of a public supply well is $500,000 with O&M annual cost of $5,000.

<u>Quality and Reliability:</u> The groundwater source will continue to be slightly brackish and may potentially deteriorate in quality slightly over time. There is a significant quantity

of slightly brackish quality water in the aquifer in the vicinity of the Districts wells; therefore, the source is considered reliable.

Impacts: Temporary land disturbance will occur during the drilling of a well and the trenching of additional pipeline routes. This will result in temporary minor environmental impacts during the construction period. There are no anticipated new impacts to water, agriculture or natural resources.

4.5.3 El Paso County Other

Table 4-1 shows an infrastructure oriented water-supply deficit occurring in the rural community of El Paso County beginning with the 2010 decade. In reality, because of county subdivision ordinances that discourage new developments without adequate water and wastewater facility planning, the projected deficits may not be as severe as shown in the table. However, for this Plan, the following strategies using Hueco and Mesilla aquifers are recommended to address the full projection.

An assumption is made that 80 percent of each decade's projected demand deficit will be met by small utility districts that are included in the Plan's named water user groups (WUGs). The utilities are expected to supply these needs by new water wells capable of producing approximately 200 gpm. Approximately 135 new wells will be needed by the 2060-decade. At $50,000 per well, the total capital cost to meet the 2060-need will be $6,750,000.

The remaining 20 percent of the deficit is assumed to be met by the drilling of private domestic wells. By 2060, as many as 677 households will require private wells capable of producing 20 gpm at a total capital cost of $5,416,000.

Quality and Reliability: The groundwater source for both District and private domestic wells will be fresh to slightly brackish and may potentially deteriorate in quality slightly over time. There is a significant quantity of slightly brackish quality water in the local aquifers; therefore, the source is considered reliable.

Impacts: Temporary land disturbance will occur during the drilling of wells and the trenching of additional pipeline routes. This will result in temporary minor environmental impacts during the construction period. There are no anticipated new impacts to water, agriculture or natural resources.

4.6 IRRIGATION STRATEGIES

Irrigation shortages in El Paso, Hudspeth, and Presidio Counties are the direct result of insufficient water in the Rio Grande during drought-of-record periods to meet anticipated needs. The quantity of water needed to meet the full demands cannot be realistically achieved and farmers in these areas have generally approached this situation by reducing irrigated acreage, changing types of crops planted, or possibly not planting crops until water becomes available during the following season.

In some cases, farmers may benefit from Best Management Practices (BMPs) for agricultural water users, which are a mixture of site-specific management, educational, and physical procedures that have proven to be effective and are cost-effective for conserving water. The Texas Water Development Board (TWDB), through the Water Conservation Implementation Task Force, has published a report titled Water Conservation Best Management Practices Guide (TWDB Report 362) which in part contains numerous BMPs for agricultural water users. The following BMPs are selected for their suitability to the irrigation practices occurring in Far West Texas.

Agricultural Irrigation Water Use Management

- Irrigation Scheduling
- Volumetric Measurement of Irrigation Water Use
- Crop Residue Management and Conservation Tillage
- On-Farm Irrigation Audit

Land Management Systems

- Land Leveling

On-Farm Water Delivery Systems

- Lining of On-Farm Irrigation Ditches
- Replacement of On-Farm Irrigation Ditches with Pipelines
- Low Pressure Center Pivot Sprinkler Irrigation Systems
- Drip/Micro-Irrigation System
- Gated and Flexible Pipe for Field Water Distribution Systems
- Surge Flow Irrigation for Field Water Distribution Systems
- Linear Move Sprinkler Irrigation Systems

Water District Delivery Systems

- Lining of District Irrigation Canals
- Replacement of Irrigation District Canals and Lateral Canals with Pipelines

Miscellaneous Systems

- Tailwater Recovery and Reuse System
- Automation and Telemetry
- Regulatory Reservoirs

4.6.1 IRRIGATION SCHEDULING

Irrigation scheduling is the act of scheduling the time and amount of water applied to a crop based on the amount of water present in the crop root zone, the amount of water consumed by the crop since the last irrigation, and other management considerations such as salt leaching requirements, deficit irrigation, and crop yield relationships. Irrigation scheduling is a water management strategy that reduces the chance of under or over watering an irrigated crop. Some common irrigation scheduling methods are:

1) Direct measurement of soil moisture content, soil water potential, or crop stress including: soil sampling, tensiometers, gypsum blocks, infrared photography of crop canopy, time domain reflectrometry, plant leaf water potential, and other methods.

2) Soil Water Balance Equations: Irrigation methods based on soil water balance equations. These equations range from simple accounting methods to complex computer models that require input of climatic measurements such as temperature, humidity, solar radiation, and wind speed.

The amount of water saved by implementing advanced irrigation scheduling is difficult to quantify, likely varies from year to year, and is strongly influenced by climatic variation, cropping practices, irrigation water quality, and total amount of water used to irrigate. The cost for implementing advanced irrigation scheduling methods depends on the method of scheduling used and the number of fields scheduled, the type of scheduling program, and the cost for technical assistance.

4.6.2 VOLUMETRIC MEASUREMENT OF IRRIGATION WATER USE

The volumetric measurement of irrigation water use provides information needed to assess the performance of an irrigation system and better manage an irrigated crop. There are numerous types of volume measurement methods that can be used to either directly measure the amount of water used or to estimate the amounts from secondary information. The following lists direct and indirect methods:

1) Direct measurement methods usually require either the installation of a flow meter or the periodic manual measurements of flow. Several common direct measurement systems for closed conduits (pipelines) are:
   - Propeller meters
   - Orifice, venturi or differential pressure meters
   - Magnetic flux meters (both insertion and flange mount)
   - Ultrasonic (travel time method)

   Several common methods for direct measurement of flow in open channels are:
   - Various Types of Weirs and Flumes
   - Stage Discharge Rating Tables
   - Area/Point Velocity Measurements
   - Ultrasonic (Doppler and travel time methods)

2) Indirect measurement methods estimate the volume of water used for irrigation from the amount of energy used, irrigation equipment operating or design information, irrigation water pressure, or other information. Indirect measurements require the correlation of energy use, water pressure, system design specifications, or other parameters to the amount of water used during the irrigation or to the flow rate of the irrigation system. Several common indirect measurements for irrigation systems are:
   - Measurement of energy used by a pump supplying water
   - Measurement of end-pressure in a sprinkler irrigation system

- Change in the elevation of water stored in a water supply reservoir
- Measurement of time of irrigation and size of irrigation delivery system

This BMP is used in coordination with other BMPs and in itself does not directly conserve any water. However, the information gained helps better inform the user of costs associated with water use and will assist the user in implementing voluntary conservation measures.

4.6.3 CROP RESIDUE MANAGEMENT AND CONSERVATION TILLAGE

Residue management and conservation tillage allow for the management of the amount, orientation and distribution of crop and other plant residue on the soil surface year-round on crops grown where the entire field surface is tilled prior to planting. Conservation tillage can include no till, strip till, mulch tillage, and ridge till and generally improves the ability of the soil to hold moisture, reduces the amount of water that runs off the field, and reduces evaporation of water from the soil surface.

The amount of water saved by conservation tillage will vary by climate and irrigation method. Increased spring soil moisture content resulting from conservation tillage may allow a farmer to conserve one or more irrigation applications per year (typically 0.25 to 0.50 acre-feet per acre). Reduction in soil moisture loss during the irrigation season may save an additional 0.5 acre-foot per acre. The cost of conservation tillage depends on the type of field operation used to manage crop residues. Some conservation tillage programs are less expensive than conventional tillage.

4.6.4 ON-FARM IRRIGATION AUDIT

Water audits are an effective method of accounting for all water usage for on-farm irrigation and to identify opportunities to improve water use efficiency. Benefits from implementation may also include energy savings and reduced chemical costs. On-farm irrigation audits include measurement of water entering the farm or withdrawn from an aquifer, the inventory and calculation of on-farm water uses, calculation of water-related costs, and identification of potential water efficiency measures.

The conservation program may consist of one or more projects in different areas of the agricultural operation. The audit will consist of gathering information on the following: field size(s) and shape, obstructions, topography, flood vulnerability, water table, and access for operation and maintenance; type of pump equipment and energy source and pumping efficiency, if any; type of irrigation equipment, age and general state of repair; records of previous and current crops and water use; human assets, available technical ability and language skills of laborers; and time and skill level of management personnel.

On-farm irrigation audits do not directly save any water but help identify other agricultural water conservation BMPs that may be implemented by the agricultural water user to save water. The cost of a farm audit varies from minimal to significant with the extent of the audit and if the audit is done internally, by a consultant, or using assistance from a governmental entity. The Texas State Soil and Water Conservation Board prepares Water Quality Management Plans which often address water conservation measures for agricultural land, and the NRCS can assist agricultural water user in implementing conservation plans.

4.6.5 LAND LEVELING

Land leveling generally applies to mechanized grading of agricultural land based on a topographic survey to increase the uniformity with which water is applied to an irrigated field. Rarely does the final product of land leveling result in a level field. Most land leveling is done using a laser-controlled scraper pulled by a tractor. The laser is set to predetermined cross and run slopes, and the scraper automatically adjusts the cut or filled land over the plane of the field as the tractor moves. Land leveling is typically used on mildly sloping land. Contour farming is used to farm on modest slopes and terrace farming is used for steeply sloping land. Land leveling employs surface methods (furrow, border, or basin) used by producers to irrigate fields or improve surface drainage of their non-irrigated field.

The quantity of water that may be saved from land leveling is difficult to estimate. Land leveling is critically important to improving surface irrigation uniformity and application efficiencies. The cost of land leveling for new irrigation fields is usually estimated based on the soil type, the cut to fill ratio, and the total number of cubic yards that must be cut. Touch-up land leveling is usually charged on by the acre or by time worked. Cost per yard of cut varies from approximately $1.00 to $2.00 per cubic yard depending largely on diesel fuel costs. Initial costs per acre for land leveling can range from $50 to $400. Touch up land leveling usually costs less than $50 per acre and most commonly less than $25 per acre.

4.6.6 LINING OF ON-FARM IRRIGATION DITCHES

This practice is accomplished by installing a fixed lining of impervious material in an existing or newly constructed irrigation field ditch. The three most commonly used impervious liners for irrigation canals in Texas are Ethylene-Propylene-Diene Monomer (EPDM), urethane, and concrete. Each type of liner has benefits and detriments specific to the liner. EPDM is the least expensive and concrete the most expensive. Reinforced concrete liners have the longest durability but may have the largest seepage rate. Urethane has low seepage rates but uses hazardous chemicals during installation. In general, most ditch lining projects require the following steps:

1) A site survey of the proposed ditch being lined which includes the length of ditch and one or more typical cross-sections of the ditch;
2) Development of a plan that details the installation and materials specifications;
3) Preparation of the ditch bed, including removal of any vegetation, bed compaction, and bed shaping;
4) Installation of liner; and
5) Finish work including inlets and outlets to lined ditch.

The seepage rate of a farm ditch can be estimated by conducting a ponding test with a typical section of the ditch prior to the ditch being lined. A ponding test measures the rate at which the level of water ponded behind an earthen dam placed in the ditch drops over two to twenty-four hours. The amount of the ditch that is wetted by the pond behind the dam must be measured. The seepage rate can be calculated as acre-feet per mile of ditch per day. The total quantity of water lost to seepage from the ditch is estimated by multiplying the seepage rate times the number of days per year the ditch is used to convey water. For example, a small farm ditch with a wetted perimeter of 5 feet and a length of 1/2 mile is found to have a seepage rate of 1.0 acre-feet per mile per day, assuming the ditch is used to carry irrigation water 40 days per year. The total seepage from the ditch is 20 acre-feet per year (1/2 x 1.0 x 40). Lining the ditch with an EPDM liner would result in minimal or no seepage. Seepage loss from a concrete lining depends on how the liner was constructed and the amount of water that seeps through cracks and expansion joints in the concrete. A conservative estimate would be that concrete lining salvages 80 percent of the original seepage, or for the example, 16 acre-feet.

According to U.S. Bureau of Reclamation, the cost for an installed EPDM liner is approximately $0.85 per square foot and $1.43 per square foot for urethane. The cost for concrete lining ranges from $2.50 to $3.50 per square foot. For the example above the cost per acre-foot of water salvaged in the first year for the EPDM liner would be $11,220 ($561 per acre-foot), for urethane liner $18,876 ($944 per acre- foot) and for concrete $33,000 ($1,650 per acre-foot). Because each of these types of liner has a different life expectancy a present value analysis of cost should be performed. For example, while the concrete liner may have the most expensive installation cost, it also has the longest life expectancy.

4.6.7 REPLACEMENT OF ON-FARM IRRIGATION DITCHES WITH PIPELINES

This BMP involves replacement of on-farm irrigation ditches with buried pipeline and appurtenances to convey water from the source (well, irrigation turnout, farm reservoir) to an irrigated field. On-farm pipelines can be used to replace most types of farm ditches. In general, on-farm pipelines are 24 inch in diameter or less, with 8 inch through 15 inch pipelines being common. Most farm pipelines use either PVC Plastic Irrigation Pipe (“PIP”) or Iron Pipe Size (“IPS”) PVC pipe. PIP is available in diameters from 6 inch to 27 inch with pressure ratings from 80 psi to 200 psi. IPS PVC pipe is available in diameters from 6 inch to 12 inch with pressure rates from 63 psi to 200 psi.

The seepage rate of a ditch can be estimated by conducting one or more ponding tests with a typical section of the ditch prior to the ditch being lined. A ponding test measures the rate at which the level of water ponded behind an earthen dam placed in the ditch drops over two to twenty-four hours. The amount of the ditch that is wetted by the pond behind the dam must be measured. The seepage rate can be calculated as acre-feet per mile of ditch per day. The total quantity of water lost to seepage from the ditch is estimated by multiplying the seepage rate times the number of days per year the ditch is used to convey water. For example a small farm ditch with a wetted perimeter of 5 feet and a length of ½ mile is found to have a seepage rate of 1.0 acre-feet-per mile per day. The ditch is used to carry irrigation water 40 days per year. The total seepage from the ditch is 20 acre-feet per year (1/2 x 1.0 x 40). Replacement of the ditch with a buried PVC pipeline would result in minimal or no seepage. The cost for low-pressure PVC PIP or IPS pipe is dependant on the pipe diameter and the distance between the pipe factory and the installation site. PIP 80 psi PVC pipe with a 15 inch diameter costs approximately $5.00 delivered to most parts of Texas. The cost for pipeline design, site preparation, trenching, bedding materials, backfill, compaction, and finish work are site and project specific.

4.6.8 LOW PRESSURE CENTER PIVOT SPRINKLER IRRIGATION SYSTEMS

The four types of Center Pivot Sprinkler Irrigation Systems that are commonly considered to be low-pressure systems and BMPs are:

1) Low Energy Precision Application (“LEPA”)
2) Low Pressure In-Canopy (“LPIC”)
3) Low Elevation Spray Application (“LESA”)
4) Medium Elevation Spray Application (“MESA”)

All four systems are low-pressure sprinkler systems (with typical pressures at the outer end of the center pivot ranging from 10 to 25 psig) and use fixed sprinkler applicators or nozzles or drop tubes or a combination of both to apply water. Center Pivots equipped with high or medium pressure (greater than 25 psig) impact sprinkler heads have lower water application efficiencies than low-pressure systems. Care should be taken to match water application rates to soil intake rates to minimize water runoff. Each of these LPCP systems can be combined with cultural practices necessary to prevent runoff during irrigation or moderate rainfall events. LEPA systems combine the LPCP system BMP with the Furrow Dikes BMP and the practice of farming with the row direction perpendicular to the direction of travel of the center pivot (i.e. farming in a circle).

The amount of water saved from converting a conventional center pivot sprinkler irrigation system to a BMP center pivot sprinkler irrigation system (i.e. LPCP system) can be estimated using the following equation:

$$\text{Water Saved (acre-feet per year)} = A1 \times (1 - E1/E2)$$

Where A1 is the annual amount of water pumped or delivered to the inlet of the non-BMP center pivot sprinkler system, E1 is the application efficiency of the non-BMP center pivot sprinkler system, and E2 is the application efficiency of the BMP center pivot sprinkler system. E1 and E2 can be directly measured or obtained from the estimated values in the table below.

System Type	**New Condition**	**Fair Condition**	**Poor Condition**
Non-BMP Systems			
Spray	78	60	40
Regular Angle Impact	65	50	30
Low Angle Impact	80	60	40
BMP Systems			
MESA	90	85	70
LESA	90	85	75
LPIC	90	85	75
LEPA (Drop Tube to Furrow Dike, concentric rows)	95	90	80

The amount of water saved is also affected by: environmental conditions during irrigation, the amount of runoff that occurs during irrigation (soil slopes, soil texture, cropping practices), and the time of irrigation (i.e. pre-plant irrigation versus irrigation once the crop canopy is established). The cost for purchase and installation of center pivot systems is typically $300 to $500 per acre. The cost per acre-foot can be estimated by dividing the estimated quantity of water conserved (acre-feet per acre) by the cost per acre of the system ($ per acre-foot).

4.6.9 DRIP/MICRO-IRRIGATION SYSTEM

Drip or micro-irrigation is a generic term for a family of irrigation equipment that provides for distribution of water directly to the plant root zone by means of surface or sub-surface applicators or emitters. TWDB's 2001 "Surveys of Irrigation in Texas" reported approximately 77,000 acres of micro-irrigated land within Texas for 2000. This amounts to approximately 1.2 percent of the total of 6.4 million acres irrigated in 2000. The three most common types of micro-irrigation used in Texas are:

1) Micro-spray or bubblers
2) Sub-Surface (buried) Drip
3) Orchard Surface Drip or Microspray Irrigation

Micro-irrigation is typically used on high value crops (vegetables, orchard, and nursery).

Recently, sub-surface drip irrigation has begun to be used on cotton, chile, and other row crops.

Considerations must be made for situations where natural precipitation or stored soil water is not sufficient for germination and systems must have the ability to provide enough water to properly germinate the seed. The amount of dissolved salts, suspended solids, and particulate (typically sand from irrigation wells or surface water) in the irrigation water must be tested to determine whether a micro-irrigation system is feasible. The following maintenance and monitoring issues must be addressed by the system manager on a nearly daily basis:

1) Cleaning and back flushing of filters;
2) Flushing lateral lines;
3) Measurement of applicator discharge and replacement of applicators as necessary;
4) Monitoring of operating pressures;
5) Injection of chemicals to prevent biological growth; and
6) Injection of chemicals to prevent precipitation of salts.

Micro-irrigation can be the most efficient form of irrigation and typically requires the most capital expense per acre of irrigated land. It is the preferred irrigation method for high value crops, including many nursery trees, small fruit trees, grapes, melons, and other vine plants. Determination of the water saved by conversion from surface irrigation to drip irrigation depends on many parameters. The primary reasons for converting from conventional irrigation to drip irrigation is for crop yield and crop quality reasons rather than reduction in water use. Micro-irrigation is typically the most capital expensive type of irrigation. Installation costs for subsurface drip irrigation range from $800 to $1,200 per acre. The operation and maintenance costs vary depending on the value of the crop being irrigated and the quality of the irrigation water supply. The high capital and operational cost for micro-irrigation is the primary reason that micro-irrigation is limited to only 1.2 percent of the irrigated land within Texas.

4.6.10 GATED AND FLEXIBLE PIPE FOR FIELD WATER DISTRIBUTION SYSTEMS

Gated pipe or flexible pipe (commonly called poly-pipe) is used to convey and distribute water to the furrow and border irrigated fields. Gated pipe is made of aluminum or PVC and ranges in diameters from 6 to 12 inches and lengths of 20 or 30 feet. Ports or gates are installed in the side of the pipe at 20 inch, 30 inch, 36 inch, or 40 inch intervals. The flow rate is controlled by the percent opening of the gate. Flexible pipe is a very low-pressure (less than 5 psi) thin wall (less than 25 mil) pipe that is unrolled and can have ports installed after the pipe is pressurized. Flexible pipe is available in 12- inch through 21-inch diameters in roll lengths of 1,320 feet. Flexible plastic pipe can also be used as a surface pipeline to convey water between fields and can improve the application efficiency of furrow irrigation by allowing the delivery of larger stream sizes of water per irrigated row.

Gated pipe has a long life cycle (10 to 40 years), whereas flexible pipe is typically used only one or two seasons before it must be replaced. Both gated pipe and flexible pipe are easy to install and remove. Flexible pipe installs faster than gated pipe and can be purchased in larger diameters than gated pipe.

The amount of water saved by switching from an unlined ditch to gated or flexible pipe can be estimated by the amount of water that was lost to seepage from the unlined ditch. Seepage rates vary with soil type and local conditions. The information in the Lining of On-Farm Irrigation Ditches BMP can be used to estimate the amount of water saved from seepage. Gated and flexible pipe can also increase the amount of water delivered to each row and reduce deep percolation of irrigation water near the head of the field. Estimation of the amount of water saved from increasing the irrigation application efficiency can be made by measuring the amount of water delivered to the field prior to installing gated or flexible pipe and comparing it to the amount of water delivered to the field using gated or flexible pipe. Under most situations, the water saved by increasing irrigation application efficiency will be significantly greater than water savings from reducing the amount of water lost to seepage. The cost for 12 inch diameter PVC gated pipe ranges from $2.00 to $2.50 per foot and flexible pipe between $0.15 and $0.20 per foot. For a field length of 1300 feet with a row spacing of thirty-six inches it takes approximately 34 feet of gated or flexible pipe per acre. Because the life cycle for gated pipe is significantly longer than that of flexible pipe, the annualized price of PVC gated pipe is similar to flexible pipe. Assuming that 0.25-acre-foot per acre per year of water is saved by using gated or flexible pipe, the annual cost per acre-foot of water saved ranges from $20 to $25.

4.6.11 SURGE FLOW IRRIGATION FOR FIELD WATER DISTRIBUTION SYSTEMS

A surge irrigation system applies water intermittently to furrows so as to create a series of on-off periods of either constant or variable time intervals. Surge flow can also increase the amount of water delivered to each row and reduce deep percolation of irrigation water near the head of the field. Surge irrigation is typically applicable to agricultural fields with medium soils. Surge irrigation may have limited applicability to fields with heavy clay soils or light sandy soil. If improperly used, surge irrigation can increase the volume of water that runs off the tail of a field during irrigation. Under this BMP, the agricultural water user will install and maintain a surge irrigation system. The system will, at a minimum, include butterfly valves or similar equipment that will provide equivalent alternating flows with adjustable time periods and a solar or battery-powered timer. The agricultural producer should consider field slope, soil type, texture, and infiltration rates to maximize effectiveness of the system. Surge flow has also been shown to reduce runoff in some fields by increasing the uniformity of infiltration and by reducing the duration of flow as the water reaches the end of the field.

The amount of water saved by switching to surge flow is estimated to be between 10 percent and 40 percent and is dependent upon soil type and timing of operations. The savings from installing the surge flow at the same time as replacing an unlined ditch with gated or flexible pipe should be considered separately as a factor in implementing that BMP. Experience has shown that differences in soil texture and field slope have a significant impact on actual water savings. Estimation of the amount of water saved from increasing the irrigation application efficiency can be made by measuring the amount of water delivered to the field prior to installing surge flow and comparing it to the amount of water delivered to the field by using surge flow. Cost for a surge valve with an automated controller will range between $800 and $2,000 depending on the size of the valve and the controller options. If installed at the same time as gated pipe, the cost for those systems is outlined in the Gated or Flexible Pipe BMP. Assuming that 0.25-acre-foot per acre per year of water is saved by using a surge valve, the annual cost per acre-foot of water saved ranges from $20 to $25.

4.6.12 LINEAR MOVE SPRINKLER IRRIGATION SYSTEMS

Linear Move Sprinkler Irrigation (linear move) Systems are an adaptation of center pivot sprinkler systems for use on fields, which are not appropriate for center pivot systems due to shape or elevation changes. The linear move sprinkler irrigation system is composed of a series of towers that suspend the irrigation system and move laterally in the direction of the rows. Water can be supplied to the towers from a open ditch adjacent to the first tower and parallel to the director of travel or by a flexible hose. The flexible hose, typically 100 to 200 feet in length, is supplied through risers connected to a buried pipeline. Use of a linear move system is normally limited to irrigating rectangular shaped fields. The four types of systems that are commonly considered to be low-pressure system include:

1) Low Energy Precision Application ("LEPA")
2) Low Pressure In-Canopy ("LPIC")
3) Low Elevation Spray Application ("LESA")
4) Medium Elevation Spray Application ("MESA")

All four systems are low-pressure sprinkler systems (with typical pressures at the farthest end of the sprinkler from the water source ranging from 10 to 35 psi) and use fixed sprinkler applicators/nozzles or drop tubes or a combination of both to apply water. Linear Move Sprinklers equipped with high or medium pressure (greater than 35 psi) impact sprinkler heads have lower water application efficiencies than low-pressure systems. Each of these linear move systems can or must be combined with cultural practices necessary to prevent runoff during irrigation or moderate rainfall events. LEPA systems can be combined with the Linear Move Systems with the Furrow Dikes.

The amount of water saved from converting from a conventional linear move sprinkler irrigation system to a BMP linear move sprinkler irrigation system can be estimated using the following equation:

$$\text{Water Saved (acre-feet per year)} = A1 \times (1 - E1/E2)$$

Where A1 is the annual amount of water pumped or delivered to the inlet of the non-BMP center pivot sprinkler system, E1 is the application efficiency of the non-BMP linear move sprinkler system, and E2 is the application efficiency of the BMP (linear move) sprinkler system. E1 and E2 can be directly measured or obtained from the estimated values in the table below.

System Type	New Condition	Fair Condition	Poor Condition
Non-BMP Systems			
Spray	78	60	40
Regular Angle Impact	65	50	30
Low Angle Impact	80	60	40
BMP Systems			
MESA	90	85	70
LESA	90	85	75
LPIC	90	85	75
LEPA (Drop Tube to Furrow Dike, concentric rows)	95	90	80

The amount of water saved is also affected by environmental conditions during irrigation, the amount of runoff that occurs during irrigation (soil slopes, soil texture, cropping practices) and the time of irrigation (i.e. pre-plant irrigation versus irrigation once the crop canopy is established). The cost for purchase and installation of linear move systems is typically \$300 to \$700 per acre. The cost per acre-foot can be estimate by dividing the estimated quantity of water conserved (acre-feet per acre) by the cost per acre of the system (dollars per acre-foot).

4.6.13 LINING OF DISTRICT IRRIGATION CANALS

A fixed lining of impervious material is installed in an existing or newly constructed irrigation canal or lateral canal. The three most commonly used impervious liners for irrigation canals in Texas are Ethylene-Propylene-Diene Monomer ("EPDM"), urethane, and concrete. Each type of liner has benefits and detriments specific to the liner. EPDM is least expensive and concrete the most. Reinforced concrete liners have the longest durability but may have the largest seepage rate. Urethane has low seepage rates but uses hazardous chemicals during the installation. The U.S. Bureau of Reclamation report titled "Canal Lining Demonstration Project Year 7 Durability Report" provides a detailed description of these and other liners.

The canal considered for lining shall be of sufficient capacity to meet its requirement as part of a planned irrigation water conveyance system without overtopping, but with enough capacity to deliver the water needed to meet the peak consumptive use. The specific steps required to implement this BMP depend on the type of canal liner used and the existing conditions of the canal to be lined. Installation specifications, material specifications and detailed installation instructions for most types of canal liners are available from liner manufacturers and governmental agencies. In general, most canal lining projects require the following steps:

1) A site survey of the proposed canal being lined including length of canal and one or more typical cross-sections of the canal.
2) Development of a plan that details the installation and materials specifications.
3) Preparation of the canal bed, including removal of any vegetation, bed compaction, and bed shaping.
4) Installation of liner.
5) Finish work including inlets and outlets to lined canal.

The seepage rate of a canal can be estimated by conducting a ponding test with a typical section of the canal prior to the canal being lined. A ponding test measures the rate at which the level of water ponded behind an earthen dam placed in the canal drops over two to twenty-four hours. The amount of the canal that is wetted by the pond behind the dam must be measured. The seepage rate can be calculated as acre-feet per mile of canal per day. The total quantity of water lost to seepage from the canal is estimated by multiplying the seepage rate times the number of days per year the canal is used to convey water.

For example, a small farm canal with a wetted perimeter of 20 feet and a length of 1 mile is found to have a seepage rate of 1.5 acre-feet per mile per day assuming the canal is used to carry irrigation water for 270 days per year. The total seepage from the canal is 405 acre-feet per year (1 x 1.5 x 270). Lining the canal with an EPDM liner would result in minimal or no seepage. Seepage loss from a concrete lining depends on how the liner was constructed and the amount of water that seeps through cracks and expansion joints in the concrete.

The U.S. Bureau of Reclamation estimates cost for an installed EPDM liner was approximately $0.85 per square foot and $1.43 per square foot for urethane. The cost for concrete lining ranges from $2.50 to $3.50 per square foot. For the example above the cost per acre-foot of water salvaged in the first year for the EPDM liner would be $89,760 ($222 per acre-foot), for urethane liner $151,008 ($373 per acre-foot) and for concrete $316,800 ($782 per acre-foot). Because each of these types of liner has a different life expectancy a present value analysis of cost should be performed. For example, while the concrete liner may have the most expensive installation cost, it also has the longest life expectancy.

4.6.14 REPLACEMENT OF IRRIGATION DISTRICT CANALS AND LATERAL CANALS WITH PIPELINES

This strategy proposes the replacement of district irrigation canals or lateral canals that have less than 44,900 gpm (100 cubic feet per second) capacity with buried pipeline and appurtenances to convey water from the source (well, river, reservoir) to a farm or irrigation turnout. District irrigation pipelines can be used to replace most types of small canals or lateral canals. In general, district irrigation pipelines are 72 inch in diameter or less, with 12 inch through 48 inch diameter pipes being common. Most district irrigation pipelines use either PVC Plastic Irrigation Pipe (“PIP”) or Reinforced Concrete Pipe (“RCP”) with joints that have gaskets. PIP is available in diameters from 6 inch to 27 inch with pressure ratings from 80 psi to 200 psi. RCP is typically available in diameters between 24 inch and 72 inch. It is common practice in the irrigation districts in the Lower Rio Grande Valley to use PIP for 24-inch or less diameter pipe and RCP for pipe diameters greater than 24 inch. On a limited basis, 36 inch and 42 inch diameter PVC pressurized sewer pipe is being used to replace open canals.

The seepage rate of a canal can be estimated by conducting a ponding test within a typical section of the canal or lateral canal prior to the canal and lateral canal being lined. A ponding test measures the rate at which the level of water ponded behind an earthen dam in a canal drops over two to twenty-four hours. The amount of the canal that is wetted by the pond behind the dam must be measured. The seepage rate can be calculated as acre-feet per mile of canal per day. The total quantity of water lost to seepage from the canal is estimated by multiplying the seepage rate times the number of days per year the canal is used to convey water. For example, a canal with a wetted perimeter of 50 feet and a length of 1 mile is found to have a seepage rate of 1.0 acre-foot per mile per day. The canal and lateral canal are used to carry irrigation water 270 days per year. The total seepage from the canal is 270 acre-feet per year per mile (1.0 x 1.0 x 270). Replacement of the canal with a buried PVC pipeline would result in minimal or no seepage. The cost for low-pressure PVC PIP pipe is based on the pipe diameter and the distance between the pipe factory and the installation site. PIP 80 psi PVC pipe with a 24 inch diameter costs between $15 and $21 delivered to most parts of Texas. Because of the heavy weight and associated transportation costs, reinforced concrete pipe is usually manufactured in the area in which the pipe is being installed. The cost for pipeline design, site preparation, trenching, bedding materials, backfill, compaction, and finish work are all site and project specific. The cost per acre-foot can be estimated by dividing the estimated quantity of water conserved in acre-feet per acre by the cost per acre of the system.

4.6.15 TAILWATER RECOVERY AND REUSE SYSTEM

A Tailwater System consists of ditches or pipelines to collect tailwater and deliver water to a storage reservoir (typically below the grade of the irrigated land) and includes a pumping and pipeline system that conveys the water to irrigated fields for reuse. Most tailwater systems also collect rainfall that may run off of the irrigated field. Natural reservoirs, such as the playa lakes located in the High Plains region of Texas, may serve to both capture irrigation runoff and rainfall runoff and may be used as part of a tailwater system. Also, capture and reuse of tailwater can improve the water quality of downstream reaches of rivers, streams, or waterways. Conservation through reduction in field runoff may reduce agricultural drain flow and the amount of water in downstream reaches of rivers, streams, or waterways. In the irrigated agricultural areas of Texas supplied by groundwater, reduction or reuse of field runoff is a common practice and can provide secondary benefits such as an open water source for wildlife (tailwater ponds). Also, capture and reuse of tailwater can improve the water quality of downstream reaches of rivers, streams, or waterways. Conservation through reduction in field runoff may reduce agricultural drain flow and the amount of water in downstream reaches of rivers, streams, or waterways.

Both direct and indirect measurements of the volume of water captured and reused by the Tailwater System can be used to determine the annual volume of water saved. The amount of runoff from a surface irrigated field varies significantly from site to site, but it is not uncommon for runoff to be 15 percent or greater of the gross volume of water applied to the field. Typical tailwater systems can reuse 0.5 to 1.5 acre-feet per acre of irrigated crop per year. The cost of constructing a tailwater system varies significantly from site to site and with land costs. The cost to construct a small storage reservoir (assuming the water user owns the land) ranges from $800 to $2,000 per acre-foot. Construction of the tailwater collection system varies from little cost (adapting an existing surface drainage system) to as much as $15 per foot of installed pipe. The cost of the pump back system is also site specific and typically costs several thousands of dollars.

4.6.16 AUTOMATION AND TELEMETRY

The larger irrigation systems in the United States commonly use automatic systems for control of irrigation equipment and telemetry to report water flow rate, weather data, and other information that assists in the management and conservation of irrigation water. A combination of automation and telemetry equipment is used in a Supervisory Control and Data Acquisition (SCADA) system. SCADA systems for irrigation management vary from the relatively simple remote control by a farmer of a center pivot sprinkler irrigation system using a cellular phone to the complex multi-nodal flow rate measurement, weather data, and pump and gate control systems used by an irrigation district.

Large SCADA systems are made up of six primary components:

1) the equipment or instruments used to measure water flow rate, soil moisture, rainfall, humidity, temperature, wind speed, water quality, and other parameters, or to control the operation of pumps, motors, gates, or other water delivery devices;

2) the remote terminal unit (RTU) consists of data acquisition and control computer and the associate power and battery system;
3) the data communication system (DCS) (radio, telephone, cellular phone, satellite, etc.) which communicates between the RTU and the Base Computer and may include radio repeater sites and a combination of different types of communication system;
4) the Telemetry Data Server (TDS) system that communicates with the field RTU, stores the data collected by the RTU, and runs control, data logging, and data display software (Human Machine Interface software);
5) the Human Machine Interface (HMI) software, this software commonly provides a graphic interface to display the location of the RTUs and is the software that collects the data measured by the RTU and distributes such data to the end user; and
6) the data distribution system (DDS), which may include the distribution of data through an Internet web site, use of email, pagers, and PDA/cellular phones.

The cost for an automatic control system for a center pivot sprinkler system ranges from approximately $1,500 to $3,500 per pivot with an additional $3,000 to $5,000 for equipment to measure soil moisture and weather data. Cost for SCADA systems used by irrigation districts range from $1,500 to $2,500 per RTU (in addition to installation cost) and the cost of the flow meters, telemetry data server computer, and HMI software. A typical irrigation district SCADA system that has approximately 20 flow measurement and control sites would cost between $150,000 and $250,000 depending on site specific conditions and the type and cost of flow meters.

4.6.17 IRRIGATION WATER REGULATING RESERVOIRS

Regulating reservoirs are typically used by irrigation districts to balance irrigation demand with water supply. These reservoirs normally range in size from 100 acre-feet to 10,000 acre-feet. One location where a regulating reservoir would conserve water is the irrigated land near El Paso, Texas. Typically it takes 3 or more days for water released from storage in Caballo Reservoir in New Mexico to reach the irrigation land in Texas. This 3-day travel time requires irrigation water users to estimate their demand for water a minimum of 3 days prior to anticipated use. Changes in weather, such as an unexpected large rainfall event will reduce the demand for irrigation water and result in the cancellation of water orders. Under this scenario, a regulating or balancing reservoir can be used to store the water released from the upstream reservoir (Caballo) for future irrigation requirements downstream of the reservoir.

The facilities for a regulating reservoir include construction of earthen sides with rock or concrete riprap covering the interior slopes, sluice or radial gates for the control of the flow of water in and out of the reservoir, one or more large capacity – low head pumps for the transfer of water from canal into the reservoir, and the associated pipe and control facilities, and a geosynthetic or clay liner to reduce seepage from the reservoir.

Small on-farm reservoirs can be used to store surface water delivered by an irrigation district for use in drip irrigation system. These reservoirs are typically 10 to 40 acre-feet in size and are used to provide a continuous supply of water to a drip irrigation system. The reservoirs are typically filled once every week or two depending on time of year, the water demand of the crop, and the availability of water from the irrigation district.

Site selection for large regulating reservoirs is dependent on the location of the existing irrigation canals within the irrigation district, the topography of the surrounding land, and the amount of downstream demand for any water that may be stored in such reservoir. Most regulating reservoirs are constructed to be approximately 8 to 10 feet deep with a freeboard of 4 feet. The slopes of the reservoir embankments are typically at a ration of 1 to 2 or greater and are constructed from the material excavated from the reservoir bed. Because it is common for the on-farm demand for irrigation water to increase rapidly, it is desirable to use a combination of gravity flow and pumping to move water out of the reservoir and to use gravity flow to fill the reservoir.

Often regulating reservoirs are constructed on fallow or unused agricultural land adjacent to existing canals. Typically such land has had most or all of the vegetation removed prior to the land being selected as a reservoir site. In addition to conserving water, regulating reservoirs have the secondary benefit of enhancing local wildlife. The three regulating reservoirs constructed in Hudspeth County are a significant resource for nearby wildlife and attract many migratory waterfowl and other birds.

Construction cost for reservoir varies significantly with land and energy cost. Typical costs for a small on-farm reservoir range from $2,000 to $3,000 per acre-foot and from $600 to $2,000 per acre-foot for large reservoirs constructed by an irrigation district.

4.7 DESALINATION POTENTIAL

The potential for desalination of brackish water in Far West Texas is not only feasible, but is currently in operation and soon to expand significantly. For desalination to be a viable alternative, a number of issues should be addressed:

- Is there a supply need
- Is the source of sufficient quantity to last the life of the plant
- Is the chemical quality of the source within a reasonable range to make desalination effective
- Is the source within an economical distance from the area of need
- Is there a satisfactory means of disposing of the process concentrate
- Is the desalination process economically comparable to other alternatives

Many of the aquifers in Far West Texas contain significant quantities of brackish groundwater containing dissolved-solids concentrations of between 1,000 and 10,000 milligrams per liter (mg/L). The process of desalination of brackish quality sources or the simple blending of brackish and fresh sources makes these resources available for municipal drinking-water use. The community of Dell City and the Horizon Regional MUD operate desalination plants to reduce the concentration of TDS in groundwater produced from the

Bone Spring-Victorio Peak and Hueco Bolson aquifers. The City of El Paso blends fresh water with marginally elevated TDS water. A joint El Paso-Fort Bliss project is currently underway to construct a desalination facility for public water supply purposes. These types of facilities allow the use of water previously unusable from a public water supply perspective. Also, by using brackish supplies to meet a portion of the total water demand, fresh groundwater sources are maintained for longer periods of time.

A supply component of the *integrated water management strategy* discussed in Section 4.4 of this chapter is the Bone Spring-Victorio Peak aquifer in Hudspeth Counties. The implementation of the use of this supply will require desalination as the aquifer contains dissolved-solids concentrations of 1,800 to 3,900 mg/L.

As discussed in Chapter 5 and illustrated in Figure 5-1, brackish groundwater exists throughout much of the Region. Besides the Bone Spring-Victorio Peak, other aquifer sources containing sufficient quantities of brackish groundwater capable of meeting desalination process needs include both the Hueco and Mesilla Bolsons in the El Paso and Hudspeth Counties, the Capitan Reef in Culberson County, Wild Horse Flat and Lobo Flat aquifers in Culberson County, and the Rio Grande Alluvium in El Paso, Hudspeth, and Presidio Counties. Distance needed to transport the sources to areas where the supply is needed will likely prevent the development of some of these sources.

4.8 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 FWTWPG 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.

APPENDIX 4A

SOCIOECONOMIC IMPACTS OF UNMET WATER NEEDS

Socioeconomic Impacts of Unmet Water Needs in the Far West Texas Water Planning Area

Prepared by

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Prepared in support of the

Far West Texas Water Planning Group and the 2006 Texas State Water Plan

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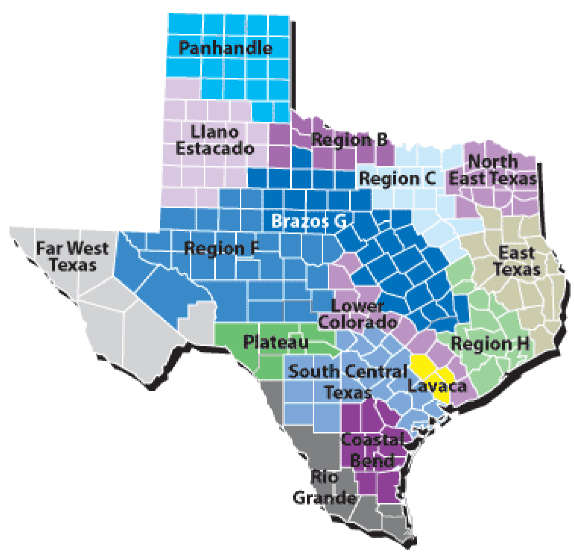

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Executive Summary

Background

Water shortages due to severe drought combined with infrastructure limitations would likely curtail or eliminate economic activity in business and industries heavily reliant on water. For example, without water farmers cannot irrigate; refineries cannot produce gasoline and paper mills cannot make paper. Unreliable water supplies would not only have an immediate and real impact on business and industry, but they might also bias corporate decision makers against plant expansion or plant location in Texas. From a societal perspective, water supply reliability is critical as well. Shortages would disrupt activity in homes, schools and government and could adversely affect public health and safety. For all of the above reasons, it is important to analyze and understand how restricted water supplies during drought could affect communities throughout the state.

Section 357.7(4) of the rules for implementing Texas Senate Bill 1 requires regional water planning groups to evaluate the social and economic impacts of projected water shortages (i.e., "unmet water needs") as part of the planning process. The rules contain provisions that direct the Texas Water Development Board (TWDB) to provide technical assistance to complete socioeconomic impact assessments. In response to requests from regional planning groups, staff of the TWDB's Office of Water Resources Planning designed and conducted analyses to evaluate socioeconomic impacts of unmet water needs.

Overview of Methodology

Two components make up the overall approach to this study: 1) an economic impact module and 2) a social impact module. Economic analysis addresses potential impacts of unmet water needs including effects on residential water consumers and losses to regional economies stemming from reductions in economic output for agricultural, industrial and commercial water uses. Impacts to agriculture, industry and commercial enterprises were estimated using regional "input-output" models commonly used by researchers to estimate how reductions in business activity might affect a given economy. Estimated impacts are *independent* and distinct "what if" scenarios for a given point in time (i.e., 2010, 2020, 2030, 2040, 2050 and 2060). Reported figures are scenarios that illustrate what could happen in a given year if: 1) water supply infrastructure and/or water management strategies do not change through time, 2) the drought of record recurs. Details regarding the methodology and assumptions for individual water use categories (i.e., municipal consumers including residential and commercial water users, manufacturing, steam-electric, mining, and agriculture) are in the main body of the report.

The social component focuses on demographic effects including changes in population and school enrollment. Methods are based on population projection models developed by the TWDB for regional and state water planning. With the assistance of the Texas State Data Center, TWDB staff modified these models and applied them for use here. Basically, the social impact module incorporates results from the economic impact module and assesses how changes in a region's economy due to water shortages could affect patterns of migration in a region.

Summary of Results

Table E-1 and Figure E-1 summarize estimated economic impacts. Variables shown include:[1]

- **sales** - economic output measured by sales revenue;
- **jobs -** number of full and part-time jobs required by a given industry including self-employment;
- **regional income -** total payroll costs (wages and salaries plus benefits) paid by industries, corporate income, rental income and interest payments for the region; and
- **business taxes -** sales, excise, fees, licenses and other taxes paid during normal operation of an industry (does not include any type of income tax).

If drought of record conditions return and water supplies are not developed, study results indicate that the Region E Water Planning Area could suffer significant losses. If such conditions occurred 2010 lost income to residents in the region could total $160 million with associated job losses as high as 4,570. State and local governments could lose nearly $8 million in tax receipts. If such conditions occurred in 2060, income losses could run $1,096 million, and job losses could be as high as 13,205. Nearly $105 million worth of state and local taxes would be lost. Reported figures are probably conservative because they are based on estimated costs for a single year; but in much of Texas, the drought of record lasted several years. For example, in 2030 models indicate that shortages would cost residents and businesses in the region $405 million in lost income. Thus, if shortages lasted for three years total losses related to unmet needs could easily approach $1,215 million.

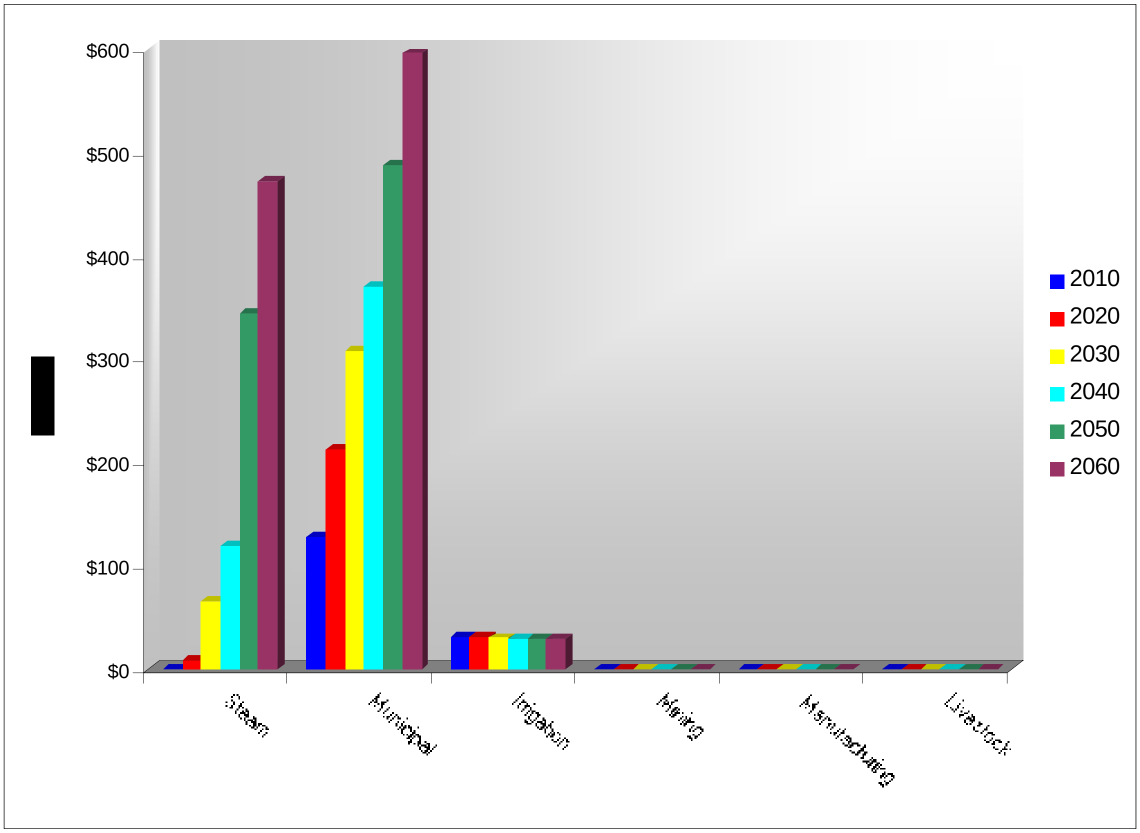
Table E-1: Annual Economic Impacts of Unmet Water Needs
(years, 2010, 2020, 2030, 2040, 2050 and 2060, constant year 2000 dollars)

Year	Sales ($millions)	Income ($millions)	Jobs	State and Local Taxes ($millions)
2010	$213.15	$159.89	4,570	$7.87
2020	$264.56	$253.76	5,060	$10.66
2030	$408.75	$405.52	6,510	$31.61
2040	$534.21	$520.91	7,690	$33.43
2050	$939.80	$860.92	10,560	$78.60
2060	$1,213.37	$1,096.01	13,205	$105.36

Source: Texas Water Development Board, Office of Water Resources Planning

[1] When aggregated at a regional level, total sales are not necessarily a good measure of economic prosperity because they include sales to other industries for further processing. For example, a farmer sells rice to a rice mill, which the rice mill processes and sells it to another consumer. Both transactions are counted in an input-output model. Thus, total sales "double count." Regional income plus business taxes are more suitable because they are a better measure of net economic returns.

Figure E-1: Distribution of Lost Income by Water Use Category
(years, 2010, 2020, 2030, 2040, 2050 and 2060, constant year 2000 dollars)



Source: Texas Water Development Board, Office of Water Resources Planning

Table E-2 shows potential losses in population and school enrollment. Changes in population stem directly from the number of lost jobs estimated as part of the economic impact module. In other words, many – but not all - people would likely relocate due to a job loss and some have families with school age children. Section 1.3 in the main body of the report discusses methodology in detail.

Table E-2: Estimated Regional Social Impacts of Unmet Water Needs
(years, 2010, 2020, 2030, 2040, 2050 and 2060)

Year	Population Losses	Declines in School Enrollment
2010	7,960	2,060
2020	8,820	2,280
2030	11,350	2,940
2040	13,400	3,470
2050	18,410	4,770
2060	23,020	5,970

Source: Based on models developed by the Texas Water Development Board, Office of Water Resources Planning and the Texas State Data Center.

Introduction

Texas is one the nation’s fastest growing states. From 1950 to 2000, population in the state grew from about 8 million to nearly 21 million. By the year 2050, the total number of people living in Texas is expected to reach 40 million. Rapid growth combined with Texas’ susceptibility to severe drought makes water supply a crucial issue. If water infrastructure and water management strategies are not improved, Texas could face serious social, economic and environmental consequences - not only in our large metropolitan cities, but also on our farms and rural areas.

Water shortages due to severe drought combined with infrastructure limitations would likely curtail or eliminate economic activity in business and industries heavily reliant on water. For example, without water farmers cannot irrigate; refineries cannot produce gasoline and paper mills cannot make paper. Unreliable water supplies would not only have an immediate and real impact on business and industry, but they might also bias corporate decision makers against plant expansion or plant location in Texas. From a societal perspective, water supply reliability is critical as well. Shortages would disrupt activity in homes, schools and government and could adversely affect public health and safety. For all of the above reasons, it is important to analyze and understand how restricted water supplies during drought could affect communities throughout the state.

Section 357.7(4) of the rules for implementing Texas Senate Bill 1 requires regional water planning groups to evaluate the social and economic impacts of unmet water needs as part of the planning process. The rules contain provisions that direct the Texas Water Development Board (TWDB) to provide technical assistance to complete socioeconomic impact analyses. In response to requests from regional planning groups, TWDB staff designed and conducted required studies. The following document prepared by the TWDB’s Office of Water Resources Planning summarizes analysis and results for the Far West Texas Water Planning Area (Region E). Section 1 provides an overview of concepts and methodologies used in the study. Sections 2 and 3 provide detailed information and analyses for each water use category employed in the planning process (i.e., irrigation, livestock, municipal, manufacturing, mining and steam-electric).

1. Overview of Terms and Methodology

Section 1 provides a general overview of how economic and social impacts were measured. In addition, it summarizes important clarifications, assumptions and limitations of the study.

1.1 Measuring Economic Impacts

Economic analysis as it relates to water resources planning generally falls into two broad areas. Supply side analysis focuses on costs and alternatives of developing new water supplies or implementing programs that provide additional water from current supplies. Demand side analysis concentrates on impacts and benefits of providing water to people, businesses and the environment. Analysis in this report focuses strictly on demand side impacts. Specifically, it addresses the potential economic impacts of unmet water needs including: 1) losses to regional economies stemming from reductions in economic output, and 2) costs to residential water consumers associated with implementing emergency water procurement and conservation programs.

1.1.1 Impacts to Agriculture, Business and Industry

As mentioned earlier, severe water shortages would likely affect the ability of business and industry to operate resulting in lost output, which would adversely affect the regional economy. A variety tools are available to estimate such impacts, but by far, the most widely used today are input-output models (IO models) combined with social accounting matrices (SAMs). Referred to as IO/SAM models, these tools formed the basis for estimating economic impacts for agriculture (irrigation and livestock water uses) and industry (manufacturing, mining, steam-electric and commercial business activity for municipal water uses).

Basically, an IO/SAM model is an accounting framework that traces spending and consumption between different economic sectors including businesses, households, government and “foreign” economies in the form of exports and imports. As an example, Table 1 shows a highly aggregated segment of an IO/SAM model that focuses on key agricultural sectors in a local economy. The table contains transactions data for three agricultural sectors (cattle ranchers, dairies and alfalfa farms). Rows in Table 1 reflect sales from each sector to other local industries and institutions including households, government and consumers outside of the region in the form of exports. Columns in the table show purchases by each sector in the same fashion. For instance, the dairy industry buys $11.62 million worth of goods and services needed to produce milk. Local alfalfa farmers provide $2.11 million worth of hay and local households provide about $1.03 million worth of labor. Dairies import $4.17 million worth of inputs and pay $2.61 million in taxes and profits. Total economic activity in the region amounts to about $807.45 million. The entire table is like an accounting balance sheet where total sales equal total purchases.

Table 1: Example of a County-level Transaction and Social Accounting Matrix for Agricultural Sectors ($millions)

Sectors	Cattle	Dairy	Alfalfa	All other Industries	Taxes, govt. & profits	Households	Exports	Total
Cattle	$3.10	$0.01	$0.00	$0.03	$0.02	$0.06	$10.76	$13.98
Dairy	$0.07	$0.13	$0.00	$0.25	$0.01	$0.00	$11.14	$11.60
Alfalfa	$0.00	$2.11	$0.00	$0.01	$0.02	$0.01	$10.38	$12.53
Other industries	$2.20	$1.56	$2.90	$50.02	$70.64	$66.03	$48.48	$241.83
Taxes, govt. & profits	$2.37	$2.61	$5.10	$77.42	$0.23	$49.43	$83.29	$220.45
Households	$0.82	$1.03	$1.38	$50.94	$45.36	$7.13	$14.64	$121.30
Imports	$5.41	$4.17	$3.16	$63.32	$104.17	$5.53	$0.00	$185.76
Total	$13.97	$11.62	$12.54	$241.99	$220.45	$128.19	$178.69	$807.45

* Columns contain purchases and rows represent sales. Source: Adapted from Harris, T.R., Narayanan, R., Englin, J.E., MacDiarmid, T.R., Stoddard, S.W. and Reid, M.E. “*Economic Linkages of Churchill County.*” University of Nevada Reno. May 1993.

To understand how an IO/SAM model works, first visualize that $1 of additional sales of milk is injected into the dairy industry in Table 1. For every $1 the dairies receive in revenue, they spend 18 cents on alfalfa to feed their cows; nine cents is paid to households who provide farm labor, and another 13 cents goes to the category “other industries” to buy items such as machinery, fuel, transportation, accounting services etc. Nearly 22 cents is paid out in the form of profits (i.e., returns to dairy owners) and taxes/fees to local, state and federal government. The value of the initial $1 of revenue in the dairy sector is referred to as a first-round or **direct effect.**

As the name implies, first-round or direct effects are only part of the story. In the example above, alfalfa farmers must make 18 cents worth of hay to supply the increased demand for their product. To do so, they purchase their own inputs, and thus, they spend part of the original 18 cents that they received from the dairies on firms that support their own operations. For example, 12 cents is spent on fertilizers and other chemicals needed to grow alfalfa. The fertilizer industry in turn would take these 12 cents and spend them on inputs in its production process and so on. The sum of all re-spending is referred to as the **indirect effect** of an initial increase in output in the dairy sector.

While direct and indirect impacts capture how industries respond to a change, **induced impacts** measure the behavior of the labor force. As demand for production increases, employees in base industries and supporting industries will have to work more; or alternatively, businesses will have to hire more people. As employment increases, household spending rises. Thus, seemingly unrelated businesses such as video stores, supermarkets and car dealers also feel the effects of an initial change.

Collectively, indirect and induced effects are referred to as **secondary impacts**. In their entirety, all of the above changes (direct and secondary) are referred to as **total economic impacts**. By nature, total impacts are greater than initial changes because of secondary effects. The magnitude of the increase is what is popularly termed a multiplier effect. Input-output models generate numerical multipliers that estimate indirect and induced effects.

In an IO/SAM model impacts stem from changes in output measured by sales revenue that in turn come from changes in consumer demand. In the case of water shortages, one is not assuming a change in demand, but rather a supply shock – in this case severe drought. Demand for a product such as corn has not necessarily changed during a drought. However, farmers in question lack a crucial input (i.e., irrigation water) for which there is no *short-term* substitute. Without irrigation, she cannot grow irrigated crops. As a result, her cash flows decline or cease all together depending upon the severity of the situation. As cash flows dwindle, the farmer's income falls, and she has to reduce expenditures on farm inputs such as labor. Lower revenues not only affect her operation and her employees directly, but they also indirectly affect businesses who sell her inputs such as fuel, chemicals, seeds, consultant services, fertilizer etc.

The methodology used to estimate regional economic impacts consists of three steps: 1) develop IO/SAM models for each county in the region and for the region as whole, 2) estimate direct impacts to economic sectors resulting from water shortages, and 3) calculate total economic impacts (i.e., direct plus secondary effects).

Step 1*: Generate IO/SAM Models and Develop Economic Baseline*

IO/SAM models were estimated using propriety software known as IMPLAN PRO™ (Impact for Planning Analysis). IMPLAN is a modeling system originally developed by the U.S. Forestry Service in the late 1970s. Today, the Minnesota IMPLAN Group (MIG Inc.) owns the copyright and distributes data and software. It is probably the most widely used economic impact model in existence. IMPLAN comes with databases containing the most recently available economic data from a variety of sources.[2] Using IMPLAN software and data, transaction tables conceptually similar to the one discussed previously (see Table 1 on page 9) were estimated for

[2]The basic IMPLAN database consists of national level technology matrices based on the Benchmark Input-Output Accounts generated the U.S. Bureau of Economic Analysis and estimates of final demand, final payments, industry output and employment for various economic sectors. IMPLAN's regional data (i.e. states, a counties or groups of counties within a state) are divided into two basic categories: 1) data on an industry basis including value-added, output and employment and 2) data on a commodity basis including final demands and institutional sales. State-level data are balanced to the national totals using a matrix ratio allocation system and county data are balanced to state totals. In other words, much of the data in IMPLAN is based on a national average for all industries.

each county in the region and for the region as a whole. Each transaction table contains 528 economic sectors and allows one to estimate a variety of economic statistics including:

- **total sales -** total production measured by sales revenues;
- **intermediate sales -** sales to other businesses and industry within a given region;
- **final sales** – sales to end users in a region and exports out of a region;
- **employment -** number of full and part-time jobs (annual average) required by a given industry including self-employment;
- **regional income -** total payroll costs (wages and salaries plus benefits) paid by industries, corporate income, rental income and interest payments; and
- **business taxes -** sales, excise, fees, licenses and other taxes paid during normal operation of an industry (does not include income taxes).

TWDB analysts developed an economic baseline containing each of the above variables using year 2000 data. Since the planning horizon extends through 2060, economic variables in the baseline were allowed to change in accordance with projected changes in demographic and economic activity. Growth rates for municipal water use sectors (i.e., commercial, residential and institutional) are based on TWDB population forecasts. Projections for manufacturing, agriculture, and mining and steam-electric activity are based on the same underlying economic forecasts used to estimate future water use for each category. Monetary impacts in future years are reported in year 2000 dollars.

It is important to stress that employment, income and business taxes are the most useful variables when comparing the relative contribution of an economic sector to a regional economy. Total sales as reported in IO/SAM models are less desirable and can be misleading because they include sales to other industries in the region for use in the production of other goods. For example, if a mill buys grain from local farmers and uses it to produce feed, sales of both the processed feed and raw corn are counted as "output" in an IO model. Thus, total sales double-count or overstate the true economic value of goods and services produced in an economy. They are not consistent with commonly used measures of output such as Gross National Product (GNP), which counts only final sales.

Another important distinction relates to terminology. Throughout this report, the term *sector* refers to economic subdivisions used in the IMPLAN database and resultant input-output models (528 individual sectors based on Standard Industrial Classification Codes). In contrast, the phrase *water use category* refers to water user groups employed in state and regional water planning including irrigation, livestock, mining, municipal, manufacturing and steam electric. All sectors in the IMPLAN database were assigned to a specific water use category (see Attachment A of this report).

Step 2: *Estimate Direct Economic Impacts of Water Shortages*

As mentioned above, direct impacts accrue to immediate businesses and industries that rely on water. Without water industrial processes could suffer. However, output responses would likely vary depending upon the severity of a shortage. A small shortage relative to total water use may have a nominal effect, but as shortages became more critical, effects on productive capacity would increase.

For example, farmers facing small shortages might fallow marginally productive acreage to save water for more valuable crops. Livestock producers might employ emergency culling strategies, or they may consider hauling water by truck to fill stock tanks. In the case of manufacturing, a good example occurred in the summer of 1999 when Toyota Motor Manufacturing experienced water shortages at a facility near Georgetown, Kentucky. As water levels in the Kentucky River fell to historic lows due to drought, plant managers sought ways to curtail water use such as reducing rinse operations to a bare minimum and recycling water by funneling it from paint shops to boilers. They even considered trucking in water at a cost of 10 times what they were paying. Fortunately, rains at the end of the summer restored river levels, and Toyota managed to implement cutbacks without affecting production. But it was a close call. If rains had not replenished the river, shortages could have severely reduced output.[3]

Note that the efforts described above are not planned programmatic or long-term operational changes. They are emergency measures that individuals might pursue to alleviate what they consider a temporary condition. Thus, they are not characteristic of long-term management strategies designed to ensure more dependable water supplies such as capital investments in conservation technology or development of new water supplies.

To account for uncertainty regarding the relative magnitude of impacts to farm and business operations, the following analysis employs the concept of elasticity. Elasticity is a number that shows how a change in one variable will affect another. In this case, it measures the relationship between a percentage reduction in water availability and a percentage reduction in output. For example, an elasticity of 1.0 indicates that a 1.0 percent reduction in water availability would result in a 1.0 percent reduction in economic output. An elasticity of 0.50 would indicate that for every 1.0 percent of unavailable water, output is reduced by 0.50 percent and so on. Output elasticities used in this study are:[4]

- if unmet water needs are 0 to 5 percent of total water demand, no corresponding reduction in output is assumed;
- if water shortages are 5 to 30 percent of total water demand, for every 1.0 one percent of unmet need, there is a corresponding 0.25 percent reduction in output;
- if water shortages are 30 to 50 percent of total water demand, for every 1.0 one percent of unmet need, there is a corresponding 0.50 percent reduction in output; and
- if water shortages are greater than 50 percent of total water demand, for every 1.0 one percent of unmet need, there is a corresponding 1.0 percent (i.e., a proportional reduction).

Once output responses to water shortages were estimated, direct impacts to total sales, employment, regional income and business taxes were derived using regional level economic multipliers estimating using IO/SAM models. When calculating direct effects for the municipal, steam electric, manufacturing and livestock water use categories, sales to final demand were applied to avoid double counting impacts. The formula for a given IMPLAN sector is:

$$D_{i,t} = Q_{i,t} *_{,} S_{i,t} * E_Q * RFD_i * DM_{i(Q, L, I, T)}$$

where:

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[3] See, Royal, W. "*High And Dry - Industrial Centers Face Water Shortages*." in Industry Week, Sept, 2000.

[4] Elasticities are based on one of the few empirical studies that analyze potential relationships between economic output and water shortages in the United States. The study, conducted in California, showed that a significant number of industries would suffer reduced output during water shortages. Using a survey based approach researchers posed two scenarios to different industries. In the first scenario, they asked how a 15 percent cutback in water supply lasting one year would affect operations. In the second scenario, they asked how a 30 percent reduction lasting one year would affect plant operations. In the case of a 15 percent shortage, reported output elasticities ranged from 0.00 to 0.76 with an average value of 0.25. For a 30 percent shortage, elasticities ranged from 0.00 to 1.39 with average of 0.47. For further information, see, California Urban Water Agencies, "*Cost of Industrial Water Shortages*." Prepared by Spectrum Economics, Inc. November, 1991.

$D_{i,t}$ = direct economic impact to sector *i* in period *t*

$Q_{i,t}$ = total sales for sector *i* in period *t* in an affected county

$RFD_{i,}$ = ratio of final demand to total sales for sector *i* for a given region

$S_{i,t}$ = water shortage as percentage of total water use in period *t*

E_Q = elasticity of output and water use

$DM_{i(L, I, T)}$ = direct output multiplier coefficients for labor (L), income (I) and taxes (T) for sector *i*.

Direct impacts to irrigation and mining are based upon the same formula; however, total sales as opposed to final sales were used. To avoid double counting, secondary impacts in sectors other than irrigation and mining (e.g., manufacturing) were reduced by an amount equal to or less than direct losses to irrigation and mining. In addition, in some instances closely linked sectors were moved from one water use category to another. For example, although meat packers and rice mills are technically manufacturers, in some regions they were reclassified as either livestock or irrigation. All direct effects were estimated at the county level and then summed to arrive at a regional figure. See Section 2 of this report for additional discussion regarding methodology and caveats used when estimating direct impacts for each water use category.

Step 3: *Estimate Secondary and Total Economic Impacts of Water Shortages*

As noted earlier, the effects of reduced output would extend well beyond sectors directly affected. Secondary impacts were derived using the same formula used to estimate direct impacts; however, regional level *indirect* and *induced* multiplier coefficients were applied and only final sales were multiplied.

1.1.2 Impacts Associated with Domestic Water Uses

IO/SAM models are not well suited for measuring impacts of shortages for domestic uses, which make up the majority of the municipal category.[5] To estimate impacts associated with domestic uses, municipal water demand and thus needs were subdivided into two categories – residential and commercial. Residential water is considered “domestic” and includes water that people use in their homes for things such as cooking, bathing, drinking and removing household waste and for outdoor purposes including lawn watering, car-washing and swimming pools. Shortages to residential uses were valued using a tiered approach. In other words, the more severe the shortage, the more costly it becomes. For instance, a 2 acre-foot shortage for a group of households that use 10 acre-feet per year would not be as severe as a shortage that amounted to 8 acre-feet. In the case of a 2 acre-foot shortage, households would probably have to eliminate some or all outdoor water use, which could have implicit and explicit economic costs including losses to the horticultural and landscaping industry. In the case of an 8 acre-foot shortage, people would have to forgo all outdoor water use and most indoor water consumption. Economic costs would be much higher in this case because people could probably not live with such a reduction, and would be forced to find emergency alternatives. The alternative assumed in this study is a very uneconomical and worst-case scenario (i.e., hauling water in from other communities by truck or rail). Section 2.3.3 of this report discusses methodology for municipal uses in greater detail.

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[5] A notable exception is the potential impacts to the nursery and landscaping industry that could arise due to reductions in outdoor residential uses and impacts to “water intensive” commercial businesses (see Section 2.3.3).

1.2 Measuring Social Impacts

As the name implies, the effects of water shortages can be social or economic. Distinctions between the two are both semantic and analytical in nature – more so analytic in the sense that social impacts are much harder to measure in quantitative terms. Nevertheless, social effects associated with drought and water shortages usually have close ties to economic impacts. For example, they might include:

- demographic effects such as changes in population,
- disruptions in institutional settings including activity in schools and government,
- conflicts between water users such as farmers and urban consumers,
- health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations),
- mental and physical stress (e.g., anxiety, depression, domestic violence),
- public safety issues from forest and range fires and reduced fire fighting capability,
- increased disease caused by wildlife concentrations,
- loss of aesthetic and property values, and
- reduced recreational opportunities.[6]

Social impacts measured in this study focus strictly on demographic effects including changes in population and school enrollment. Methods are based on models used by the TWDB for state water planning and by the U.S. Census Bureau for national level population projections. With the assistance of the Texas State Data Center (TSDC), TWDB staff modified population projection models used for state water planning and applied them here. Basically, the social impact model incorporates results from the economic component of the study and assesses how changes in labor demand due to unmet water needs could affect migration patterns in a region. Before discussing particulars of the approach model, some background information regarding population projection models is useful in understanding the overall approach.

1.2.1 Overview of Demographic Projection Models

More often than not, population projections are reported as a single number that represents the size of an overall population. While useful in many cases, a single number says nothing about the composition of projected populations, which is critical to public officials who must make decisions regarding future spending on public services. For example, will a population in the future have more elderly people relative to today, or will it have more children? More children might mean that more schools are needed. Conversely, a population with a greater percentage of elderly people may need additional healthcare facilities. When projecting future populations, cohort-survival models break down a population into groups (i.e., cohorts) based on factors such as age, sex and race. Once a population is separated into cohorts, one can estimate the magnitude and composition of future population changes.

Changes in a population's size and makeup in survival cohort models are driven by three factors:

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[6] Based on information from the website of the National Drought Mitigation Center at the University of Nebraska Lincoln. Available online at: http://www.drought.unl.edu/risk/impacts.htm. See also, Vanclay, F. "*Social Impact Assessment*." in Petts, J. (ed) International Handbook of Environmental Impact Assessment. 1999.

1. *Births:* Obviously, more babies mean more people. However, only certain groups in a population are physically capable of bearing children– typically women between the ages of 13 and 49. The U.S. Census Bureau and the TSDC continually updates fertility rates for different cohorts. For each race/ethnicity category, birth rates decline and then stabilize in the future.

2. *Deaths:* When people die, populations shrink. Unlike giving birth, however, everyone is capable of dying and mortality rates are applied to all cohorts in a given population. Hence their name, cohort-survival models use survival rates as opposed to mortality rates. A survival rate is simply the probability that a given person with certain attributes (i.e., race, age and sex) will survive over a given period of time.

3. *Migration*: Migration is the movement of people in or out of a region. Migration rates used to project future changes in a region are usually based on historic population data. When analyzing historic data, losses or increases that are not attributed to births or deaths are assumed to be the result of migration. Migration can be further broken down into changes resulting from economic and non-economic factors. Economic migrants include workers and their families that relocate because of job losses (or gains), while non-economic migrants move due to lifestyles choices (e.g., retirees fleeing winter cold in the nation's heartland and moving to Texas).

In summary, knowledge of a population's composition in terms of age, sex and race combined with information regarding birth and survival rates, and migratory patterns, allows a great deal of flexibility and realism when estimating future populations. For example, an analyst can isolate population changes due to deaths and births from changes due to people moving in and out of a region. Or perhaps, one could analyze how potential changes in medical technology would affect population by reducing death rates among certain cohorts. Lastly, one could assess how changes in *economic conditions* might affect a regional population

1.2.2 Methodology for Social Impacts

Two components make up the model. The first component projects populations for a given year based on the following six steps:

1) *Separate "special" populations from the "general" population of a region:* The general population of a region includes the portion subject to rates of survival, fertility, economic migration and non-economic migration. In other words, they live, die, have children and can move in and out of a region freely. "Special populations," on the other hand, include college students, prisoners and military personnel. Special populations are treated differently than the general population. For example, fertility rates are not applied to prisoners because in general inmates at correctional facilities do not have children, and they are incapable of freely migrating or out of a region. Projections for special populations were compiled by the TSDC using data from the Higher Education Coordinating Board, the Texas Department of Criminal Justice and the U.S. Department of Defense. Starting from the 2000 Census, general and special populations were broken down into the following cohorts:

- age cohorts ranging from age zero to 75 and older,
- race/ethnicity cohorts, including Anglo, Black, Hispanic and "other," and
- gender cohorts (male and female).

2) *Apply survival and fertility rates to the general population* : Survival and fertility rates were compiled by the TSDC with data from the Texas Department of Health (TDH). Natural decreases (i.e., deaths) are estimated by applying survival rates to each cohort and then subtracting estimated deaths from the total population. Birth rates were then applied to females in each age

and race cohort in general and special populations (college and military only) to arrive at a total figure for new births.

3) *Estimate economic migration based on labor supply and demand*: TSDC year 2000 labor supply estimates include all non-disabled and non-incarcerated civilians between the ages of 16 and 65. Thus, prisoners are not included. Labor supply for years beyond 2001 was calculated by converting year 2000 data to rates according to cohort and applying these rates to future years. Projected labor demand was estimated based on historical employment rates. Differences between total labor supply and labor demand determines the amount of in or out migration in a region. If supply is greater than demand, there is an out-migration of labor. Conversely, if demand is greater than supply, there is an in-migration of labor. The number of migrants does not necessarily reflect total population changes because some migrants have families. To estimate how many people might accompany workers, a migrant worker profile was developed based on the U.S. Census Bureau's Public Use Microdata Samples (PUMs) data. Migrant profiles estimate the number of additional family members, by age and gender that accompany migrating workers. Together, workers and their families constitute economic migration for a given year.

4) *Estimate non-economic migration*: As noted previously, migration patterns of individuals age 65 and older are generally independent of economic conditions. Retirees usually do not work, and when they relocate, it is primarily because of lifestyle preferences. Migratory patterns for people age 65 or older are based on historical PUMs data from the U.S. Census.

5) *Calculate ending population for a given year*: The total year-ending population is estimated by adding together: 1) surviving population from the previous year, 2) new births, 3) net economic migration, 4) net non-economic migration and 5) special populations. This figure serves as the baseline population for the next year and the process repeats itself.

The second component of the social impact model is identical to the first and includes the five steps listed above for each year where water shortages are reported (i.e., 2010, 2020, 2030, 2040, 2050 and 2060). The only difference is that labor demand changes in years with shortages. Shifts in labor demand stem from employment impacts estimated as part of the economic analysis component of this study with some slight modifications. IMPLAN employment data is based on the number of full and part-time jobs as opposed to the number of people working. To remedy discrepancies, employment impacts from IMPLAN were adjusted to reflect the number of people employed by using simple ratios (i.e., labor supply divided by number of jobs) at the county level. Declines in labor demand as measured using adjusted IMPLAN data are assumed to affect net economic migration in a given regional water planning area. Employment losses are adjusted to reflect the notion that some people would not relocate but would seek employment in the region and/or public assistance and wait for conditions to improve. Changes in school enrollment are simply the proportion of lost population between the ages of 5 and 17.

1.3 Clarifications, Assumptions and Limitations of Analysis

As with any attempt to measure and quantify human activities at a societal level, assumptions are necessary and every model has limitations. Assumptions are needed to maintain a level of generality and simplicity such that models can be applied on several geographic levels and across different economic sectors. In terms of the general approach used here several clarifications and cautions are warranted:

1) While useful for planning purposes, this study is not a benefit-cost analysis (BCA). BCA is a tool widely used to evaluate the economic feasibility of specific policies or projects as opposed to estimating economic impacts of unmet water needs. Nevertheless, one could include some impacts measured in this study as part of a BCA if done so properly.

2) Since this is not a BCA, future impacts are not weighted differently. In other words, estimates are not “discounted.” If used as a measure of benefits in a BCA, one must consider the uncertainty of estimated monetary impacts.

3) All monetary figures are reported in constant year 2000 dollars.

4) Shortages reported by regional planning groups are the starting point for socioeconomic analyses. No adjustments or assumptions regarding the magnitude or distributions of unmet needs among different water use categories are incorporated in the analysis.

5) Estimated impacts are point estimates for years in which needs are reported (i.e., 2010, 2020, 2030, 2040, 2050 and 2060).They are independent and distinct “what if” scenarios for each particular year and water shortages are assumed to be temporary events resulting from severe drought conditions combined with infrastructure limitations. In other words, growth occurs and future shocks are imposed on an economy at 10-year intervals and resultant impacts are measured. Given, that reported figures are not cumulative in nature, it is inappropriate to sum impacts over the entire planning horizon. Doing so, would imply that the analysis predicts that drought of record conditions will occur every ten years in the future, which is not the case. Similarly, authors of this report recognize that in many communities needs are driven by population growth, and in the future total population will exceed the amount of water available due to infrastructure limitations, *regardless of whether or not there is a drought*. This implies that infrastructure limitations would constrain economic growth. However, since needs as defined by planning rules are based upon water supply and demand under the assumption of drought of record conditions, it improper to conduct economic analysis that focuses on growth related impacts over the planning horizon. Figures generated from such an analysis would presume a 50-year drought of record, which is unrealistic. Estimating lost economic activity related to constraints on population and commercial growth due to lack of water would require developing water supply and demand forecasts under “normal” or “most likely” future climatic conditions. *It is critical to stress that this is a modeling assumption necessary to maintain consistency with planning criteria, which states that water availability be evaluated assuming drought of record conditions. Analysis in this report does not predict that the drought of record will recur, nor does it predict or imply that growth will or should occur as projected.*

6) IO multipliers measure the strength of backward linkages to supporting industries (i.e., those who sell inputs to an affected sector). However, multipliers say nothing about forward linkages consisting of businesses that purchase goods from an affected sector for further processing. For example, ranchers in many areas sell most of their animals to local meat packers who process animals into a form that consumers ultimately see in grocery stores and restaurants. Multipliers do not capture forward linkages to meat packers, and since meat packers sell livestock purchased from ranchers as “final sales,” multipliers for the ranching sector do fully account for all losses to a region’s economy. Thus, as mentioned previously, in some cases closely linked sectors were moved from on water use category to another.

7) Cautions regarding interpretations of direct and secondary impacts are warranted. IO/SAM multipliers are based on ”fixed-proportion production functions,” which basically means that input use - including labor - moves in lockstep fashion with changes in levels of output. In a scenario where output (i.e., sales) declines, losses in the immediate sector or supporting sectors could be much less than predicted by an IO/SAM model for several reasons. For one, businesses will likely expect to continue operating so they might maintain spending on inputs for future use; or they may be under contractual obligations to purchase inputs for an extended period regardless of external conditions. Also, employers may not lay-off workers given that experienced labor is sometimes scarce and skilled personnel may not be readily available when water shortages subside. Lastly people who lose jobs might find other employment in the region. As a result, direct losses

for employment and secondary losses in sales and employment should be considered an *upper bound*. Similarly, since population projections are based on reduced employment in the region, they should be considered an upper bound as well.

8) IO models are static in nature. Models and resultant multipliers are based upon the structure of the U.S. and regional economies in the year 2000. In contrast, unmet water needs are projected to occur well into the future (i.e., 2010 through 2060). Thus, the analysis assumes that the general structure of the economy remains the same over the planning horizon.

9) With respect to municipal needs, an important assumption is that people would eliminate all outdoor water use before indoor water uses were affected, and people would implement emergency indoor water conservation measures before commercial businesses had to curtail operations, and households had to seek alternative sources of water. Section 2.3.3 discusses this in greater detail.

10) Impacts are annual estimates. If one were to assume that conditions persisted for more than one year, figures should be adjusted to reflect the extended duration. The drought of record in Texas for many communities lasted several years.

2. Economic Impacts

Part 2 of this report summarizes analysis for individual water use categories. Section 2.1 presents the year 2000 economic baseline for Region E. Section 2.2 summarizes results for agricultural water uses including livestock and irrigated crop production, while Section 2.3 reviews impacts to municipal and industrial water uses including manufacturing, mining, steam-electric and municipal demands. Attachment B of this report contains tables showing the distribution of impacts at the county level and city level (municipal uses only).

2.1 Economic Baseline

Table 2 summarizes baseline economic variables for Region E. In year 2000, economic output in the region totaled $29,741 million. This generated $14,866 million worth of income and supported approximately 347,897 jobs. Business and industry also contributed $1,209 million in taxes for state, local and federal governments. Sections 2.2.and 2.3 discuss contributions of individual water use categories in greater detail.

Table 2: Year 2000 Economic Baseline for Region E (monetary figures are reported in $millions)

	Sales Activity			Employment	Regional Income	Business Taxes
	Sales	Intermediate	Final			
Irrigation	$124.17	$22.51	$101.66	3,405	$38.23	$8.00
% of Total	<1%	<1%	<1%	<1%	1%	<1%
Livestock	$92.54	$27.32	$65.22	1,684	$33.57	$1.86
% of Total	<1%	<1%	<1%	<1%	<1%	<1%
Manufacturing	$8,095.35	$939.49	$7,155.86	40,928	$2,043.38	$73.67
% of Total	27%	17%	35%	12%	14%	6%
Mining	$152.96	$135.36	$17.60	352	$63.88	$7.47
% of Total	1%	2%	0%	0%	0%	1%
Municipal *	$20,979.19	$4,486.82	$12,995.78	300,898	$12,474.94	$1,079.90
% of Total	71%	79%	63%	87%	83%	90%
Steam Electric	$297.53	$70.39	$227.14	631	$212.78	$38.10
% of Total	1%	1%	1%	0%	1%	3%
Total	$29,741.74	$5,681.89	$20,563.25	347,897	$14,866.78	$1,209.01
% of Total	100%	100%	100%	100%	100%	100%

* Municipal includes all non-industrial commercial enterprises and institutional water uses such as the military, schools and other government organizations. Source: Generated using IMPLAN models and data from MIG, Inc.

2.2 Agriculture

In 2000, farmers in Region E using irrigation produced about $124 million dollars worth of crops that generated $38 million in regional income. The livestock industry contributed $33 million in wages, salaries and profits and supported an estimated 1,684 jobs.

2.2.1 Irrigation

The first step in estimating impacts to irrigation required calculating gross sales for IMPLAN crop sectors. Default IMPLAN data do not distinguish irrigated production from dry-land production. Once gross sales were known other statistics such as employment and income were derived using IMPLAN direct multiplier coefficients. Gross sales for a given crop are based on two data sources:

1) county-level statistics collected and maintained by the TWDB and the USDA Natural Resources Conservation Service (NRCS) including the number of irrigated acres by crop type and water application per acre, and

2) regional-level data published by the Texas Agricultural Statistics Service (TASS) including prices received for crops (marketing year averages), crop yields and crop acreages.

Crop categories used by the TWDB differ from those used in IMPLAN datasets. To maintain consistency, sales and other statistics are reported using IMPLAN crop classifications. Table 3 shows the TWDB crops included in corresponding IMPLAN sectors. Table 4 summarizes acreage and estimated annual water use for each crop classification (year 2000). Table 5 shows year 2000 economic data for irrigated crop production in the region. When measured in dollars, cotton, hay and pasture (primarily alfalfa) and tree-nuts (pecans) are the largest sectors.

Table 3: Crop Classifications Used in TWDB Water Use Survey and Corresponding IMPLAN Crop Sectors Applied in Socioeconomic Impact Analysis

IMPLAN Sector	TWDB Sector
Cotton	Cotton
Feed Grains	Corn, sorghum and “forage crops”
Food Grains	Rice, wheat and "other grains"
Fruits	Citrus
Hay and Pasture	Alfalfa and “other hay and pasture”
Oil Crops	Peanuts, soybeans and “other oil crops”
Sugar Crops	Sugarbeets and sugarcane
Tree Nuts	Pecans
Vegetables *	Deep-rooted vegetables, shallow-rooted vegetables and potatoes
Other Crops	"All other crops" "other orchards" and vineyards

* includes melons.

Table 4. Summary of Irrigated Crop Acreage and Water Use in Region E (Year 2000)				
Sector	Acres (1000s)	Distribution of Acres	Water Use (1000s of AF)	Distribution of Water Use
Cotton	46.5	33%	131.5	26%
Food Grains	13.0	9%	48.5	10%
Feed Grains	19.8	14%	66.9	13%
Hay and Pasture	40.3	28%	168.5	33%
Tree Nuts	11.5	8%	60.7	12%
Vegetables	11.4	8%	30.2	6%
Other	0.5	<1%	1.9	<1%
Total	142.9	100%	508.27	100%

Source: Water demand figures are taken from the Texas Water Development Board 2006 Water Plan Projections data for year 2000. Statistics for irrigated crop acreage are based upon annual survey data collected by the TWDB and the National Resources Conservation Service (USDA).

Table 5: Year 2000 Baseline for Irrigation in Region E (monetary figures reported in $millions)						
Sector	Sales Activity			Jobs	Regional Income	Business Taxes
	Total	Intermediate	Final			
Cotton	$37.20	$1.17	$36.03	427	$13.50	$2.97
Hay and Pasture	$36.27	$4.02	$32.25	2,048	$8.58	$3.26
Tree Nuts	$25.88	$12.43	$13.44	582	$6.43	$0.67
Vegetables	$21.43	$4.33	$17.10	260	$8.28	$0.77
Food Grains	$2.57	$0.29	$2.29	54	$1.18	$0.26
Feed Grains	$0.78	$0.25	$0.53	33	$0.24	$0.07
Total	$124.17	$22.51	$101.66	3,405	$38.23	$8.00

Based on data from the Texas Water Development Board, the Texas Agricultural Statistics Service and the Minnesota IMPLAN Group, Inc.

An important consideration when estimating impacts to irrigation was determining which crops are affected by water shortages. One approach is the so-called rationing model, which assumes that farmers respond to water supply cutbacks by fallowing the lowest value crops in the region first and the highest valued crops last until the amount of water saved equals the shortage.[7] For example, if farmer A grows vegetables (higher value) and farmer B grows wheat (lower value) and they both face a proportionate cutback in irrigation water, then farmer B will sell water to farmer A. Farmer B will fallow her irrigated acreage before farmer A fallows anything. Of course, this assumes that farmers can and do transfer enough water to allow this to happen. A different approach involves constructing farm-level profit maximization models that conform to widely-accepted economic theory that farmers make decisions based on marginal net returns.

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7 The rationing model was initially proposed by researchers at the University of California at Berkeley, and was then modified for use in a study conducted by the U.S. Environmental Protection Agency that evaluated how proposed water supply cutbacks recommended to protect water quality in the Bay/Delta complex in California would affect farmers in the Central Valley. See, Zilberman, D., Howitt, R. and Sunding, D. "*Economic Impacts of Water Quality Regulations in the San Francisco Bay and Delt*a." Western Consortium for Public Health. May 1993.

Such models have good predictive capability, but data requirements and complexity are high. Given that a detailed analysis for each region would require a *substantial* amount of farm-level data and analysis, the following investigation assumes that projected shortages are distributed equally across predominant crops in the region. “Predominant” in this case are crops that comprise at least one percent of total acreage in the region (see Table 4).

The following steps outline the general approach used to estimate direct impacts to irrigated agriculture in all planning areas:

1. *Distribute shortages across predominant crop types in the region*. Again, unmet water needs were distributed equally across crop sectors that constitute one percent or more of irrigated acreage in 2000.

2. *Estimate associated reductions in output for affected crop sectors*. Output reductions are based on elasticities discussed in Section 1.2.1 and on estimated values per acre for different crops. Values per acre stem from the same data used to estimate output for the year 2000 baseline. Given that 2000 may have been an unusually poor or productive year for some crops and not necessarily representative of normal conditions, statistics regarding yield, price and acreage for crop sectors were averaged over a five-year period (1995-2000) if sufficient data were available.

3. *Offset reductions in output by revenues from dry-land production.* If TASS acreage data indicate that farmers grow a dry-land version of a given crop in the region (e.g., cotton or corn), estimated losses from irrigated acreage are offset by assumed revenues from dry-land harvests. Basically, the analysis assumes that farmers who use irrigation would try and grow something even if irrigation water were not available. **However, given the extremely arid conditions that would prevail in Region E during a drought of record, it is assumed that dry-land output would be nominal and it is not considered as part of the analysis.**

Table 6: Data Used to Estimate Impacts to Irrigated Crop Production in Region E

Crop sector	Gross sales revenue per irrigated acre	Data Sources for yield, prices and planted acreage used to estimate gross sales per acre
Cotton	$800	Based on Trans-Pecos District CEB data for “Irrigated Cotton.”
Food Grains	$60	Based on TAMU Crop Enterprise Budgets for West Texas “Wheat Sprinkler Irrigated”
Feed Grains	$130	Based on TAMU Crop Enterprise Budgets for West Texas for “Hybrid Sudan Sorghum”
Hay and Pasture	$900	Based on Trans-Pecos District CEB data for “Irrigated Alfalfa.”
Tree Nuts	$2,250	Based on TAMU Crop Enterprise Budgets for West Texas.
Vegetables	$1,880	Average *weighted* by acreage for “Shallow-rooted Vegetables” and “Deep-rooted Vegetables.” Based on data from TASS statewide surveys for vegetable crops (5-year averages values from 1995-2000).

*All values are rounded. TASS = Texas Agricultural Statistics Service. TAMU = Texas A&M University.

The Region E 2006 Water Plan indicates that under drought of record conditions, irrigation water shortages would occur in El Paso, Hudspeth and Presidio counties. Table 7 summarizes estimated impacts to domestic uses, commercial businesses, water utilities and the horticultural industry.

Table 7: Annual Economic Impacts Associated with Unmet Irrigation Water Needs
(years 2010, 2020, 2030, 2040, 2050 and 2060, constant year 2000 dollars)

Year	Sales ($millions)	Regional Income ($millions)	Jobs	Business Taxes ($millions)
2010	$84.99	$31.57	1,465	$1.31
2020	$83.97	$31.19	1,445	$1.23
2030	$83.21	$30.91	1,435	$1.29
2040	$79.45	$30.31	1,405	$1.26
2050	$80.53	$29.91	1,390	$1.24
2060	$79.45	$29.51	1,370	$1.23

* Estimates are based on projected economic activity in the region. Source: Based on economic impact models developed by the Texas Water Development Board, Office of Water Planning.

2.2.2 Livestock

No shortages for livestock were reported for Region E.

2.3 Municipal and Industrial Uses

Municipal and industrial (M&I) water uses make up the overwhelming majority of economic activity in Region E. In 2000, M&I users generated $29,525 million in sales and nearly $14,794 million in income for residents in the region. M&I added $1,199 million to state, local and federal coffers and provided an estimated 342,808 jobs for people in the region.

2.3.1 Mining

No shortages for mining were reported for Region E.

2.3.2 Manufacturing

No shortages for manufacturing were reported for Region E.

2.3.3 Municipal

Table 8 summarizes economic activity for municipal uses. In 2000, businesses and institutions that make up the municipal category produced nearly $20,979 million worth of goods and services. In return, they received $12,474 million in wages, salaries and profits. Municipal uses generate the bulk of business taxes in the region –$1,079 million (90 percent of all business taxes generated in the region). Top commercial sectors in terms of income and output include real estate, wholesale trade, federal and state government, transportation, banking, doctors and dentists and restaurants.

Table 8: Year Baseline for Municipal Uses (monetary figures reported in $millions)							
Sector	Sales Activity			Jobs	Regional Income	Business Taxes
	Total	Intermediate	Final			
Real Estate	$1,433.32	$393.14	$1,040.18	7,006	$850.00	$169.56
Wholesale Trade	$1,428.93	$749.08	$679.86	14,981	$783.40	$203.78
Federal Government (Military)	$1,144.85	na	na	11,870	$1,144.85	$0.00
State & Local Government (Education)	$1,051.81	na	na	31,998	$1,051.81	$0.00
Motor Freight Transport and Warehousing	$895.41	$403.25	$492.16	8,783	$351.15	$11.03
Eating & Drinking Establishments	$709.05	$37.32	$671.73	20,514	$321.06	$44.80
All other municipal sectors	$14,315.82	$2,904.03	$10,111.86	205,747	$7,972.67	$650.73
Total	$20,979.19	$4,486.82	$12,995.78	300,898	$12,474.94	$1,079.90

"na" = not applicable. Source: Generated using IMPLAN models and data from MIG, Inc.

Estimating direct economics impacts for the municipal category is complicated for a number of reasons. For one, municipal uses comprise a range of different consumers including commercial businesses, institutions (e.g., schools and government) and households. However, reported shortages do not specify how needs are distributed among different consumers. In other words, how much of a municipal need is commercial and how much is residential? The amount of commercial water use as a percentage of total municipal demand was estimated based on "GED" coefficients (gallons per employee per day) published in secondary sources (see Attachment A). For example, if year 2000 baseline data for a given economic sector (e.g., amusement and recreation services) shows employment at 30 jobs and the GED coefficient is 200, then average daily water use by that sector is (30 x 200 = 6,000 gallons) and thus annual use is 6.7 acre-feet. Water not attributed to commercial use is considered domestic, which includes single and multi-family residential consumption, institutional uses and all use designated as "county-other." The estimated proportion of water used for commercial purposes ranges from about 5 to 35 percent of total municipal demand at the county level. Less populated rural counties occupy the lower end of the spectrum, while larger metropolitan counties are at the higher end.

As mentioned earlier, a key study assumption is that people would eliminate outdoor water use before indoor water consumption was affected; and they would implement *voluntary* emergency indoor water conservation measures before people had to curtail business operations or seek emergency sources of water. This is logical because most water utilities have drought contingency plans. Plans usually specify curtailment or elimination of outdoor water use during periods of drought. In Texas, state law requires retail and wholesale water providers to prepare and submit plans to the Texas Commission on Environmental Quality (TCEQ). Plans must specify demand management measures for use during drought including curtailment of "non-essential water uses."[8] Thus, when assessing municipal needs there are several important considerations:

[8] Non-essential uses include, but are not limited to, landscape irrigation and water for swimming pools or fountains. For further information see the Texas Environmental Quality Code §288.20.

1) how much of a need would people reduce via eliminating outdoor uses and implementing emergency indoor conservation measures; and 2) what are the economic implications of such measures?

Determining how much water is used for outdoor purposes is key to answering these questions. The proportion used here is based on several secondary sources. The first is a major study sponsored by the American Water Works Association, which surveyed cities in states including Colorado, Oregon, Washington, California, Florida and Arizona. On average across all cities surveyed 58 percent of residential water use was for outdoor activities. In cities with climates comparable to large metropolitan areas of Texas, the average was 40 percent.[9]Earlier findings of the U.S. Water Resources Council showed a national average of 33 percent. Similarly, the United States Environmental Protection Agency (USEPA) estimated that landscape watering accounts for 32 percent of total residential and commercial water use on annual basis.[10] A study conducted for the California Urban Water Agencies (CUWA) calculated values ranging from 25 to 35 percent.[11] Unfortunately, there does not appear to be any comprehensive research that has estimated non-agricultural outdoor water use in Texas. As an approximation, an average annual value of 30 percent based on the above references was selected to serve as a rough estimate in this study. With respect to emergency indoor conservation measures, this analysis assumes that citizens in affected communities would reduce needs by an additional 20 percent. Thus, 50 percent of total needs could be eliminated before households and businesses had to implement emergency water procurement activities.

Eliminating outdoor watering would have a range of economic implications. For one, such a restriction would likely have adverse impacts on the landscaping and horticultural industry. If people are unable to water their lawns, they will likely purchase less lawn and garden materials such as plants and fertilizers. On the other hand, during a bad drought people may decide to invest in drought tolerant landscaping, or they might install more efficient landscape plumbing and other water saving devices. But in general, the horticultural industry would probably suffer considerable losses if outdoor water uses were restricted or eliminated. For example, many communities in Colorado, which is in the midst of a prolonged drought, have severely restricted lawn irrigation. In response, the turf industry in Colorado has laid off at least 50 percent of its 2,000 employees.[12] To capture impacts to the horticultural industry, regional sales net of exports for the greenhouse and nursery sectors and the landscaping services sector were reduced by proportion equal to reductions in outdoor water use. Note that these losses would not necessarily appear as losses to the regional or state economies because people would likely spend the money that they would have spent on landscaping on other goods in the economy. Thus, the net effect to state or regional accounts could be neutral.

Other considerations include the "welfare" losses to consumers who had to forgo outdoor and indoor water uses to reduce needs. In other words, the water that people would have to give up has an economic value. Estimating the economic value of this forgone water for each planning area would be a very time consuming and costly task, and thus secondary sources served as a proxy. Previous research funded by the TWDB, explored consumer "willingness to pay" for

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[9] See, Mayer, P.W., DeOreo, W.B., Opitz, E.M., Kiefer, J.C., Davis, W., Dziegielewski, D., Nelson, J.O. "*Residential End Uses of Water*." Research sponsored by the American Water Works Association and completed by Aquacraft, Inc. and Planning and Management Consultants, Ltd. (PMCL@CDM).

[10] U.S. Environmental Protection Agency. *"Cleaner Water through Conservation*." USEPA Report no. 841-B-95-002. April, 1995.

[11] Planning and Management Consultants, Ltd. "*Evaluating Urban Water Conservation Programs: A Procedures Manual*." Prepared for the California Urban Water Agencies. February 1992.

[12] Based on assessments of the Rocky Mountain Sod Growers. See, "*Drought Drying Up Business for Landscapers*." Associated Press. September, 17 2002.

avoiding restrictions on water use.[13] Surveys revealed that residential water consumers in Texas would be willing to pay – on average across all income levels - $36 to avoid a 30 percent reduction in water availability lasting for at least 28 days. Assuming the average person in Texas uses 140 gallons per day and the typical household in the state has 2.7 persons (based on U.S. Census data), total monthly water use is 13,205 gallons per household. Therefore, the value of restoring 30 percent of average monthly water use during shortages to residential consumers is roughly one cent per gallon or $2,930 per acre-foot. This figure serves as a proxy to measure consumer welfare losses that would result from restricted outdoor uses and emergency indoor restrictions.

The above data help address the impacts of incurring water needs that are 50 percent or less of projected use. Any amount greater than 50 percent would result in municipal water consumers having to seek alternative sources. Costs to residential and non-water intensive commercial operations (i.e., those that use water only for sanitary purposes) are based on the most likely alternative source of water in the absence of water management strategies. In this case, the most likely alternative is assumed to be "hauled-in" water from other communities at annual cost of $6,530 per acre-foot for small rural communities and approximately and $10,995 per acre-foot for metropolitan areas.[14]

This is not an unreasonable assumption. It happened during the 1950s drought and more recently in Texas and elsewhere. For example, in 2000 at the heels of three consecutive drought years Electra - a small town in North Texas - was down to its last 45 days worth of reservoir water when rain replenished the lake, and the city was able to refurbish old wells to provide supplemental groundwater. At the time, residents were forced to limit water use to 1,000 gallons per person per month - less than half of what most people use - and many were having water hauled delivered to their homes by private contractors.[15] In 2003 citizens of Ballinger, Texas, were also faced with a dwindling water supply due to prolonged drought. After three years of drought, Lake Ballinger, which supplies water to more than 4,300 residents in Ballinger and to 600 residents in nearby Rowena, was almost dry. Each day, people lined up to get water from a well in nearby City Park. Trucks hauling trailers outfitted with large plastic and metal tanks hauled water to and from City Park to Ballinger.[16] In Australia, four cities have run out of water as a result of drought, and residents have been trucking in water since November 2002. One town has five trucks carting about one acre-foot eight times daily from a source 20 miles away. They had to build new roads and infrastructure to accommodate the trucks. Residents are currently restricted to indoor water use only.[17]

Direct impacts to commercial sectors were estimated in a fashion similar to other business sectors. Output was reduced among "water intensive" commercial sectors according to the severity of projected shortages. Water intensive is defined as non-medical related sectors that are heavily dependent upon water to provide their services. These include:

- car-washes,
- laundry and cleaning facilities,

[13] See, Griffin, R.C., and Mjelde, W.M. "*Valuing and Managing Water Supply Reliability*. Final Research Report for the Texas Water Development Board: Contract no. 95-483-140." December 1997.

[14] For rural communities, figure assumes an average truck hauling distance of 50 miles at a cost of 8.4 cents per ton-mile (an acre foot of water weighs about 1,350 tons) with no rail shipment. For communities in metropolitan areas, figure assumes a 50 mile truck haul, and a rail haul of 300 miles at a cost of 1.2 cents per ton-mile. Cents per ton-mile are based on figures in: Forkenbrock, D.J., "*Comparison of External Costs of Rail and Truck Freight Transportation*." Transportation Research. Vol. 35 (2001).

[15] Zewe, C. "*Tap Threatens to Run Dry in Texas Town*." July 11, 2000. CNN Cable News Network.

[16] Associated Press, "*Ballinger Scrambles to Finish Pipeline before Lake Dries Up*." May 19, 2003.

[17] Healey, N. (2003) *Water on Wheels*, Water: Journal of the Australian Water Association, June 2003.

- sports and recreation clubs and facilities including race tracks,
- amusement and recreation services,
- hotels and lodging places, and
- eating and drinking establishments.

For non-water intensive sectors, it is assumed that businesses would haul water by truck and/or rail.

An example will illustrate the breakdown of municipal water needs and the overall approach to estimating impacts of municipal needs. Assume City B has an unmet need of 50 acre feet in 2020 and projected demands of 200 acre-feet. In this case, residents of City B could eliminate needs via restricting all outdoor water use. City A, on the other hand, has an unmet need of 150 acre-feet in 2020 with a projected demand of 200 acre-feet. Thus, total shortages are 75 percent of total demand. Emergency outdoor and indoor conservation measures would eliminate 50 percent of projected needs; however, 50 acre-feet would still remain. This remaining portion would result in costs to residential and commercial water users. Water intensive businesses such as car washes, restaurants, motels, race tracks would have to curtail operations (i.e., output would decline), and residents and non-water intensive businesses would have to have water hauled-in assuming it was available.

The last element of municipal water shortages considered focused on lost water utility revenues. Estimating these was straightforward. Analyst used annual data from the "*Water and Wastewater Rate Survey*" published annually by the Texas Municipal League to calculate an average value per acre-foot for water and sewer. For water revenues, averages rates multiplied by total water needs served as a proxy. For lost wastewater, total unmet needs were adjusted for return flow factor of 0.60 and multiplied by average sewer rates for the region. Needs reported as "county-other" were excluded under the presumption that these consist primarily of self-supplied water uses. In addition, 15 percent of water demand and needs are considered non-billed or "unaccountable" water that comprises things such leakages and water for municipal government functions (e.g., fire departments). Lost tax receipts are based on current rates for the "miscellaneous gross receipts tax, "which the state collects from utilities located in most incorporated cities or towns in Texas.

The Region E 2006 Water Plan indicates that under drought of record conditions municipal water shortages would occur in communities throughout El Paso County. Tables 9 through 12 summarize estimated impacts to domestic uses, commercial businesses, water utilities and the horticultural industry.

Table 9: Annual Economic Impacts of Unmet Water Needs for Commercial Businesses
(years 2010, 2020, 2030, 2040, 2050 and 2060, constant year 2000 dollars)

Year	Sales ($millions)	Regional Income ($millions)	Jobs	Business Taxes ($millions)
2010	$111.22	$68.84	2,995	$6.24
2020	$123.52	$76.46	3,326	$6.92
2030	$160.14	$99.12	4,312	$17.20
2040	$188.40	$99.12	5,073	$8.98
2050	$243.05	$150.44	6,545	$13.63
2060	$306.72	$189.85	8,259	$17.20

* Estimates are based on *projected* economic activity in the region. Source: Source: Texas Water Development Board, Office of Water Resources Planning.

Table 10: Annual Economic Impacts of Unmet Water Needs for the Horticultural Industry
(years 2010, 2020, 2030, 2040, 2050 and 2060, constant year 2000 dollars)

Year	Sales ($millions)	Regional Income ($millions)	Jobs	Business Taxes ($millions)
2010	$3.46	$1.93	110	$0.08
2020	$7.35	$4.08	230	$0.17
2030	$11.67	$6.47	365	$0.27
2040	$15.52	$8.60	490	$0.36
2050	$17.92	$9.93	565	$0.41
2060	$23.75	$13.16	750	$0.55

Source: Generated by the Texas Water Development Board, Office of Water Resources Planning.

Table 11: Annual Impacts Associated with Unmet Domestic Water Needs
(years 2010, 2020, 2030, 2040, 2050 and 2060, constant year 2000 dollars)

Year	$millions
2010	$57.54
2020	$132.47
2030	$202.79
2040	$262.75
2050	$326.31
2060	$392.23

Source: Generated by Texas Water Development Board, Office of Water Resources Planning.

Table 12: Impacts to Water Utilities
(years 2010, 2020, 2030, 2040, 2050 and 2060, constant year 2000 dollars)

Year	Revenues ($millions)	Utility Taxes ($millions)
2010	$13.48	$0.24
2020	$35.72	$0.63
2030	$56.83	$1.00
2040	$75.08	$1.32
2050	$94.54	$1.66
2060	$113.97	$2.01

Source: Texas Water Development Board, Office of Water Resources Planning.

2.3.4 Steam Electric

The steam electric sector represents economy activity associated with retail and wholesale transactions of electricity. As shown in Table 13, in 2000 the electric services sector generated annual sales of approximately $297 million that resulted in nearly $212 million in income for Region E residents. Electric utilities support 630 full and part-time jobs.

Table 13:Year 2000 Direct Economic Activity Associated with Steam Electric Production in Region E (monetary figures are in $millions)

Sector	Sales Activity			No. of Jobs	Regional Income	Business Taxes
	Total	Intermediate	Final			
Electric Services	$297.53	$70.39	$227.14	631	$212.78	$38.10

Source: Generated using data from MIG, Inc., and models developed by the TWDB using IMPLAN software.

Without adequate cooling water, power plants cannot safely operate. As water availability falls below projected demands, water levels in lakes and rivers that provide cooling water would also decline, particularly during drought when surface flows are reduced. Low water levels could affect raw water intakes and water discharge outlets (i.e., outfalls) at power facilities in several ways. For one, power plants are regulated by thermal emission guidelines that specify the maximum amount of heat that can go back into a river or lake via discharged cooling water. Low lake or river levels could result in permit compliance issues due to reduced dilution and dispersion of heat and subsequent impacts on aquatic biota near outfalls.[18] But the primary concern would be a loss of head (i.e., pressure) over intake structures that would decrease flows through intake tunnels. This could affect safety related pumps, increase operating costs and/or result in sustained shut-downs. Assuming plants did shutdown, they would not be able to generate electricity, which implies that output (i.e., sales of electricity) would decline.

Among all water use categories, steam-electric is unique and cautions are necessary when applying methods used in this study. Measured changes to an economy using input-output models stem directly from changes in sales revenue. In the case of water shortages, one assumes that businesses will suffer lost output if process water is in short supply. For power generation facilities this is true as well. However, the electric services sector in IMPLAN represents a corporate entity that may own and operate several power plants in a given region. If one plant became inoperable due to water shortages, plants in other areas or generation facilities that do not rely heavily water (e.g., gas powered turbines or "peaking plants") might be able to compensate for lost generating capacity. Utilities could also offset lost production via purchases on the spot market.[19] Thus, to presume that electricity would stop flowing may be unrealistic, but to maintain consistency, the model assumes that water shortages would result in lost sales of

[18] Section 316 (b) of the Clean Water Act requires that thermal wastewater discharges do not harm fish and other wildlife.

[19] Today, most utilities participate in large interstate "power pools" and can buy or sell electricity "on the grid" from other utilities or power marketers. Thus, assuming power was available to buy, and assuming that no contractual or physical limitations were in place (e.g., transmission constraints); utilities could offset lost power that resulted from waters shortages with purchases via the power grid.

electricity.[20] Another related consideration is that IMPLAN output data report all sales transactions for particular utility in a given county - including sales generated from stations outside a county. As a countermeasure, analysts estimated sales for affected counties using production and price data from the U.S. Energy Information Administration.

The Region E 2006 Water Plan indicates that under drought of record conditions, steam-electric water shortages would occur in El Paso County in the Rio Grande River Basin. Table 14 summarizes estimated impacts.

Table 14: Annual Economic Impacts of Unmet Water Needs for Steam-electric Water Uses (years 2010, 2020, 2030, 2040, 2050 and 2060, constant year 2000 dollars)

Year	Total Sales	Regional Income ($millions)	Jobs	Business Taxes
2010	$0.00	$0.00	0	$0.00
2020	$14.00	$9.57	60	$1.71
2030	$96.90	$66.23	400	$11.86
2040	$175.75	$120.13	720	$21.51
2050	$503.76	$344.32	2,065	$61.66
2060	$689.47	$471.25	2,830	$84.39

Source: Texas Water Development Board Office of Water Resources Planning.

3. Regional Social Impacts

As discussed previously in Section 1.2, estimated social impacts focus changes including population loss and subsequent related in school enrollment. As shown in Table 15, water shortages in 2010 could result in a population loss of 7,960 people with a corresponding reduction is school enrollment of 2,060. Models indicate that shortages in 2060 could cause population in the region to fall by 23,020 people and school enrollment by 5,970 students.

[20] Losses offset through grid purchases or from peaking plants would likely result in higher production costs, which utilities would ultimately pass on to consumers in the form of higher utility bills. Determining the impacts of higher costs is not considered in this study.

Table 15: Estimated Regional Social Impacts of Unmet Water Needs (years, 2010, 2020, 2030, 2040, 2050 and 2060)		
Year	Population Losses	Declines in School Enrollment
2010	7,960	2,060
2020	8,820	2,280
2030	11,350	2,940
2040	13,400	3,470
2050	18,410	4,770
2060	23,020	5,970
Source: Generated by the Texas Water Development Board, Office of Water Planning.		

Attachment A: Baseline Regional Economic Data

Tables A-1 through A-6 contain data from several sources that form a basis of analyses in this report. Economic statistics were extracted and processed via databases purchased from MIG, Inc. using IMPLAN Pro™ software. Values for gallons per employee (i.e. GED coefficients) for the municipal water use category are based on several secondary sources.[21] County-level data sets along with multipliers are not included given their large sizes (i.e., 528 sectors per county each with 12 different multiplier coefficients). Fields in Tables A-1 through A-6 contain the following variables:

- *GED -* average gallons of water use per employee per day (municipal use only);
- *total sales -* total industry production measured in millions of dollars (equal to shipments plus net additions to inventories);
- *intermediate sales -* sales to other industries in the region measured in millions of dollars;
- *final sales -* sales to end-users including sales to households in the region and exports out of the region;
- *jobs -* number of full and part-time jobs (annual average) required by a given industry;
- *regional income* - total payroll costs (wages and salaries plus benefits), proprietor income, corporate income, rental income and interest payments;
- *business taxes –* sales taxes, excise taxes, fees, licenses and other taxes paid during normal business operations (includes all payments to federal, state and local government except income taxes).

[21] Sources for GED coefficients include: Gleick, P.H., Haasz, D., Henges-Jeck, C., Srinivasan, V., Wolff, G. Cushing, K.K., and Mann, A. "*Waste Not, Want Not*: *The Potential for Urban Water Conservation in California*." Pacific Institute. November 2003. U.S. Bureau of the Census. 1982 Census of Manufacturers: Water Use in Manufacturing. USGPO, Washington D.C. See also: "*U.S. Army Engineer Institute for Water Resources, IWR Report 88-R-6.*," Fort Belvoir, VA. See also, Joseph, E. S., 1982, "*Municipal and Industrial Water Demands of the Western United States*." Journal of the Water Resources Planning and Management Division, Proceedings of the American Society of Civil Engineers, v. 108, no. WR2, p. 204-216. See also, Baumann, D. D., Boland, J. J., and Sims, J. H., 1981, "*Evaluation of Water Conservation for Municipal and Industrial Water Supply*." U.S. Army Corps of Engineers, Institute for Water Resources, Contract no. 82-C1.

Table A-1: Baseline Economic Data for Irrigated Crops in Region E (Year 2000)

Sector	Total Sales	Intermediate Sales	Final Sales	Jobs	Regional Income	Business Taxes
Cotton	$37.20	$1.17	$36.03	427	$13.50	$2.97
Food Grains	$0.78	$0.25	$0.53	33	$0.24	$0.07
Feed Grains	$2.57	$0.29	$2.29	54	$1.18	$0.26
Hay and Pasture	$36.27	$4.02	$32.25	2,048	$8.58	$3.26
Tree Nuts	$25.88	$12.43	$13.44	582	$6.43	$0.67
Vegetables	$21.43	$4.33	$17.10	260	$8.28	$0.77
Total	$124.13	$22.49	$101.64	3,403	$38.21	$8.00

Table A-2: Baseline Economic Data for Livestock Sectors, Region E (Year 2000)

Sector	Total Sales	Intermediate Sales	Final Sales	Jobs	Regional Income	Business Taxes
Dairy Farm Products	$28.42	$14.55	$13.87	293	$8.15	$0.06
Poultry and Eggs	$0.88	$0.17	$0.71	6	$0.18	$0.00
Ranch Fed Cattle	$1.62	$0.22	$1.39	47	$0.33	$0.02
Range Fed Cattle	$41.33	$11.01	$30.32	1044	$11.59	$0.75
Cattle Feedlots	$17.84	$1.06	$16.78	131	$12.61	$0.99
Sheep, Lambs and Goats	$0.98	$0.09	$0.88	105	$0.37	$0.02
Hogs, Pigs and Swine	$0.24	$0.02	$0.23	4	$0.04	$0.00
Other Meat Animal Products	$0.46	$0.04	$0.42	11	$0.12	$0.01
Miscellaneous Livestock	$0.77	$0.15	$0.62	43	$0.19	$0.00
Total	$92.54	$27.32	$65.22	1684	$33.57	$1.86

Table A-3: Baseline Economic Data for Manufacturing Sectors, Region E (Year 2000)

Sector	Total Sales	Intermediate Sales	Final Sales	Jobs	Regional Income	Business Taxes
Adhesives and Sealants	$0.71	$0.53	$0.18	2	$0.30	$0.01
Agricultural, Forestry, Fishery Services	$12.79	$4.16	$8.63	754	$6.87	$0.30
Aircraft	$22.22	$1.05	$21.17	86	$5.16	$0.20
Aircraft and Missile Engines and Parts	$36.79	$3.95	$32.84	160	$13.46	$0.34
Aircraft and Missile Equipment,	$24.28	$0.26	$24.02	153	$12.64	$0.25
Aluminum Foundries	$0.51	$0.06	$0.45	5	$0.19	$0.00
Animal and Marine Fats and Oils	$12.84	$7.84	$5.00	55	$2.88	$0.07
Apparel Made From Purchased	$1,173.30	$27.14	$1,146.16	10709	$310.73	$5.11
Architectural Metal Work	$24.40	$0.83	$23.56	358	$11.41	$0.19
Asphalt Felts and Coatings	$1.11	$1.07	$0.04	3	$0.75	$0.01
Automatic Temperature Controls	$2.94	$2.42	$0.52	40	$1.65	$0.03
Automotive and Apparel Trimmings	$7.86	$6.43	$1.43	58	$1.29	$0.04
Automotive Stampings	$29.07	$11.19	$17.88	183	$5.54	$0.19
Bags, Plastic	$1.00	$0.01	$1.00	5	$0.28	$0.01
Blast Furnaces and Steel Mills	$100.05	$9.99	$90.05	312	$17.95	$0.85
Book Publishing	$75.81	$2.45	$73.36	366	$18.80	$0.65
Bottled and Canned Soft Drinks & Water	$113.77	$0.49	$113.28	352	$20.04	$0.73
Bread, Cake, and Related Products	$37.14	$11.46	$25.68	212	$13.60	$0.23
Brick and Structural Clay Tile	$0.28	$0.00	$0.28	3	$0.10	$0.00
Brooms and Brushes	$2.11	$0.20	$1.91	27	$0.85	$0.02
Burial Caskets and Vaults	$1.82	$0.21	$1.61	28	$1.42	$0.02
Canned Specialties	$223.00	$1.13	$221.87	544	$58.41	$1.35
Canvas Products	$0.44	$0.26	$0.17	7	$0.17	$0.00
Carbon Paper and Inked Ribbons	$7.67	$0.16	$7.52	56	$4.21	$0.11
Ceramic Wall and Floor Tile	$14.89	$0.50	$14.39	231	$4.45	$0.12
Chemical Preparations, N.E.C	$2.01	$1.30	$0.71	5	$0.74	$0.02
Coated Fabrics, Not Rubberized	$2.91	$0.08	$2.83	18	$0.52	$0.02
Cold Finishing Of Steel Shapes	$1.65	$0.16	$1.48	8	$0.32	$0.01
Commercial Fishing	$24.57	$1.07	$23.50	816	$22.28	$0.78
Commercial Printing	$80.86	$43.47	$37.40	754	$24.94	$0.75

Table A-3: Baseline Economic Data for Manufacturing Sectors, Region E (Year 2000)

Communications Equipment N.E.C.	$12.69	$6.31	$6.38	182	$7.07	$0.10
Computer Peripheral Equipment,	$7.36	$2.58	$4.78	24	$1.79	$0.06
Concrete Block and Brick	$13.24	$0.13	$13.11	84	$4.33	$0.19
Concrete Products, N.E.C	$9.24	$0.04	$9.20	83	$2.90	$0.11
Condensed and Evaporated Milk	$106.98	$13.64	$93.34	200	$25.87	$0.72
Construction Machinery and Equipment	$0.44	$0.03	$0.41	2	$0.05	$0.00
Converted Paper Products, N.E.C	$35.64	$0.50	$35.14	194	$8.29	$0.26
Conveyors and Conveying Equipment	$0.54	$0.26	$0.28	4	$0.11	$0.00
Cookies and Crackers	$0.34	$0.01	$0.33	3	$0.11	$0.00
Copper Rolling and Drawing	$39.35	$1.29	$38.05	114	$5.79	$0.41
Costume Jewelery	$1.92	$0.04	$1.88	19	$1.26	$0.02
Curtains and Draperies	$0.60	$0.04	$0.56	7	$0.11	$0.00
Die-cut Paper and Board	$0.21	$0.00	$0.21	2	$0.04	$0.00
Dog, Cat, and Other Pet Food	$95.76	$0.06	$95.70	248	$10.34	$0.40
Dolls	$0.00	$0.00	$0.00	1	$0.00	$0.00
Drugs	$0.39	$0.09	$0.30	2	$0.20	$0.00
Electric Lamps	$0.55	$0.01	$0.54	4	$0.35	$0.01
Electrical Equipment, N.E.C.	$0.84	$0.15	$0.69	3	$0.36	$0.01
Electronic Components, N.E.C.	$195.42	$79.25	$116.17	781	$38.09	$1.35
Electronic Computers	$59.64	$12.65	$46.99	278	$11.05	$0.23
Engine Electrical Equipment	$152.24	$24.27	$127.96	1012	$48.49	$1.19
Fabricated Metal Products, N.E.C.	$5.08	$0.85	$4.23	44	$1.15	$0.03
Fabricated Plate Work (Boiler Shops)	$2.54	$0.04	$2.50	36	$1.20	$0.02
Fabricated Rubber Products, N.E.C.	$0.46	$0.01	$0.45	3	$0.12	$0.00
Fabricated Structural Metal	$36.83	$0.79	$36.05	232	$13.39	$0.35
Fabricated Textile Products, N.E.C.	$0.45	$0.22	$0.22	3	$0.12	$0.00
Farm Machinery and Equipment	$1.43	$0.60	$0.83	7	$0.55	$0.01
Fertilizers, Mixing Only	$1.81	$0.21	$1.61	6	$0.21	$0.01
Fluid Milk	$79.85	$6.27	$73.58	226	$10.64	$0.48
Food Preparations, N.E.C	$36.77	$0.18	$36.59	237	$7.24	$0.15
Footwear Cut Stock	$9.18	$0.04	$9.13	60	$3.88	$0.11
Forestry Products	$0.47	$0.00	$0.47	4	$0.35	$0.07
Frozen Specialties	$11.31	$0.15	$11.16	74	$2.87	$0.06
Games, Toys, and Childrens Vehicles	$1.60	$0.01	$1.59	10	$0.97	$0.02
General Industrial Machinery, N.E.C	$0.36	$0.01	$0.35	2	$0.09	$0.00
Glass and Glass Products, Exc	$0.35	$0.29	$0.06	3	$0.13	$0.00
Hand and Edge Tools, N.E.C.	$11.29	$1.18	$10.11	52	$6.81	$0.12
Hardware, N.E.C.	$0.59	$0.23	$0.35	3	$0.30	$0.01
Household Appliances, N.E.C.	$48.43	$2.73	$45.70	166	$15.22	$0.60
Household Vacuum Cleaners	$455.50	$4.22	$451.28	2152	$116.20	$2.74
Ice Cream and Frozen Desserts	$0.38	$0.13	$0.26	2	$0.07	$0.00
Industrial and Fluid Valves	$0.62	$0.25	$0.37	3	$0.11	$0.00
Industrial Gases	$0.38	$0.24	$0.14	2	$0.29	$0.01
Industrial Machines N.E.C.	$36.23	$0.39	$35.84	397	$13.07	$0.26
Industrial Patterns	$0.09	$0.00	$0.09	2	$0.04	$0.00
Industrial Trucks and Tractors	$0.35	$0.16	$0.19	2	$0.05	$0.00
Inorganic Chemicals Nec.	$0.84	$0.54	$0.30	2	$0.45	$0.03
Internal Combustion Engines, N.E.C.	$49.00	$16.46	$32.54	148	$7.08	$0.33
Jewelers Materials and Lapidary Work	$0.13	$0.00	$0.13	1	$0.05	$0.00
Jewelry, Precious Metal	$4.55	$0.03	$4.52	35	$1.90	$0.05
Knit Fabric Mills	$0.63	$0.59	$0.05	4	$0.09	$0.00
Lead Pencils and Art Goods	$0.16	$0.00	$0.16	2	$0.11	$0.00
Leather Gloves and Mittens	$4.94	$0.13	$4.82	84	$1.79	$0.00
Leather Goods, N.E.C	$6.37	$0.27	$6.09	132	$4.82	$0.04
Leather Tanning and Finishing	$2.82	$1.58	$1.25	10	$0.60	$0.02
Lighting Fixtures and Equipment	$8.61	$0.11	$8.50	52	$3.32	$0.10
Machine Tools, Metal Cutting Types	$0.34	$0.14	$0.20	5	$0.13	$0.00
Manufactured Ice	$1.17	$0.08	$1.08	29	$0.67	$0.01
Manufacturing Industries, N.E.C.	$4.77	$0.14	$4.63	49	$1.94	$0.05
Mattresses and Bedsprings	$4.07	$0.19	$3.87	36	$1.11	$0.02
Mechanical Measuring Devices	$0.16	$0.04	$0.12	1	$0.07	$0.00
Metal Coating and Allied Services	$2.11	$0.92	$1.19	15	$0.70	$0.02
Metal Doors, Sash, and Trim	$10.04	$0.40	$9.63	91	$4.24	$0.09
Metal Household Furniture	$30.80	$2.65	$28.15	268	$6.75	$0.14
Metal Stampings, N.E.C.	$28.45	$6.26	$22.18	161	$11.44	$0.26
Millwork	$23.43	$16.88	$6.55	272	$6.56	$0.16
Minerals, Ground Or Treated	$9.64	$0.09	$9.55	62	$4.27	$0.12
Miscellaneous Fabricated Wire Products	$10.84	$2.18	$8.66	117	$4.19	$0.08
Miscellaneous Metal Work	$115.74	$2.86	$112.88	281	$15.69	$0.91
Miscellaneous Plastics Products	$674.82	$9.97	$664.85	4085	$169.57	$3.98
Miscellaneous Publishing	$7.31	$5.04	$2.27	62	$3.49	$0.08
Motor Vehicle Parts and Accessories	$94.10	$40.12	$53.99	418	$23.59	$0.32

Table A-3: Baseline Economic Data for Manufacturing Sectors, Region E (Year 2000)

Motor Vehicles	$493.56	$4.53	$489.04	725	$130.45	$2.94
Motors and Generators	$5.56	$2.98	$2.58	36	$2.65	$0.08
Musical Instruments	$0.47	$0.01	$0.47	3	$0.30	$0.00
Narrow Fabric Mills	$5.90	$2.57	$3.33	88	$2.83	$0.05
Newspapers	$48.02	$33.64	$14.38	535	$24.05	$0.55
Nonferrous Wire Drawing and Insulating	$223.76	$5.75	$218.00	798	$49.44	$1.92
Nonmetallic Mineral Products, N.E.C.	$1.13	$0.02	$1.11	14	$0.40	$0.01
Optical Instruments & Lenses	$0.10	$0.04	$0.06	2	$0.04	$0.00
Paints and Allied Products	$47.34	$0.78	$46.56	143	$14.83	$0.44
Paper Coated & Laminated N.E.C.	$1.58	$0.09	$1.49	7	$0.64	$0.02
Paper Coated & Laminated Packaging	$5.60	$0.31	$5.29	26	$1.05	$0.03
Paperboard Containers and Boxes	$200.56	$71.96	$128.60	1010	$40.77	$1.54
Paving Mixtures and Blocks	$0.74	$0.70	$0.04	3	$0.23	$0.00
Periodicals	$5.06	$2.74	$2.33	35	$1.61	$0.04
Petroleum Refining	$600.83	$214.01	$386.82	220	$70.89	$4.95
Photographic Equipment and Supplies	$15.54	$1.76	$13.78	66	$1.20	$0.05
Pickles, Sauces, and Salad Dressings	$31.45	$0.65	$30.80	91	$12.17	$0.22
Pipe, Valves, and Pipe Fittings	$1.58	$0.64	$0.94	15	$0.53	$0.01
Plastics Materials and Resins	$1.16	$1.03	$0.14	2	$0.17	$0.01
Plate Making	$0.10	$0.01	$0.09	2	$0.08	$0.00
Plating and Polishing	$0.68	$0.35	$0.32	16	$0.54	$0.01
Pleating and Stitching	$16.74	$9.22	$7.53	268	$11.05	$0.16
Pottery Products, N.E.C	$0.60	$0.00	$0.60	11	$0.13	$0.00
Poultry Processing	$0.67	$0.11	$0.56	6	$0.11	$0.00
Prefabricated Metal Buildings	$1.43	$0.04	$1.39	14	$0.51	$0.01
Prefabricated Wood Buildings	$0.17	$0.00	$0.17	2	$0.03	$0.00
Prepared Feeds, N.E.C	$11.74	$0.16	$11.58	31	$1.22	$0.08
Primary Copper	$964.59	$18.84	$945.75	1137	$165.86	$24.22
Printed Circuit Boards	$0.99	$0.40	$0.59	18	$0.45	$0.01
Printing Ink	$2.13	$1.84	$0.30	8	$0.75	$0.02
Pumps and Compressors	$0.72	$0.02	$0.70	3	$0.13	$0.00
Radio and TV Receiving Sets	$59.59	$7.15	$52.44	384	$16.86	$0.48
Ready-mixed Concrete	$105.50	$0.84	$104.66	719	$34.02	$1.38
Refrigeration and Heating Equipment	$3.01	$2.05	$0.96	15	$0.65	$0.02
Salted and Roasted Nuts & Seeds	$7.36	$0.05	$7.31	19	$0.97	$0.05
Sausages and Other Prepared Meats	$10.81	$1.66	$9.15	54	$1.14	$0.04
Screw Machine Products and Bolts, Etc.	$0.70	$0.45	$0.24	7	$0.24	$0.01
Search & Navigation Equipment	$4.12	$0.46	$3.66	24	$0.81	$0.03
Semiconductors and Related Devices	$242.19	$83.31	$158.88	1384	$100.45	$1.66
Service Industry Machines, N.E.C.	$9.74	$1.64	$8.10	60	$2.70	$0.07
Sheet Metal Work	$24.53	$0.69	$23.85	215	$8.24	$0.17
Shoes, Except Rubber	$123.05	$0.49	$122.56	1252	$66.88	$1.13
Signs and Advertising Displays	$7.61	$3.15	$4.46	87	$3.33	$0.08
Small Arms	$0.30	$0.00	$0.30	5	$0.22	$0.03
Soap and Other Detergents	$0.79	$0.13	$0.66	5	$0.42	$0.01
Special Dies and Tools and Accessories	$36.97	$9.89	$27.08	456	$18.39	$0.30
Special Industry Machinery N.E.C.	$15.90	$3.50	$12.40	44	$1.95	$0.06
Sporting and Athletic Goods, N.E.C.	$6.40	$0.03	$6.37	45	$2.80	$0.24
Storage Batteries	$1.13	$0.28	$0.85	3	$0.62	$0.02
Structural Wood Members, N.E.C	$4.53	$4.25	$0.28	44	$1.31	$0.04
Surgical and Medical Instrument	$2.54	$1.11	$1.43	15	$0.62	$0.02
Surgical Appliances and Supplies	$15.07	$2.56	$12.50	79	$3.90	$0.16
Switchgear and Switchboard Apparatus	$27.16	$4.54	$22.61	159	$11.91	$0.23
Telephone and Telegraph Apparatus	$1.04	$0.73	$0.31	3	$0.14	$0.00
Textile Bags	$0.13	$0.08	$0.05	2	$0.04	$0.00
Thread Mills	$0.59	$0.29	$0.31	10	$0.18	$0.00
Toilet Preparations	$0.72	$0.02	$0.70	2	$0.32	$0.01
Transformers	$14.65	$0.48	$14.17	123	$5.77	$0.11
Transportation Equipment, N.E.C	$1.02	$0.02	$1.00	4	$0.19	$0.01
Truck and Bus Bodies	$0.72	$0.14	$0.58	5	$0.24	$0.00
Typesetting	$1.64	$0.47	$1.17	20	$0.60	$0.01
Upholstered Household Furniture	$0.69	$0.00	$0.68	8	$0.24	$0.00
Veneer and Plywood	$0.49	$0.45	$0.04	5	$0.10	$0.00
Vitreous Plumbing Fixtures	$0.31	$0.00	$0.31	4	$0.16	$0.00
Wiring Devices	$18.70	$0.74	$17.96	122	$9.19	$0.18
Womens Handbags and Purses	$1.68	$0.01	$1.67	31	$0.67	$0.01
Wood Household Furniture	$0.63	$0.02	$0.61	9	$0.13	$0.00
Wood Kitchen Cabinets	$11.87	$10.01	$1.86	168	$4.85	$0.10
Wood Pallets and Skids	$5.14	$3.33	$1.81	76	$1.87	$0.04
Wood Partitions and Fixtures	$3.35	$2.10	$1.25	38	$0.83	$0.01
Wood Products, N.E.C	$1.22	$0.61	$0.61	15	$0.31	$0.01
Yarn Mills and Finishing Of Textiles,	$20.89	$8.45	$12.44	166	$5.78	$0.20
Total	$8,095.35	$939.49	$7,155.86	40928	$2,043.38	$73.67

NEC = not elsewhere classified. “na” = not available.

Table A-3: Baseline Economic Data for Municipal Sectors, Region E (Year 2000)

Sector	GED	Total Sales	Intermediate Sales	Final Sales	Jobs	Regional Income	Business Taxes
Accounting, Auditing and Bookkeeping	120	$88.53	$77.41	$11.12	1760	$69.77	$0.79
Advertising	117	$57.24	$55.22	$2.03	540	$29.23	$0.53
Air Transportation	171	$160.43	$36.18	$124.25	1768	$78.87	$11.28
Amusement and Recreation Services,	427	$97.67	$5.37	$92.30	2889	$56.88	$5.51
Apparel & Accessory Stores	68	$115.25	$6.46	$108.79	3026	$63.70	$18.39
Arrangement Of Passenger	130	$29.19	$13.10	$16.09	226	$20.16	$0.87
Automobile Parking and Car Wash	681	$36.55	$3.25	$33.30	909	$24.69	$1.69
Automobile Rental and Leasing	147	$66.98	$47.98	$19.00	707	$39.10	$5.29
Automobile Repair and Services	55	$137.67	$53.13	$84.55	1957	$67.13	$6.08
Automotive Dealers & Service Stations	49	$383.85	$70.09	$313.76	5524	$228.91	$59.37
Banking	59	$289.66	$106.52	$183.14	1603	$187.14	$4.68
Beauty and Barber Shops	216	$40.96	$4.39	$36.57	1726	$24.53	$0.48
Bowling Alleys and Pool Halls	86	$4.27	$0.01	$4.26	184	$2.33	$0.38
Building Materials & Gardening	35	$69.25	$8.99	$60.26	1546	$49.41	$11.39
Business Associations	160	$34.35	$12.20	$22.15	655	$26.18	$0.02
Child Day Care Services	120	$60.93	$0.00	$60.93	1578	$18.52	$0.53
Colleges, Universities, Schools	75	$7.22	$0.09	$7.13	356	$4.00	$0.00
Commercial Sports Except Racing	391	$5.18	$3.10	$2.08	217	$3.29	$0.27
Communications, Except Radio and TV	47	$464.37	$212.25	$252.12	1903	$232.19	$24.72
Computer and Data Processing	40	$118.12	$69.00	$49.12	2458	$95.56	$1.80
Credit Agencies	156	$255.75	$135.61	$120.15	7359	$132.66	$8.64
Detective and Protective Services	84	$107.15	$26.91	$80.24	3507	$81.08	$1.48
Doctors and Dentists	203	$587.62	$0.00	$587.62	5,692	$396.18	$7.60
Domestic Services	-	$34.75	$0.00	-	4243	$34.48	$0.00
Eating & Drinking	157	$709.05	$37.32	$671.73	20,514	$321.06	$44.80
Electrical Repair Service	37	$16.06	$6.11	$9.96	250	$5.39	$0.46
Elementary and Secondary Schools	169	$16.00	$0.00	$16.00	716	$9.41	$0.00
Engineering, Architectural Services	87	$147.63	$118.87	$28.76	1615	$64.38	$0.95
Equipment Rental and Leasing	29	$49.60	$38.21	$11.39	412	$21.73	$1.51
Federal Government - Military	-	$1,144.85	$0.00	-	11870	$1,144.85	$0.00
Federal Government - Non-Military	-	$650.53	$0.00	-	11231	$650.53	$0.00
Food Stores	98	$242.28	$8.05	$234.23	6716	$181.64	$38.72
Funeral Service and Crematories	111	$14.22	$0.00	$14.22	317	$9.42	$0.40
Furniture & Home Furnishings Stores	42	$84.40	$8.56	$75.84	2350	$54.77	$13.24
Gas Production and Distribution	51	$779.54	$175.03	$604.51	582	$249.91	$69.11
General Merchandise Stores	47	$251.40	$7.73	$243.68	7962	$158.10	$40.12
Greenhouse and Nursery Products	-	$3.31	$1.05	$2.26	74	$1.16	$0.02
Hospitals	76	$489.70	$0.27	$489.43	7047	$310.30	$1.74
Hotels and Lodging Places	230	$153.20	$67.35	$85.85	3299	$80.58	$10.37
Insurance Agents and Brokers	89	$114.00	$21.63	$92.36	2497	$88.47	$1.22
Insurance Carriers	136	$107.82	$10.41	$97.41	553	$62.49	$6.40
Inventory Valuation Adjustment	-	-$11.03	na	-	0	-$10.81	$0.00
Job Trainings & Related Services	141	$58.66	$15.59	$43.08	1605	$28.96	$0.13
Labor and Civic Organizations	122	$96.60	$0.55	$96.05	6120	$73.63	$0.01
Landscape and Horticultural Services	-	$19.99	$15.45	$4.53	762	$11.71	$0.50
Laundry, Cleaning and Shoe Repair	517	$58.90	$12.10	$46.80	2301	$43.35	$1.50
Legal Services	76	$172.94	$64.79	$108.15	1888	$133.12	$1.55
Local Government Passenger Transit	-	$12.44	$1.71	$10.73	303	-$30.15	$0.00
Local, Interurban Passenger Transit	68	$51.10	$7.16	$43.94	1048	$31.63	$1.13
Maintenance and Repair Oil and Gas	25	$12.09	$8.63	$3.46	140	$6.98	$0.48
Maintenance and Repair Other	25	$321.15	$151.13	$170.02	6009	$215.45	$1.44
Maintenance and Repair, Residential	25	$244.56	$70.88	$173.69	1904	$63.29	$0.86
Management and Consulting Services	87	$122.53	$86.03	$36.50	1649	$56.53	$0.75
Membership Sports and Recreation	427	$17.18	$0.68	$16.50	644	$8.57	$0.61
Miscellaneous Personal Services	129	$61.21	$5.06	$56.15	1005	$13.44	$1.02
Miscellaneous Repair Shops	124	$64.66	$33.29	$31.36	1036	$28.46	$1.78
Miscellaneous Retail	132	$433.08	$28.94	$404.13	10938	$271.64	$66.17
Motion Pictures	113	$66.29	$37.86	$28.43	829	$22.28	$0.78
Motor Freight Transport and	85	$895.41	$403.25	$492.16	8,783	$351.15	$11.03
New Government Facilities	63	$412.64	$0.00	$412.64	2867	$146.11	$2.30
New Highways and Streets	45	$100.98	$0.00	$100.98	977	$35.83	$0.59
New Industrial and Commercial	63	$399.70	$0.00	$399.70	3594	$129.68	$2.69
New Mineral Extraction Facilities	63	$245.99	$2.85	$243.13	4246	$145.54	$11.74
New Residential Structures	35	$776.27	$0.00	$776.27	5130	$131.80	$4.47
New Utility Structures	63	$172.13	$0.00	$172.13	1757	$65.68	$0.86
Noncomparable Imports	-	$0.00	na	-	0	$0.00	$0.00
Nursing and Protective Care	197	$53.36	$0.00	$53.36	1659	$38.76	$1.31
Other Business Services	84	$425.67	$326.36	$99.31	4846	$154.01	$5.60
Other Educational Services	116	$92.55	$5.00	$87.55	1910	$34.95	$2.62
Other Federal Government Enterprises	-	$77.73	$8.32	$69.41	603	$9.59	$0.00
Other Medical and Health Services	168	$282.07	$10.66	$271.41	6409	$141.84	$4.43
Other Nonprofit Organizations	122	$16.72	$1.36	$15.36	677	$8.72	$0.11
Other State and Local Govt Enterprises	-	$202.63	$56.74	$145.89	1067	$69.23	$0.00
Owner-occupied Dwellings	89	$1,208.71	$0.00	$1,208.71	0	$758.84	$156.73
Personnel Supply Services	484	$201.47	$150.55	$50.92	10432	$194.02	$3.83

Table A-3: Baseline Economic Data for Municipal Sectors, Region E (Year 2000)

Photofinishing, Commercial	112	$26.40	$19.48	$6.92	264	$9.53	$0.59
Pipe Lines, Except Natural Gas	49	$10.95	$8.01	$2.93	18	$7.60	$0.90
Portrait and Photographic Studios	184	$9.21	$0.76	$8.45	228	$4.39	$0.22
Racing and Track Operation	391	$0.74	$0.02	$0.72	16	$0.29	$0.13
Radio and TV Broadcasting	64	$105.66	$94.38	$11.28	627	$41.34	$1.52
Railroads and Related Services	68	$158.08	$39.91	$118.17	1400	$43.00	$2.28
Real Estate	89	$1,433.32	$393.14	$1,040.18	7,006	$850.00	$169.56
Religious Organizations	328	$8.34	$0.00	$8.34	65	$1.23	$0.00
Research, Development & Testing	123	$36.54	$11.49	$25.05	589	$20.26	$0.37
Residential Care	111	$21.15	$0.00	$21.15	768	$13.17	$0.19
Rest Of The World Industry	-	$0.00	$0.00	-	0	$0.00	$0.00
Sanitary Services and Steam Supply	51	$43.87	$27.70	$16.17	243	$18.33	$8.03
Scrap	-	$0.00	$0.00	-	0	$0.00	$0.00
Security and Commodity Brokers	59	$39.78	$23.75	$16.03	210	$15.52	$1.34
Services To Buildings	67	$69.50	$53.87	$15.63	1871	$30.54	$1.21
Social Services, N.E.C.	42	$78.68	$6.87	$71.80	1502	$30.31	$0.09
State & Local Government - Education	-	$1,051.81	$0.00	-	31998	$1,051.81	$0.00
State & Local Government - Non-	-	$625.67	$0.00	-	12893	$625.67	$0.00
Theatrical Producers, Bands Etc.	36	$15.13	$9.54	$5.59	291	$2.84	$0.25
Transportation Services	40	$115.04	$36.51	$78.53	1150	$85.91	$1.00
U.S. Postal Service	-	$95.77	$57.74	$38.02	1162	$71.47	$0.00
Used and Secondhand Goods	-	$0.00	$0.00	-	0	$0.00	$0.00
Watch, Clock, Jewelry and Furniture	50	$6.04	$0.05	$5.99	113	$2.05	$0.28
Water Supply and Sewerage Systems	51	$3.42	$0.82	$2.60	20	$1.86	$0.23
Water Transportation	353	$2.24	$0.93	$1.31	11	$0.40	$0.04
Wholesale Trade	43	$1,428.93	$749.08	$679.86	14,981	$783.40	$203.78
Total	-	$20,979.1	$4,486.82	$12,995.78	300,898	$12,474.94	$1,079.90

NEC = not elsewhere classified. "na" = not available.

Table A-5: Baseline Economic Data for Mining Sectors, Region E (Year 2000)

Sector	Total Sales	Intermediate Sales	Final Sales	Jobs	Regional Income	Business Taxes
Chemical, Fertilizer Mineral Mining	$5.08	$1.58	$3.50	39	$3.29	$0.22
Clay, Ceramic, Refractory Minerals	$1.89	$0.02	$1.88	7	$1.13	$0.06
Coal Mining	$0.23	$0.12	$0.11	1	$0.06	$0.02
Dimension Stone	$2.69	$0.05	$2.65	28	$1.64	$0.08
Misc. Nonmetallic Minerals	$0.74	$0.00	$0.74	5	$0.46	$0.02
Natural Gas & Crude Petroleum	$108.21	$101.68	$6.54	240	$48.77	$5.72
Natural Gas Liquids	$33.97	$31.91	$2.05	29	$8.44	$1.33
Sand and Gravel	$0.15	$0.00	$0.14	3	$0.09	$0.00
Total	$152.96	$135.36	$17.60	352	$63.88	$7.47

Table A-6: Baseline Economic Data for the Steam Electric Sector, Region E (Year 2000)

Sector	Total Sales	Intermediate Sales	Final Sales	Jobs	Regional Income	Business Taxes
Electric Services	$297.53	$70.39	$227.14	631	$212.78	$38.10

na = "not available"

Attachment B: Distribution of Economic Impacts at the County Level

Tables B-1 through B-7 show economic impacts by county; however, caution is warranted. Figures shown for specific counties are *direct* impacts only. For the most part, figures reported in the main text for all water use categories uses include *direct and secondary* impacts. Secondary effects were estimated using regional level multipliers that treat each regional water planning area as an aggregate and autonomous economy. Multipliers do not specify where secondary impacts will occur at a sub-regional level (i.e., in which counties or cities). All economic impacts that would accrue to a region as a whole due to secondary economic effects are reported in Tables B-1 through B-7 as “secondary regional level impacts.”

For example, assume that in a given county (or city) water shortages caused significant reductions in output for a manufacturing plant. Reduced output resulted in lay-offs and lost income for workers and owners of the plant. This is a *direct* impact. Direct impacts were estimated at a county level; and thus one can say with certainty that direct impacts occurred in that county. However, secondary impacts accrue to businesses and households throughout the region where the business operates, and it is impossible using input-output models to determine where these businesses are located spatially.

The same logic applies to changes in population and school enrollment. Since employment losses and subsequent out-migration from a region were estimated using *direct* and *secondary* multipliers, it is impossible to say with any degree of certainty how many people a given county would lose regardless of whether the economic impact was direct or secondary. For example, assume the manufacturing plant referred to above is in County A. If the firm eliminated 50 jobs, one could state with certainty that water shortages in County A resulted in a loss of 50 jobs in that county. However, one could not unequivocally say whether 100 percent of the population loss due to lay-offs at the manufacturing would accrue to County A because many affected workers might commute from adjacent counties. This is particularly true in large metropolitan areas that overlay one or counties. Thus, population and school enrollment impacts cannot be reported at a county level.

Irrigation

Table B-1: Distribution of Economic Impacts by County and Water User Groups: (Irrigation)						
Lost Sales, $millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$32.27	$31.92	$31.76	$30.32	$30.67	$30.32
Secondary Regional Level Impacts	15.956	15.78	15.7	14.99	15.165	14.99
Hudspeth						
Direct	$24.11	$23.79	$23.47	$22.47	$22.81	$22.47
Secondary Regional Level Impacts	$12.37	$12.21	$12.04	$11.53	$11.70	$11.53
Presidio						
Direct	$0.19	$0.17	$0.15	$0.10	$0.12	$0.10
Secondary Regional Level Impacts	$0.10	$0.09	$0.08	$0.05	$0.06	$0.05
Total	$84.99	$83.97	$83.21	$79.45	$80.53	$79.45
Lost Income ($millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$9.53	$9.43	$9.38	$9.16	$9.06	$8.96
Secondary Regional Level Impacts	8.2725	8.183	8.141	7.952	7.862	7.772
Hudspeth						
Direct	$7.18	$7.09	$6.99	$6.89	$6.79	$6.69
Secondary Regional Level Impacts	$6.48	$6.39	$6.31	$6.22	$6.13	$6.04
Presidio						
Direct	$0.06	$0.05	$0.05	$0.04	$0.04	$0.03
Secondary Regional Level Impacts	$0.05	$0.05	$0.04	$0.04	$0.03	$0.03
Total	$31.57	$31.19	$30.91	$30.31	$29.91	$29.51
Lost Jobs						
El Paso	2010	2020	2030	2040	2050	2060
Direct	600	594	591	577	570	564
Secondary Regional Level Impacts	257	254	253	247	244	241
Hudspeth						
Direct	402	396	391	386	380	374
Secondary Regional Level Impacts	199	196	194	191	188	185
Presidio						
Direct	5	5	4	4	3	3
Secondary Regional Level Impacts	2	2	1	1	1	1
Total	1,465	1,447	1,434	1,405	1,387	1,368
Lost Business Taxes ($millions)						
El Paso	2010	2020	2030	2040	2050	2060
Direct	$0.58	$0.54	$0.57	$0.55	$0.55	$0.54
Secondary Regional Level Impacts	0.174	0.164	0.171	0.167	0.166	0.164
Hudspeth						
Direct	$0.49	$0.46	$0.48	$0.47	$0.46	$0.46
Secondary Regional Level Impacts	$0.07	$0.06	$0.06	$0.06	$0.06	$0.06
Presidio						
Direct	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Secondary Regional Level Impacts	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total	$1.31	$1.23	$1.29	$1.26	$1.24	$1.23
Source: Texas Water Development Board, Office of Water Resources Planning						

Municipal

Table B-2: Distribution of Economic Impacts by County and Water User Groups: (Commercial Water Uses)						
Lost Output (Total Sales, $millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$77.37	$85.92	$111.39	$131.05	$169.07	$213.36
Secondary Regional Level Impacts	$33.85	$37.60	$48.74	$57.34	$73.98	$93.36
Total	$111.22	$123.52	$160.14	$188.40	$243.05	$306.72
Lost Income ($millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$49.27	$54.72	$70.95	$70.95	$107.68	$135.89
Secondary Regional Level Impacts	$19.57	$21.73	$28.18	$28.18	$42.76	$53.97
Total	$68.84	$76.46	$99.12	$99.12	$150.44	$189.85
Lost Jobs (numbers may not sum to figures in text due to rounding)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	2,504	2,781	3,605	4,242	5,472	6,906
Secondary Regional Level Impacts	491	545	706	831	1,072	1,353
Total	2,995	3,326	4,312	5,073	6,545	8,259
Lost Business Taxes ($millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$4.39	$4.87	$12.10	$6.32	$9.59	$12.10
Secondary Regional Level Impacts	$1.85	$2.05	$5.10	$2.66	$4.04	$5.10
Total	$6.24	$6.92	$17.20	$8.98	$13.63	$17.20
Source: Texas Water Development Board, Office of Water Resources Planning						

Table B-3: Distribution of Economic Impacts by County and Water User Groups: (Horticultural and Landscaping Industry)						
Lost Output (Total Sales, $millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$2.95	$6.25	$9.92	$13.19	$15.23	$20.19
Secondary Regional Level Impacts	$0.51	$1.10	$1.75	$2.33	$2.69	$3.56
Total	$3.46	$7.35	$11.67	$15.52	$17.92	$23.75
Lost Income ($millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$1.64	$3.45	$5.47	$7.28	$8.40	$11.14
Secondary Regional Level Impacts	$0.29	$0.63	$1.00	$1.33	$1.53	$2.03
Total	$1.93	$4.08	$6.47	$8.60	$9.93	$13.16
Lost Jobs (numbers may not sum to figures in text due to rounding)						

County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	107	224	356	474	547	725
Secondary Regional Level Impacts	3	7	11	15	18	25
Total	110	231	367	489	565	750

Lost Business Taxes ($millions)

County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$0.07	$0.14	$0.23	$0.30	$0.35	$0.46
Secondary Regional Level Impacts	$0.01	$0.03	$0.04	$0.06	$0.06	$0.08
Total	$0.08	$0.17	$0.27	$0.36	$0.41	$0.55

Source: Texas Water Development Board, Office of Water Resources Planning

Table B-4: Impacts Associated with Unmet Needs for Domestic Water Uses

County	2010	2020	2030	2040	2050	2060
El Paso	$57.54	$132.47	$202.79	$262.75	$326.31	$392.23

Source: Texas Water Development Board, Office of Water Resources Planning

Table B-5: Lost Water Utility Revenues (Municipal)

County	2010	2020	2030	2040	2050	2060
El Paso	$13.48	$35.72	$56.83	$75.08	$94.54	$113.97

Source: Texas Water Development Board, Office of Water Resources Planning

Table B-6: Lost Water Utility Taxes (Municipal)

County	2010	2020	2030	2040	2050	2060
El Paso	$0.24	$0.63	$1.00	$1.32	$1.66	$2.01

Source: Texas Water Development Board, Office of Water Resources Planning

Steam Electric

Table B-7: Distribution of Economic Impacts by County and Water User Groups: (Horticultural and Landscaping Industry)						
Lost Output (Total Sales, $millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$0.00	$11.58	$80.16	$145.40	$416.76	$570.39
Secondary Regional Level Impacts	$0.00	$2.42	$16.74	$30.35	$87.01	$119.08
Total	$0.00	$14.00	$96.90	$175.75	$503.76	$689.47
Lost Income ($millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$0.00	$8.28	$57.33	$103.98	$298.04	$407.92
Secondary Regional Level Impacts	$0.00	$1.29	$8.90	$16.14	$46.27	$63.33
Total	$0.00	$9.57	$66.23	$120.13	$344.32	$471.25
Lost Jobs (numbers may not sum to figures in text due to rounding)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	0	25	170	308	884	1,210
Secondary Regional Level Impacts	0	33	227	412	1,182	1,617
Total	0	57	397	721	2,065	2,827
Lost Business Taxes ($millions)						
County	2010	2020	2030	2040	2050	2060
El Paso						
Direct	$0.00	$1.48	$10.27	$18.62	$53.37	$73.05
Secondary Regional Level Impacts	$0.00	$0.23	$1.59	$2.89	$8.29	$11.34
Total	$0.00	$1.71	$11.86	$21.51	$61.66	$84.39
Source: Texas Water Development Board, Office of Water Resources Planning						

APPENDIX 4B

ADDITIONAL STRATEGIES FOR

FUTURE CONSIDERATION

APPENDIX 4B
ADDITIONAL STRATEGIES FOR FUTURE CONSIDERATION

Tri-County Water Supply Proposal

The Tri-County Coalition (El Paso, Hudspeth and Culberson Counties) is evaluating the feasibility of a regional water treatment, storage, and distribution facility. Funding for the evaluation is under the auspices of the Hudspeth County Conservation and Reclamation District No. 1. The preliminary feasibility study is considering the following components to the proposed plan:

- 45 MGD (50,000 acre-foot per year) water treatment plant
- Pre-treatment and desalination
- Off-channel 30,000 acre-foot settling and storage reservoir
- Water supplied primarily by irrigation district canals
- Secondary supply by hydrograph trimming of flood flows
- Drought contingency supply from Dell City or ASR
- Brine disposal by deep well injection or evaporation ponds
- Primary facilities located upstream of Ft, Quitman
- 60 miles of 48" diameter treated water transmission line
- ROW availability from U.S. or from irrigation districts

CHAPTER 5

WATER QUALITY IMPACTS AND IMPACTS ON MOVING WATER FROM AGRICULTURAL AREAS

5.1 INTRODUCTION

Water quality plays an important role in determining the availability of water supplies to meet current and future water needs in the Region. This chapter describes the general water quality of the groundwater and surface water sources in Far West Texas, discusses specific water quality issues, details potential impacts resulting from the implementation of water management strategies, and the potential impacts of moving water from agricultural areas. Primary and secondary safe drinking water standards are the key parameters of water quality identified by the Far West Texas Water Planning Group (FWTWPG) as important to the use of the water resource (Table 5-1).

A groundwater quality database using water quality analyses from the TWDB groundwater database was established for the primary aquifers in the Region. Tables 5-2 through 5-5 provide information pertaining to the number of mineral constituent analyses available and the percent of these analyses that depict concentration levels above safe drinking water standards.

While there appears to be a sufficient number of evenly distributed sample locations (Figure 5-1) for making regional quality assumptions, many of the sample dates are relatively old and thus less reliable as current indicators. It is recommended that these older analyses be replaced by re-sampling the same wells or, if not available, new wells in the same general area. Additional analyses are needed for the southern portion of the Davis Mountains Igneous aquifer in Presidio County and the Marathon aquifer in Brewster County. Groundwater conservations districts should take the lead in this task within their respective areas.

5.2 WATER QUALITY STANDARDS

Screening levels for public drinking water supplies were used for comparisons of water quality data in the region. Drinking water standards are classified as primary and secondary and are listed in terms of maximum contaminant levels (MCLs) as defined in the Texas Administrative Code (30 TAC, Chapter 290, Subchapter F). U.S. Environmental Protection Agency (EPA) MCLs for certain secondary constituents are more stringent than the State standards.

Primary MCLs are legally enforceable standards that apply to public drinking water supplies in order to protect human health from contaminants in drinking water. Secondary standards are non-enforceable guidelines based on aesthetic effects that these constituents may cause (taste, color, odor, etc.). In addition to primary MCLs and secondary standards, two constituents, lead and copper, have action levels specified. These action levels apply to community and non-transient non-community water systems, and to new water systems when notified by the Texas Commission on Environmental Quality (TCEQ) Executive Director. A summary of the public drinking water supply parameters used to evaluate water quality is provided in Table 5-1. Certain constituents on the State list are not included on the table because there is a significant lack of analyses containing these elements in the public databases that were used.

On October 31, 2001, the U.S. Environmental Protection Agency (EPA) announced that the new arsenic maximum contaminant level (MCL) for drinking water is lowered from 50 to 10 parts per billion (ppb) with a compliance date of January 23, 2006. Because of this impending new standard, a screening level of 10 ppb is used for this evaluation.

TABLE 5-1. SELECTED PUBLIC DRINKING WATER SUPPLY PARAMETERS

Constituent	Maximum Contaminant Level (mg/l unless otherwise noted)	Type of Standard
Nitrate-N	10	Primary
Fluoride	4	Primary
Barium	2	Primary
Alpha	15 pc/L	Primary
Cadmium	0.005	Primary
Chromium	0.1	Primary
Selenium	0.05	Primary
Arsenic	0.01	Primary
Lead	0.015	Action Level
Copper	1.3	Action Level
TDS	1000	Secondary
Chloride	300	Secondary
Sulfate	300	Secondary
pH	6.5 – 8.5	Secondary
Fluoride	2	Secondary
Iron	0.3	Secondary
Manganese	0.05	Secondary
Copper	1	Secondary

Primary drinking water standard from 30 TAC Chapter 290, Subchapter F, Rule 290.106
Action Level for Copper and Lead from 30 TAC Chapter 290, Subchapter F, Rule 290.117
Secondary drinking water standard from 30 TAC Chapter 290 Subchapter F, Rule 290.118

5.3 GROUNDWATER QUALITY

All groundwater contains minerals carried in solution and their concentration is rarely uniform throughout the extent of an aquifer. The degree and type of mineralization

of groundwater determines its suitability for municipal, industrial, irrigation and other uses. Groundwater resources in Far West Texas vary from potable to nonpotable, often within the same aquifer. Groundwater quality issues in the Region are generally related to naturally high concentrations of total dissolved solids (TDS) or to the occurrence of elevated concentrations of individual dissolved constituents. High concentrations of TDS are primarily the result of the lack of sufficient recharge and restricted circulation. Together, these retard the flushing action of fresh water moving through the aquifers.

Some aquifers, however, have a low TDS but may contain individual constituent levels that exceed safe drinking-water standards. For example, some wells in the Davis Mountains Igneous aquifer have exceptionally low TDS but contain unsatisfactory levels of fluoride. Also fresh-water wells in the Study Butte-Terlingua- Lajitas area have elevated levels of radioactivity.

Groundwater quality changes are often the result of man’s activities. In agricultural areas, aquifers such as the Bone Spring-Victorio Peak have increased in TDS. Irrigation water applied on the fields percolates back to the aquifer carrying salts leached from the soil. Beneath El Paso and Ciudad Juarez, the average concentration of dissolved solids in the Hueco Bolson aquifer has increased as the fresher water in the aquifer is being consumed. Although local instances of groundwater quality degradation have occurred in the Region, there are no major trends that suggest a widespread water-quality problem due to the downward percolation of surface contaminants.

The quality of groundwater in the aquifers within the Region was evaluated to help determine the suitability of groundwater sources for use and the potential impacts on these sources that might result from the implementation of recommended water management strategies. Water-quality data was compiled from the TWDB groundwater database and the TCEQ public water-supply well database.

TDS is commonly used to generally define groundwater quality. TDS refers to the sum of the concentrations of all of the dissolved ions in groundwater, which are chiefly composed of sodium, calcium, magnesium, potassium, chloride, sulfate, and bicarbonate ions. The TWDB has defined gross aquifer water quality in terms of TDS concentrations expressed in milligrams per liter (mg/l), and has classified water into four broad categories:

- fresh (less than 1,000 mg/l);
- slightly saline (1,000 - 3,000 mg/l);
- moderately saline (3,000 - 10,000 mg/l); and
- saline (10,000 - 35,000 mg/l).

Because of its usefulness as an indicator of general groundwater quality, TDS served as a primary parameter of interest for this evaluation. Figure 5-1 shows the TDS of groundwater samples from across the Region. As can be seen in this figure, a large amount of groundwater throughout the region is slightly to moderately saline, including most or all of the Rustler and Bone Spring-Victorio Peak aquifers and parts of the Hueco and Mesilla Bolsons, the Rio Grande Alluvium, and the Capitan Reef aquifers.

5.3.1 Hueco Bolson Aquifer

The quality of Hueco Bolson groundwater differs according to location and depth, with the freshest water occurring at shallower depths along the eastern front of the Franklin Mountains and extending a short distance into Mexico. Outward from the mountain front and at deeper depths, the aquifer contains groundwater of slightly saline quality. Likewise, the overlying Rio Grande Alluvium contains slightly to moderately saline groundwater.

As indicated in Table 5-2, water quality in the Hueco Bolson aquifer contains low numbers of detections of primary contaminants above screening levels. Arsenic is detected above the 10 ppb (0.01 mg/l) screening level in 24% of the samples. Several other parameters with primary standards are detected above the MCL, but they represent only 2% or lower of the samples. Of the secondary drinking water standards, all of the parameters except chloride and copper exceed standard limits in some of the results.

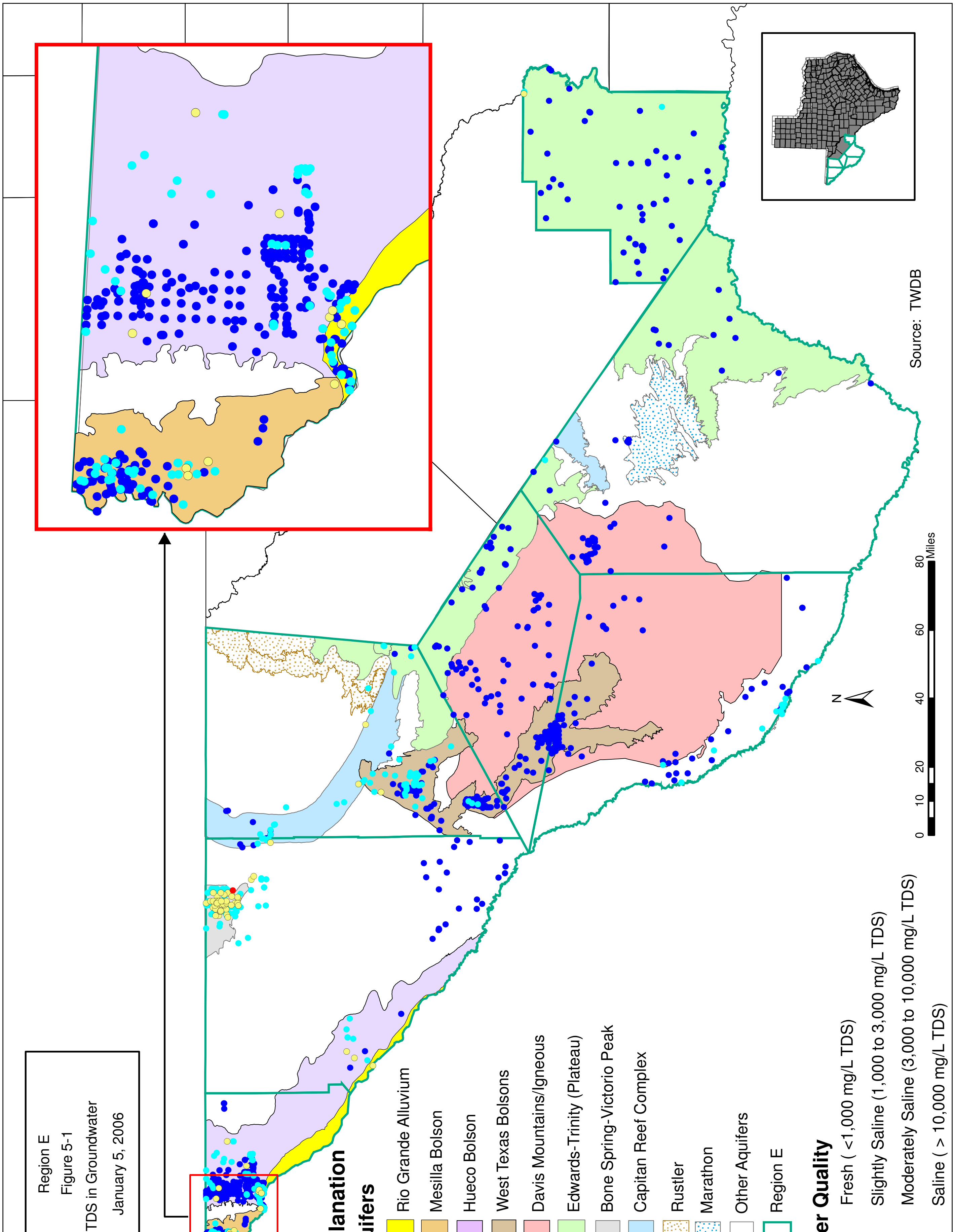

FIGURE 5-1. TOTAL DISSOLVED SOLIDS IN GROUNDWATER IN THE FAR WEST TEXAS REGION

Pumping primarily for municipal use has negatively impacted water quality in the Hueco Bolson. As the fresh water portion of the aquifer has been extracted over time, brackish quality water as migrated inward toward the pumping centers. The placement of wells to supply brackish groundwater to the new joint desalination facility is positioned to capture the poorer quality water before it can into the fresh water zones.

TABLE 5-2. OCCURRENCE AND LEVELS OF SELECTED PUBLIC DRINKING WATER SUPPLY PARAMETERS IN THE HUECO BOLSON AQUIFER

Constituent	Number of Results	Screening Level (mg/l unless otherwise noted)	Type of Standard	Percent of Results Exceeding Screening Level
Nitrate-N	414	10	MCL	2%
Fluoride	453	4	MCL	1%
Barium	195	2	MCL	1%
Cadmium	141	0.005	MCL	1%
Chromium	173	0.1	MCL	1%
Selenium	159	0.05	MCL	1%
Arsenic	186	0.01	MCL	24%
Lead	165	0.015	Action Level	2%
Copper	160	1.3	Action Level	0%
TDS	483	1000	SS	32%
Chloride	483	300	SS	36%
Sulfate	483	300	SS	20%
pH	470	6.5 – 8.5	SS	4%
Fluoride	556	2	SS	5%
Iron	320	0.3	SS	12%
Manganese	268	0.05	SS	18%
Copper	160	1	SS	0%

MCL- Primary drinking water standard (maximum contaminant level) from 30 TAC Chapter 290 Subchapter F

Action Level- Copper and Lead have action levels as defined by 30 TAC 290.117

SS- Secondary drinking water standard from 30 TAC Chapter 290 Subchapter F

5.3.2 Mesilla Bolson Aquifer

Only a small portion of the Mesilla Bolson occurs in Texas. Of that part, the freshest water is found in the deeper zones of the Bolson in and near the El Paso Water Utility's Canutillo well field. Water quality becomes increasingly brackish in shallower zones and is saline in the southernmost extent of the aquifer in Texas. Of particular concern is the occurrence of arsenic in Mesilla Bolson water. Table 5-3 shows that 59% of 27 sample analyses report arsenic levels above the MCL. Secondary standards are also exceeded in a number of the samples.

TABLE 5-3. OCCURRENCE AND LEVELS OF SELECTED PUBLIC DRINKING WATER SUPPLY PARAMETERS IN THE MESILLA BOLSON AQUIFER

Constituent	Number of Results	Screening Level (mg/l unless otherwise noted)	Type of Standard	Percent of Results Exceeding Screening Level
Nitrate-N	96	10	MCL	0%
Fluoride	100	4	MCL	2%
Barium	25	2	MCL	0%
Cadmium	25	0.005	MCL	0%
Chromium	25	0.1	MCL	0%
Selenium	25	0.05	MCL	0%
Arsenic	27	0.01	MCL	59%
Lead	27	0.015	Action Level	0%
Copper	24	1.3	Action Level	0%
TDS	102	1000	SS	28%
Chloride	102	300	SS	30%
Sulfate	102	300	SS	22%
pH	101	6.5 – 8.5	SS	21%
Fluoride	100	2	SS	12%
Iron	27	0.3	SS	21%
Manganese	41	0.05	SS	17%
Copper	24	1	SS	0%

MCL- Primary drinking water standard (maximum contaminant level) from 30 TAC Chapter 290 Subchapter F

Action Level- Copper and Lead have action levels as defined by 30 TAC 290.117

SS- Secondary drinking water standard from 30 TAC Chapter 290 Subchapter F

5.3.3 Bone Spring-Victorio Peak Aquifer

Groundwater of the Bone Spring-Victorio Peak aquifer is slightly saline to moderately saline. Total dissolved solids range from approximately 1,000 to more than 6,500 mg/l. The average is about 3,500 mg/l. The highest concentrations occur along the eastern half of the valley, where concentrations exceed 5,000 mg/l.

Both nitrate (20% of the results) and alpha radiation (44%) are detected above the primary MCL in the Bone Spring-Victorio Peak aquifer (Table 5-4). None of the other parameters with primary standards are detected above the screening level. Nearly all of the secondary drinking water standards are detected above the screening levels, including TDS and sulfate in all of the results, as well as chloride (82% of the results), fluoride (36%), iron (7%), manganese (3%), and pH (1%).

TABLE 5-4. OCCURRENCE AND LEVELS OF SELECTED PUBLIC DRINKING WATER SUPPLY PARAMETERS IN THE BONE SPRING-VICTORIO PEAK AQUIFER

Constituent	Number of Results	Screening Level (mg/l unless otherwise noted)	Type of Standard	Percent of Results Exceeding Screening Level
Nitrate-N	102	10	MCL	20%
Fluoride	97	4	MCL	0%
Barium	41	2	MCL	0%
Alpha	25	15 pc/L	MCL	44%
Cadmium	18	0.005	MCL	0%
Chromium	19	0.1	MCL	0%
Selenium	38	0.05	MCL	0%
Arsenic	34	0.01	MCL	0%
Lead	18	0.015	Action Level	0%
Copper	37	1.3	Action Level	0%
TDS	107	1000	SS	100%
Chloride	107	300	SS	100%
Sulfate	107	300	SS	82%
pH	102	6.5 – 8.5	SS	1%
Fluoride	97	2	SS	36%
Iron	42	0.3	SS	7%
Manganese	39	0.05	SS	3%
Copper	37	1	SS	0%

MCL- Primary drinking water standard (maximum contaminant level) from 30 TAC Chapter 290 Subchapter F

Action Level- Copper and Lead have action levels as defined by 30 TAC 290.117

SS- Secondary drinking water standard from 30 TAC Chapter 290 Subchapter F

5.3.4 Igneous Aquifer

Groundwater from the Igneous aquifer is of excellent quality. Total dissolved solids are generally within the range of 300 to 500 mg/l, but elevated levels of fluoride, a common constituent of igneous rocks, are common.

The only parameters with detections above the primary MCL in the Igneous aquifer are nitrate (3% of the results) and alpha radiation (6%) (Table 5-5). Of the secondary drinking water standards, only fluoride (27%), iron (9%), manganese (4%), and pH (1%) were detected above the screening levels.

TABLE 5-5. OCCURRENCE AND LEVELS OF SELECTED PUBLIC DRINKING WATER SUPPLY PARAMETERS IN THE IGNEOUS AQUIFER

Constituent	Number of Results	Screening Level (mg/l unless otherwise noted)	Type of Standard	Percent of Results Exceeding Screening Level
Nitrate-N	118	10	MCL	3%
Fluoride	118	4	MCL	0%
Barium	28	2	MCL	0%
Alpha	16	15 pc/L	MCL	6%
Cadmium	26	0.005	MCL	0%
Chromium	26	0.1	MCL	0%
Selenium	27	0.05	MCL	0%
Arsenic	26	0.01	MCL	0%
Lead	26	0.015	Action Level	0%
Copper	26	1.3	Action Level	0%
TDS	120	1000	SS	0%
Chloride	121	300	SS	0%
Sulfate	121	300	SS	0%
pH	117	6.5 – 8.5	SS	1%
Fluoride	118	2	SS	27%
Iron	43	0.3	SS	9%
Manganese	23	0.05	SS	4%
Copper	26	1	SS	0%

MCL- Primary drinking water standard (maximum contaminant level) from 30 TAC Chapter 290 Subchapter F
Action Level- Copper and Lead have action levels as defined by 30 TAC 290.117
SS- Secondary drinking water standard from 30 TAC Chapter 290 Subchapter F

5.3.5 West Texas Bolsons Aquifer

The parameters with detections above the primary MCL in the West Texas Bolsons aquifer include nitrate (4% of the results), arsenic (16%) and alpha radiation (5%) (Table 5-6). Most of the secondary drinking water standards were detected above screening levels in some results, including TDS (20%), sulfate (19%), chloride (19%), fluoride (31%), iron (5%), and pH (7%).

TABLE 5-6. OCCURRENCE AND LEVELS OF SELECTED PUBLIC DRINKING WATER SUPPLY PARAMETERS IN THE WEST TEXAS BOLSONS AQUIFER

Constituent	Number of Results	Screening Level (mg/l unless otherwise noted)	Type of Standard	Percent of Results Exceeding Screening Level
Nitrate-N	238	10	MCL	74%
Fluoride	206	4	MCL	7%
Barium	74	2	MCL	0%
Alpha	60	15 pc/L	MCL	5%
Cadmium	57	0.005	MCL	0%
Chromium	70	0.1	MCL	0%
Selenium	75	0.05	MCL	0%
Arsenic	68	0.01	MCL	16%
Lead	57	0.015	Action Level	0%
Copper	68	1.3	Action Level	0%
TDS	249	1000	SS	20%
Chloride	248	300	SS	19%
Sulfate	248	300	SS	19%
pH	243	6.5 – 8.5	SS	7%
Fluoride	206	2	SS	31%
Iron	97	0.3	SS	5%
Manganese	88	0.05	SS	0%
Copper	68	1	SS	0%

MCL- Primary drinking water standard (maximum contaminant level) from 30 TAC Chapter 290 Subchapter F
Action Level- Copper and Lead have action levels as defined by 30 TAC 290.117
SS- Secondary drinking water standard from 30 TAC Chapter 290 Subchapter F

5.3.6 Capitan Reef Aquifer

The only parameters with detections above the primary MCL in the Capitan Reef aquifer were nitrate (3% of the results) and alpha radiation (8%) (Table 5-7). Most of the secondary drinking water standards were detected above the screening level, including TDS (62%), sulfate (77%), chloride (20%), fluoride (19%), iron (40%), manganese (33%), and pH (9%).

TABLE 5-7. OCCURRENCE AND LEVELS OF SELECTED PUBLIC DRINKING WATER SUPPLY PARAMETERS IN THE CAPITAN REEF AQUIFER

Constituent	Number of Results	Screening Level (mg/l unless otherwise noted)	Type of Standard	Percent of Results Exceeding Screening Level
Nitrate-N	31	10	MCL	3%
Fluoride	31	4	MCL	0%
Barium	18	2	MCL	0%
Alpha	12	15 pc/L	MCL	8%
Cadmium	17	0.005	MCL	0%
Chromium	17	0.1	MCL	0%
Selenium	17	0.05	MCL	0%
Arsenic	17	0.01	MCL	0%
Lead	17	0.015	Action Level	0%
Copper	17	1.3	Action Level	0%
TDS	34	1000	SS	62%
Chloride	35	300	SS	20%
Sulfate	35	300	SS	77%
pH	32	6.5 – 8.5	SS	9%
Fluoride	31	2	SS	19%
Iron	20	0.3	SS	40%
Manganese	18	0.05	SS	33%
Copper	17	1	SS	0%

MCL- Primary drinking water standard (maximum contaminant level) from 30 TAC Chapter 290 Subchapter F
Action Level- Copper and Lead have action levels as defined by 30 TAC 290.117
SS- Secondary drinking water standard from 30 TAC Chapter 290 Subchapter F

5.3.7 Edwards-Trinity (Plateau) Aquifer

Water quality in the Edwards-Trinity (Plateau) aquifer is generally good, with most of the water produced from wells being fresh, with only a few parameters being detected above screening levels (Table 5-8). Of the primary maximum contaminant levels, only alpha radiation (9% of the results) and arsenic (2%) were above the primary MCL. Most of the secondary drinking water standards were detected in some of the results above the screening level, including TDS (11% of the results), sulfate (14%), chloride (10%), fluoride (15%), iron (12%), and manganese (2%).

TABLE 5-8. OCCURRENCE AND LEVELS OF SELECTED PUBLIC DRINKING WATER SUPPLY PARAMETERS IN THE EDWARDS-TRINITY (PLATEAU) AQUIFER

Constituent	Number of Results	Screening Level (mg/l unless otherwise noted)	Type of Standard	Percent of Results Exceeding Screening Level
Nitrate-N	79	10	MCL	0%
Fluoride	79	4	MCL	0%
Barium	58	2	MCL	0%
Alpha	43	15 pc/L	MCL	9%
Cadmium	44	0.005	MCL	0%
Chromium	44	0.1	MCL	0%
Selenium	45	0.05	MCL	0%
Arsenic	57	0.01	MCL	2%
Lead	57	0.015	Action Level	0%
Copper	57	1.3	Action Level	0%
TDS	79	1000	SS	11%
Chloride	82	300	SS	10%
Sulfate	81	300	SS	14%
pH	82	6.5 – 8.5	SS	0%
Fluoride	79	2	SS	15%
Iron	60	0.3	SS	12%
Manganese	59	0.05	SS	2%
Copper	57	1	SS	0%

MCL- Primary drinking water standard (maximum contaminant level) from 30 TAC Chapter 290 Subchapter F

Action Level- Copper and Lead have action levels as defined by 30 TAC 290.117

SS- Secondary drinking water standard from 30 TAC Chapter 290 Subchapter F

5.4 SURFACE WATER QUALITY

The Rio Grande and the Pecos River are the principal surface water sources in Far West Texas. Unlike groundwater, surface water quality can vary significantly depending on the amount of flow in the streambed and the rate and source of runoff from adjacent lands. Surface water, as it occurs on the land surface, is also more susceptible to biological and petrochemical contamination. Treatment cost to prepare surface water for municipal distribution is generally much greater than cost for groundwater sources, although desalination of brackish groundwater may be similar.

5.4.1 Rio Grande Water Quality

The quality of water in the segment of the Rio Grande that flows through Far West Texas varies significantly from specific location and season of the year. Of prime consideration is that there is little natural flow in the River. An inventory of water quality in the state (TNRCC, 1996) cites drainage area and a wide range of geologic and climatic conditions in Far West Texas as factors responsible for water-quality conditions in the Rio Grande.

Salinity is an issue associated with the Rio Grande, especially during drought conditions. River flows arriving at El Paso contain a substantial salinity contribution from irrigation return flow and municipal wastewater return in New Mexico. Under current conditions, approximately 25% of the applied irrigation water is needed to move through the project in El Paso County to keep the salt loading at reasonable and manageable levels given average surface flow rates. Studies have shown that salinities in the Rio Grande can increase to over 1,000 mg/l during May and September, depending on actual irrigation demands and releases from reservoirs. Prolonged low flow increase salt storage in riverbanks and riparian zones, which can then be flushed out during high flows.

Increasing water salinity has a negative impact on agriculture. The amount of impact depends on the amount of salinity and amount of sodium in a given water source. With respect to animal agriculture, increased salinity of drinking water creates additional stress on animals, particularly young or lactating animals. As irrigation water salinity increases, potential crop yields decrease. Salt buildup in soils can have a long-term detrimental effect. Most crop production practices in El Paso County have been modified to deal with the use of saline irrigation water. If salinity levels increase, the mixture of crops grown may change to reflect crops with greater tolerance to soil salinity. Unfortunately, many of those salt tolerant crops are not high value crops. Elevated concentrations of chloride and sulfate in the Rio Grande should only be considered indicators of elevated irrigation water salinity. Since very little sprinkler irrigation takes place in the valley, chloride should have less impact on agriculture.

Downstream from El Paso, most of the flow consists of irrigation return flow, and small amounts of treated and untreated municipal wastewater. Heavy metals and pesticides have been identified along this segment of the Rio Grande. Flow is intermittent downstream to Presidio, where the Rio Conchos augments flow. Fresh water springs contribute to the Rio Grande flow in the Big Bend and enhance the overall quality of the river through this reach.

5.4.2 Pecos River Water Quality

The Pecos River is not a source of drinking water for communities in Far West Texas; however, it is the most prominent tributary to the Rio Grande on the Texas side of the river above Amistad Reservoir. According to IBWC data, the Pecos River contributes an average of 11 percent of the annual stream flow in the Rio Grande above the Reservoir and 29 percent of the annual salt load. Concentrations of chloride, sulfate, and total dissolved solids are significantly higher in the Pecos in the counties upstream of its traverse along Terrell County. Natural contributions of salts from the soil, as well as numerous saline groundwater seeps and springs, contribute to the high concentration of dissolved solids. Independence Creek's contribution in Terrell County increases the Pecos River water volume by 42 percent at the confluence and reduces the total suspended solids by 50 percent, thus improving both water quantity and quality. Salinity in the Pecos River is currently being studied by Texas A&M.

5.5 Current Water Quality Issues

Within Far West Texas, several specific water quality issues should be mentioned, including the presence of arsenic and alpha radiation in some groundwater supplies, water quality deterioration in the Bone Spring-Victorio Peak aquifer, general salinity problems, and the positive impact of brackish groundwater use as a drinking water source.

5.5.1 Arsenic

As discussed in the introductory section, the EPA has announced that the new arsenic maximum contaminant level (MCL) for drinking water is lowered from 50 to 10 parts per billion (ppb) with a compliance date of January 23, 2006. As can be seen in Figure 5-2, arsenic is found in concentrations above 10 ppb in significant numbers of results for the Hueco and Mesilla Bolsons and the West Texas Bolsons aquifers. Smaller numbers of results above this screening limit are present in the Edwards-Trinity (Plateau) aquifer. The new standard will have a significant impact on those public water supply entities that currently use groundwater with arsenic concentrations above 10 ppb.

The City of El Paso recently completed one of the largest arsenic removal plants in the country and the first in the state in order to meet this pending drinking water standard. This 30-mgd plant and three smaller plants cost $76 million to complete, and will allow the continued use of nearly 40 percent of the City's wells that contain elevated levels of arsenic. The larger plant will allow the City to treat groundwater produced from 24 of their wells in the Canutillo well field producing from the Mesilla Bolson aquifer. The three smaller plants will remove arsenic from water produced from 31 wells in the Hueco Bolson aquifer.

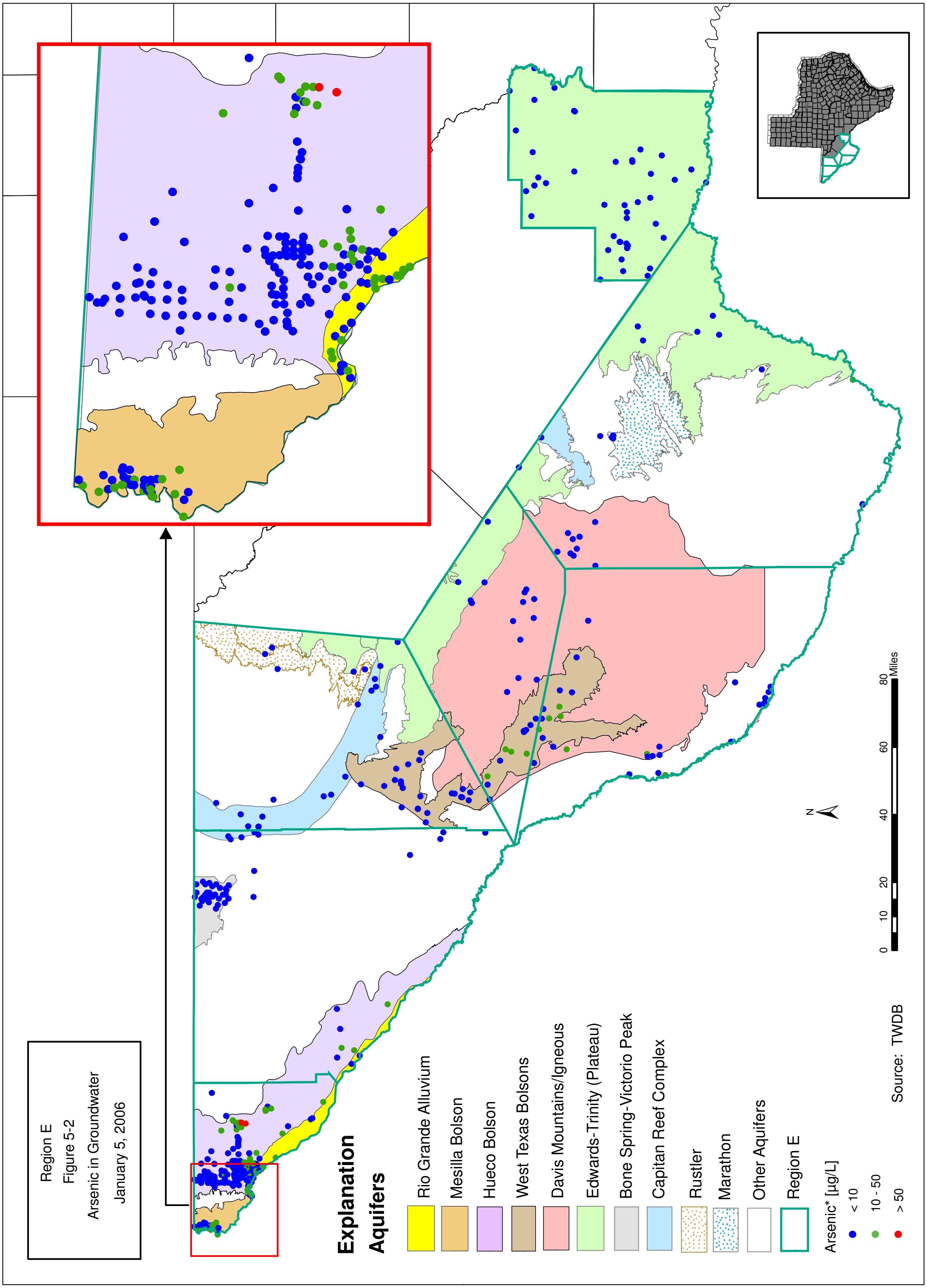

FIGURE 5-2. ARSENIC IN GROUNDWATER IN THE FAR WEST TEXAS REGION

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5.5.2 Radioactivity

Another specific water quality issue for the region is radioactivity in groundwater. Alpha radioactivity is found above the primary MCL in 5 to 10 percent of the results in the Hueco and Mesilla Bolsons, Capitan Reef, West Texas Bolsons, and Igneous aquifers, and in nearly half of the results in the Bone Spring-Victorio Peak aquifer. Radioactivity is a constituent of major concern in the resort town of Lajitas, where wells producing water from the deep Cretaceous limestones consistently have alpha radiation concentrations above the drinking water standard. This area currently has to treat groundwater to meet the applicable drinking water standards.

5.5.3 Bone Spring-Victorio Peak Aquifer Water Quality

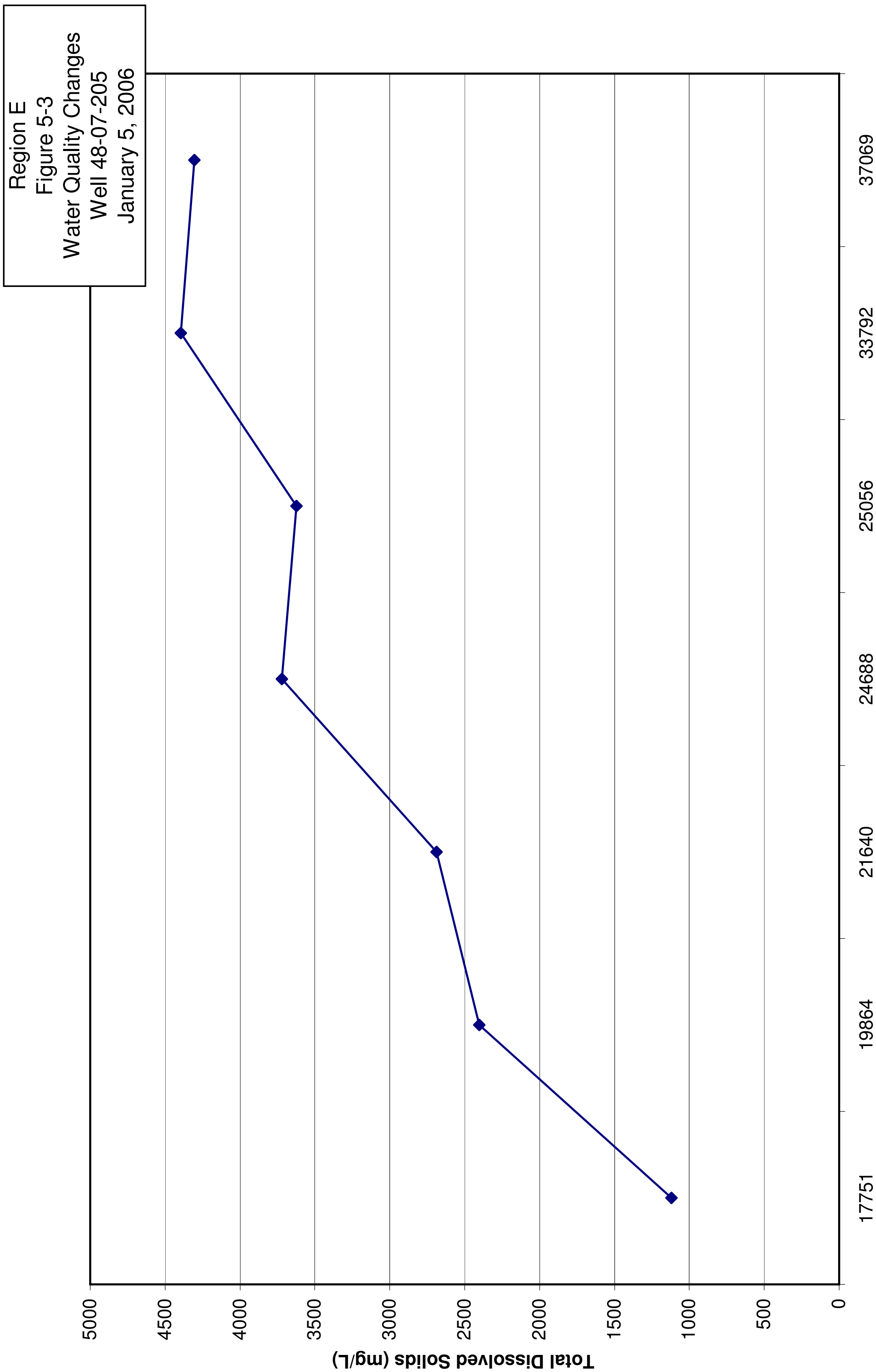
Groundwater quality in the Bone Spring-Victorio Peak aquifer contains high concentrations of chloride, sulfate, and TDS in nearly all sample results reported. Farmers in the area have been able to irrigate with this high salinity water by applying greater than normal quantities to the fields, thus flushing salts downward through the permeable soil horizon. This practice has prevented damaging salt buildup in the soils; however, the downward movement of salts over time has led to the slow water-quality degradation of the underlying aquifer (Figure 5-3).

5.5.4 SALT WATER ENCROACHMENT

"Salt-water encroachment" is a common term used to describe the migration of poorer quality water into a water well that has previously been withdrawing fresh water. This process has occurred in a number of City of El Paso public-supply wells and has resulted in the abandonment of several of these wells. Left unchecked, salt-water encroachment could eventually seriously affect the serviceable life of the well field. El Paso Water Utilities and Fort Bliss are jointly constructing a large desalination facility that will serve two purposes. The facility will extract brackish groundwater to be desalinated from a location that will prevent the further migration of poorer quality water into the existing freshwater well field. Also, by using brackish supplies to meet a portion of the total water demand, fresh groundwater sources are maintained for longer periods of time.

5.5.5 Salinity

Salinity of the Rio Grande has a significant impact on El Paso's surface water supply. Total dissolved solids in the river water increase almost two fold during low-flow periods when water is not being released from upstream reservoirs for irrigation use. The city's water treatment plants shut down when sulfate concentrations near 300 ppm or TDS approaches 1,000 ppm. This generally limits the City's ability to access surface water supplies to the months of March through August. Local organizations such as the Paso del Norte Watershed Council, supported by local universities and research centers, actively pursue measures to combat the growing problem of salinity. The El Paso Water Utility is a member of the Multi-State Salinity Coalition, an organization that seeks advancements in desalination-related technologies and salinity control strategies to enhance the quality and quantity of water sources.



Source: TWDB

FIGURE 5-3. WATER QUALITY CHANGES IN WELL 48-07-205 FROM 1948 TO 2001

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5.6 WATER QUALITY IMPACTS OF IMPLEMENTING WATER MANAGEMENT STRATEGIES

The El Paso County Integrated Water Management Strategy includes the conversion of surface-water rights, groundwater from the Bone Spring-Victorio Peak aquifer in the Dell Valley area, and the Capitan Reef aquifer underlying Diablo Farms. Water available under conversion of surface-water rights would have the same current quality of water used for irrigation, which is suitable for conventional treatment.

Groundwater from wells in the Dell Valley area contains concentrations of iron, chloride, nitrate, sulfate, and aluminum exceed water quality standards for municipal supply. Total dissolved solids in the area range from 1,810 to 3,900 mg/l. Desalination would be required before distribution for municipal use.

TDS concentrations in the Capitan Reef aquifer range from 850 to 1,500 mg/l, although all the operating wells on Diablo Farms have TDS values below 1,000 mg/l. It is expected that significant increases in historical pumping amounts would result in movement of poorer quality groundwater into the area. EPWU has completed preliminary evaluations of groundwater availability in the area, and has concluded that pumping less than 10,000 acre-feet per year would require no desalination. Pumping between 10,000 and 25,000 acre-feet per year would be sustainable, but the groundwater would likely have to be desalinated over time. Pumping above 25,000 acre-feet per year would not be sustainable.

5.7 IMPACT OF MOVING WATER FROM AGRICULTURAL AREAS

The El Paso County Integrated Water Management Strategy involves the conversion of water and some properties previously used for agricultural purposes to municipal use. An additional 20,000 acre-feet per year from the Rio Grande would be obtained after the retirement of about 5,000 acres of land from irrigation. This represents a reduction of agricultural activities in El Paso County. Two factors drive this conversion: expected population growth in El Paso County and economics. As more people live in El Paso County, some cropland necessarily will be converted to urban use. In addition, as population grows the cropland adjacent to urbanized area will become more valuable than the crops produced on the land or the rights of the Rio Grande Project water associated with the land. At that point, many agricultural producers will make the decision to convert their property to residential, commercial or some purpose other than irrigated agriculture. This conversion is primarily the result of urbanization, not the implementation of this water management strategy. Conversion would be voluntary by lease, sale, or forbearance agreements.

The integrated strategy would also utilize the water rights for 24,000 acres of land in Hudspeth County, which would reduce irrigation activities near Dell City. The transfer to El Paso County is near 80% of the maximum limit. Conversion of water rights to transfer water to El Paso County would be voluntary. Land may became unsuitable for agriculture after extensive irrigation with brackish water due to accumulation of salt in the soil, and some acreage would be retired from irrigation regardless of how much water is exported to El Paso County. It is expected that irrigators will find it economically beneficial to transfer or sale their land or water rights. EPWU owns the land above the Capitan Reef aquifer. Therefore, the conversion of use from agricultural to municipal will have no impact on agricultural ownership in that area.

Additional discussion pertaining to the economic impact of converting agricultural water to other uses (primarily municipal) is available in the TWDB "Socioeconomic Impact of Unmet Water Needs in Far West Texas" report provided as Appendix 4A in Chapter 4.

CHAPTER 6

WATER CONSERVATION AND DROUGHT CONTINGENCY

6.1 WATER CONSERVATION

Water conservation are those practices, techniques, programs, and technologies that will protect water resources, reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling or reuse of water so that a water supply is made available for future or alternative uses. Water conservation and drought contingency planning implemented by municipalities, water providers, and other water users supersede recommendations in this plan are considered consistent with this plan.

Texas Water Code §11.1271 requires water conservation plans for all municipal and industrial water users with surface water rights of 1,000 acre-feet per year or more and irrigation water users with surface water rights of 10,000 acre-feet per year or more. Water conservation plans of three entities in Far West Texas that meet this criteria are included in the appendices at the end of this chapter. These entities include El Paso Water Utilities (EPWU) (Appendix 6A), El Paso County Water Improvement District No.1 (Appendix 6B), and Hudspeth County Conservation and Reclamation District No.1 (Appendix 6C). Water conservation plans are also required for all other water users applying for a State water right, and may also be required for entities seeking State funding for water supply projects.

6.1.1 Regional Water Conservation Recommendations

EPWU is the largest supplier of municipal water in Far West Texas, supplying approximately 95 percent of all municipal needs in 2000. The City of El Paso through the EPWU has been implementing an aggressive water conservation program for the past 13 years and has reduced the per capita demand from 200 gpcd in 1990 to 139 gpcd in 2004. The low consumption in recent years occurred because the area was under drought restrictions in 2003 and 2004. The conservation goal for El Paso is 140 gpcd, which would be the lowest large city per capita use in Texas. The continuation of the conservation effort is a key component of the El Paso Integrated Water Management Strategy discussed in Chapter 4. El Paso's Water Conservation Plan is provided in Appendix 6A.

Irrigation represents approximately 76 percent of all the water used in Far West Texas. Most of this water is diverted from the Rio Grande and is applied to crops on farms located along the Rio Grande floodplain in El Paso, Hudspeth, and Presidio Counties. During significantly dry periods, insufficient water is available in upstream reservoirs to meet the full permitted allotments, and farmers in these areas have generally approached this situation by reducing acreage irrigated, changing types of crops planted, or possibly not planting crops until water becomes available during the following season. In some cases, farmers may benefit from a number of Best Management Practices described in Chapter 4, which are a mixture of site-specific management, educational, and physical procedures that have proven to be effective and are cost-effective for conserving water.

The implementation of water conservation programs that are cost effective, meet state mandates, and result in permanent real reductions in water use will be a challenge for the citizens of Far West Texas. Smaller communities that lack financial and technical resources will be particularly challenged and will look to the State for assistance. Irrigation conservation may result in significant reductions in water use. However, without financial and technical assistance, it is unlikely that aggressive irrigation conservation programs will be implemented.

6.1.2 Water Conservation Considerations

6.1.2.1 Water-Saving Plumbing Fixture Program

The Texas Legislature created the Water-Savings Plumbing Fixture Program on Jan. 1, 1992 to promote water conservation. Manufacturers of plumbing fixtures sold in Texas must comply with the Environmental Performance Standards for Plumbing Fixtures, which requires all plumbing fixtures such as showerheads, toilets and faucets sold in Texas to conform with specific water use efficiency standards.

Because more water is used in the bathroom than any other place in the home, water-efficient plumbing fixtures play an integral role in reducing water consumption, wastewater production, and consumers' water bills. It is estimated that switching to water-efficient fixtures can save the average household between $50 and $100 per year on water and sewer bills. Many hotels and office buildings find that water-efficient fixtures can save 20 percent on water and wastewater costs.

6.1.2.2 Water Conservation Best Management Practice

The 78th Texas Legislature under Senate Bill 1094 created the Texas Water Conservation Implementation Task Force and charged the group with reviewing, evaluating, and recommending optimum levels of water use efficiency and conservation for the state. TWDB Report 362, Water Conservation Best Management Practices Guide was prepared in partial fulfillment of this charge. The Guide is organized into three sections, for municipal, industrial, and agricultural water user groups with a total of 55 Best Management Practices (BMPs). Each BMP has several elements that describe the efficiency measures, implementation techniques, schedule of implementation, scope, water savings estimating procedures, cost effectiveness considerations, and references to assist end-users in implementation. This document can be accessed at the following TWDB web site: http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITFBMPGuide.pdf.

6.1.2.3 Water Conservation Tips

The TWDB provides a significant amount of information and services pertaining to water conservation that can be accessed at: http://www.twdb.state.tx.us/assistance/conservation/consindex.asp . Likewise, Water Conservation Tips were developed by the TCEQ's Clean Texas 2000.

6.1.3 Model Water Conservation Plans

Water Conservation Plan forms are available from TCEQ in WordPerfect and PDF formats. The forms for the following entity types listed below are available at http://www.tceq.state.tx.us/permitting/water_supply/water_rights/conserve.html. You can receive a print copy of a form by calling 512/239-4691 or by email to wras@tceq.state.tx.us.

Municipal Use - Utility Profile and Water Conservation Plan Requirements for Municipal Water Use by Public water Suppliers (TCEQ-10218)

Wholesale Public Water Suppliers - Profile and Water Conservation Plan Requirements for Wholesale Public Water Suppliers (TCEQ-20162)

Industrial/Mining Use - Industrial/Mining Water Conservation Plan (TCEQ-10213)

Agricultural Uses –
Agriculture Water Conservation Plan-Non-Irrigation (TCEQ-10541)
System Inventory and Water Conservation Plan for Individually-Operated Irrigation System (TCEQ-10238)
System Inventory and Water Conservation Plan for Agricultural Water Suppliers Providing Water to More Than One User (TCEQ-10244)

6.2 DROUGHT CONTINGENCY

Drought is a frequent and inevitable factor in the climate of Texas. Therefore, it is vital to plan for the effect that droughts will have on the use, allocation and conservation of water in the state. Far West Texas is perennially under drought or near-drought conditions compared with more humid areas of the State. Although residents of the Region are generally accustomed to these conditions, the low rainfall and the accompanying high levels of evaporation underscore the necessity of developing plans that respond to potential disruptions in the supply of groundwater and surface water caused by drought conditions.

Because of the range of conditions that affected the more than 4,000 water utilities throughout the state in 1997, the Texas Legislature directed the TCEQ to adopt rules establishing common drought plan requirements for water suppliers. As a result, the TCEQ requires all wholesale public water suppliers, retail public water suppliers serving 3,300 connections or more, and irrigation districts to submit drought contingency plans. For all retail public water suppliers serving less than 3,300 connections, the drought contingency plans must have been prepared and adopted no later than May 1, 2005, and shall be available for inspection upon request.

6.2.1 Drought Response Triggers

Droughts typically develop slowly and insidiously 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 diminishes or water demand increases. 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. Entities providing drought contingency plans to the Far West Texas Water Planning Group are listed in Section 6.3.

Drought response triggers should be specific to each water supplier and should be based on an assessment of the water user's vulnerability. For instance, a user on a surface-water source is likely to experience shortage from a drought sooner than a user on a groundwater source, simply due to the nature of the supply source. 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 a storage tank. However, this type of trigger will likely come too late for the entity to know it is in trouble; therefore, a supply source trigger is preferable. Triggers based on demand levels can also be effective as long as the entity does not overestimate how far it can stretch its supply or how much water its retail customers can manage to conserve. 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.

6.2.2 Surface Water Triggers

The annual allotment of Rio Grande Project water is determined by the U.S. Bureau of Reclamation (USBR) based on the amount of usable water in storage in Elephant Butte and Caballo reservoirs. Based on the amount of storage remaining in Elephant Butte and Caballo Reservoirs at the end of the primary irrigation season (early- to mid-October), the USBR determines the amount of water that will be delivered the following year. In general, a one-year drought in the Upper Rio Grande drainage basin will have little effect on overall storage in the reservoirs. However, a long-term drought would have a significant effect on water releases downstream. Downstream users, both irrigation and municipal, are thus aware in advance of coming surface water supply shortages and can react accordingly.

The City of El Paso's Drought and Emergency Management Plan (2002) is administered through EPWU and is based on three Drought or Water Emergency Stages: (1) A Stage I water emergency is triggered when water stored in Elephant Butte Reservoir is less than 500,000 acre-feet; or when the El Paso County Water Improvement District No. 1 (EPCWID#1) declares surface water allotment is less than 3.0 acre-feet per acre on or before March 15th; or when water demand is projected to exceed 90 percent of available capacity as determined by El Paso Water Utilities; (2) A Stage II water emergency is triggered when the EPCWID#1 declares surface water allotment of less than 2.5 acre-feet per acre on or before March 15th and river water quality is projected to exceed 300 parts per million (ppm) of sulfates or 1,000 ppm of total dissolved solids in April, May or September; or when water demand is projected to exceeds 95 percent of available capacity as determined by El Paso Water Utilities; (3) A Stage III water emergency is triggered when the EPCWID#1 declares surface water allotment of less than 2.0 acre-feet per acre on or before March 15th or river water quality is projected to exceed 300 parts per million (ppm) of sulfates or 1,000 ppm of total dissolved solids during the months of June, July and August; or when water demand is projected to exceeds 100 percent of available capacity as determined by El Paso Water Utilities. A water emergency may also be declared based on a water system failure due to weather, electrical or mechanical failure or contamination of source. Once any stage is declared, the General Manager of the EPWU can implement a variety of response measures designed to conserve water. These range from use restrictions to citations for noncompliance.

Most of the other communities in El Paso County receive their water supplies from EPWU or from other water-supply entities including the Horizon Regional MUD, El Paso County WCID No.4, and the Lower Valley Water District. Because of their reliance on supply provided by EPWU, the Lower Valley Water District drought contingency triggers and responses should be similar to the triggers and responses developed by EPWU. The other wholesale water providers rely on groundwater, which is discussed under the following Groundwater Triggers section.

Irrigation districts depend on runoff from watersheds in the Upper Rio Grande drainage basins of New Mexico and southern Colorado to provide surface water to support irrigation in El Paso and Hudspeth Counties. Hence, drought triggers for the El Paso County Water Improvement District No.1 (EPCWID #1) and the Hudspeth County Conservation and Reclamation District No.1 (HCCR #1) are established based on storage levels in Elephant Butte and Caballo Reservoirs, which are in turn dependent on meteorological and hydrological conditions in these water sheds.

Drought conditions, which impact the EPCWID #1, are those that affect the headwaters of the Rio Grande and its tributaries, such that Rio Grande Compact water deliveries into Elephant Butte Reservoir are reduced. The district's board of directors determines when a drought exists and establishes the yearly delivery allotment to its water users based on its diversion allocation from the USBR. Generally, when water storage in Elephant Butte Reservoir is less than 0.9 million acre-ft during the irrigation season (March through September), the USBR declares drought conditions and sets its diversion allocations (using the D1 and D2 curves) to the irrigation districts based on a delivery allotment of less than its normal (non-drought) 3 acre-foot per acre. During times of drought, the district will lower its delivery allotment based on the amount of its reduced diversion allocation from the USBR and its delivery commitments to its users. The extent of the reductions in the water allotments will be dependent on the severity of the drought conditions, and will remain in effect until the conditions that triggered the drought contingency no longer exist.

The HCCRD #1 bases drought contingency planning on evaluation of the water supply projected and received by the EPCWID #1, since all waters received by HCCRD #1 are return flows and operational spills for El Paso County. Since conditions, to a degree, can be predicted prior to a crop season, the drought mitigation plan largely affects agricultural producers cropping plan. When a mild or moderate predicted shortage occurs, the HCCRD #1 will notify its clientele of the amount of the expected shortage. For a severe shortage, where the water supply will provide less than 50 percent of the expected demand, agricultural producers will be asked to prioritize their water requests based upon crop needs.

Water in the Lower Rio Grande segment is used principally for irrigation, recreation, and environmental needs. A drought trigger for this segment of the river is based on flows of less than 35,438 acre-feet. The TCEQ Rio Grande Watermaster administers the allocation of Texas' share of the international water and is responsible for informing water-rights users of expected diversions during drought years.

6.2.3 Groundwater Triggers

Groundwater triggers that indicate the onset of drought in Far West Texas 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 groundwater 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 groundwater.

Several groundwater basins are identified in Chapter 3 as aquifers that will likely not experience consistent water-level decline, or mining, 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 to 2050 planning period. Because of minimal water-level changes in these aquifers, water levels are not recommended as a drought-condition trigger. Atmospheric conditions are a better indicator for these areas.

Basins that do not receive sufficient recharge to offset natural discharge and pumpage may be depleted of groundwater (e.g., mined). The rate and extent of groundwater mining 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 during drought as a sufficient indicator.

Because of the above described problems with using water levels as drought-condition indicators, most municipal water-supply entities in Far West Texas that rely on groundwater generally establish drought-condition triggers based on levels of demand that exceed a percentage of the systems production capacity. Table 6-1 provides a list of groundwater dependent entities, their supply source, their type of triggers and 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 groundwater 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.

TABLE 6-1. SUGGESTED OR MANDATED DROUGHT TRIGGERS FOR GROUNDWATER DEPENDENT ENTITIES

Water-Supply Entity	Entity Water Supply Source	Drought Trigger	Trigger Response
Alpine	Igneous Aquifer	Daily water demand exceeds 75% of production capacity.	Multi-stage limitation on water use.
Van Horn	West Texas Bolsons Aquifer (Wild Horse Flat)	1. System demand exceeds production or storage capacity measured over a 24-hour period.	4-stage increasing limitation on water use.
El Paso (EPWU) *	Hueco and Mesilla Bolson Aquifers	Drought triggers are based on three surface-water allotment stages beginning with an annual allotment of less than 3.0 acre-feet per acre.	EPWU Manager can implement a variety of response measures designed to conserve water.
Anthony	Mesilla Bolson Aquifer	Daily water demand exceeds 75% of production capacity.	Multi-stage limitation on water use.
Vinton	Mesilla Bolson Aquifer	1. Daily water demand exceeds 75% of production capacity; 2. Water levels in wells drop below pump intake level; 3. Power failure of over 30 minutes.	Multi-stage limitation on water use.
Horizon Regional MUD Horizon City	Hueco Bolson Aquifer	Daily water demand exceeds 75% of production capacity.	Multi-stage limitation on water use.
Dell City	Bone Spring-Victorio Peak Aquifer	Daily water demand exceeds 75% of production capacity.	Multi-stage limitation on water use.
Sierra Blanca	West Texas Bolsons Aquifer (Wild Horse Flat)	Linked to Van Horn	Linked to Van Horn
Fort Davis WSC Fort Davis	Igneous Aquifer	4 trigger levels beginning with mild shortages. Second stage begins when daily water demand exceeds 60% of production capacity.	4-stage increasing limitation on water use.
Marfa	Igneous Aquifer	Daily water demand exceeds 75% of production capacity.	Multi-stage limitation on water use.
Presidio	West Texas Bolsons Aquifer (Presidio Bolson)	Daily water demand exceeds 75% of production capacity.	Multi-stage limitation on water use.
Terrell County WCID #1 Sanderson	Edwards-Trinity (Plateau) Aquifer	3 trigger levels beginning when daily water demand exceeds 80% of production capacity.	3-stage increasing limitation on water use.

* The Far West Texas Water Planning Group considers groundwater triggers for El Paso (EPWU) not to be relevant.

Water-use categories in the Region other than municipal that are dependent on groundwater 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, groundwater levels in this part of the State 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, Table 6-2 provides a selection of wells (one per aquifer) with a history of measurements and a proposed drought trigger level. Staff of the TWDB measure most of these wells annually. Wells selected for drought contingency triggers should be re-evaluated for appropriateness during the next planning period.

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. Appropriate drought responses are the responsibility of and at the discretion of private well owners.

TABLE 6-2. SUGGESTED GROUNDWATER LEVEL TRIGGERS BY SOURCE

Aquifer	County	Well Number	Avg. Depth to Water in 1990s	Trigger Depth to Water
Hueco Bolson **	El Paso	49-13-710 EPWU #67	14.7 decline to 5.5 rise *	Unknown **
Mesilla Bolson **	El Paso	49-04-138 JL-EPWU #117	4.6 decline to 3.4 rise *	Unknown **
Rio Grande Alluvium	El Paso	49-04-701	6.4	7.3
Edwards-Trinity (Plateau)	Terrell	53-53-601	Unknown	30 ft. below avg summer depth
Bone Spring-Victorio Peak	Hudspeth	48-07-516	121	135
Igneous	Brewster	52-35-709	113	144
Marathon	Brewster	52-55-106	Unknown	30 ft. below avg. summer depth
Rustler ***				
Salt Basin				
Wild Horse	Culberson	47-59-106	227	20 ft. below avg. summer depth
Lobo	Culberson	51-02-903	197	20 ft. below avg summer depth
Ryan	Jeff Davis	51-19-902	109	30 ft. below avg. summer depth
Other West Texas Bolsons***				

* Ranges of annual drawdown.

** The Hueco and Mesilla Bolson aquifers are undergoing a continuous water-level decline and, therefore, a depth trigger is inappropriate. Water-level changes shown are related to normal variations in groundwater pumping at the well and the well field in general, and are not believed to be drought induced. Drawdown levels that may be used as drought triggers during drought-of-record conditions have not been identified in these or any other wells in the well field. However, due to their proximity to the Rio Grande, it is believed that these wells would be most likely to show effects if a drought-of-record were to occur.

*** Very little pumpage, if any, comes from these aquifers and, therefore, a depth trigger is meaningless.

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

6.2.3.1 Model Drought Contingency Plans

The TCEQ has prepared model drought contingency plans for wholesale and retail public water suppliers, water supply corporations, and investor owned utilities that meet the TCEQ's minimum requirements. The forms for the entity types listed below are available at http://www.tceq.state.tx.us/permitting/water_supply/water_rights/contingency.html. You can receive a print copy of the model plan by calling 512/239-4691, or by e-mail to wras@tceq.state.tx.us.

- Handbook for Drought Contingency Planning for Retail Public Water Suppliers.
- Handbook for Drought Contingency Planning for Wholesale Public Water Suppliers.
- Handbook for Drought Contingency Planning for Irrigation Districts.
- Model Drought Contingency Plan for the Investor Owned Utility.
- Model Drought Contingency Plan for the Water Supply Corporation.

The model drought contingency plans for the above categories incorporate the following guidelines:

- Specific, quantified targets for water use reductions
- Drought response stages
- Triggers to begin and end each stage
- Supply management measures
- Demand management measures
- Descriptions of drought indicators
- Notification procedures
- Enforcement procedures
- Procedures for granting exceptions
- Public input to the plan
- Ongoing public education
- Adoption of plan
- Coordination with regional water planning group

6.3 WATER CONSERVATION MANAGEMENT AND DROUGHT CONTINGENCY PLANS

In the consideration of regional conservation and drought management issues, the Far West Texas Water Planning Group reviewed active water conservation management and drought contingency plans provided to the planning group by the following entities.

Public Supply Entities

- City of Alpine - Water Conservation and Drought Contingency Plan (August 2005)
- Dell City – Water Conservation and Drought Contingency Plan (August 2000)

- El Paso County Water Authority – Water Conservation and Drought Contingency Plan (May 2001)
- El Paso County WCID #4 – Drought Contingency Plan (August 2000)
- El Paso Water Utilities – El Paso's Water Conservation Plan (May 2005)
- El Paso Water Utilities – EPWU Drought and Water Emergency Management Response Plan (November 2002)
- Esperanza Water Service Company – Drought Contingency Plan (August 2000)
- Fort Davis WSC – Drought Contingency Plan (August 2000)
- Fort Davis Estates – Drought Contingency Plan (August 2001)
- Green Acres/River View Water Works – Drought Contingency Plan (August 2000)
- Horizon Regional MUD – Water Conservation and Drought Contingency Plan (April 2005)
- Lajitas Utility Company – Drought Contingency Plan (November 2005)
- Marathon Water Supply and sewer Service Corp. – Drought Contingency Plan (July 2000)
- City of Sanderson – Comprehensive Plan (1994)
- Study Butte WSC – Drought Contingency Plan (April 2001)
- Terrell County WCID No.1 – Drought Contingency Plan
- Turf Water System – Drought Contingency Plan (August 2000)
- Town of Valentine – Drought Contingency Plan (August 2000)
- Town of Van Horn – Water Conservation and Drought Contingency Plan (July 1996)
- Villa Alegre estates – Drought Contingency Plan (August 2000)
- Vinton Hills Water System – Drought Contingency Plan (August 2000)
- Vinton Village Estates – Drought Contingency Plan (August 2000)

Irrigation Districts

- El Paso County Water Improvement District No.1 – *Management Plan*
- Hudspeth County Conservation and Reclamation District No.1 – *Management Plan*

6.4 GROUNDWATER CONSERVATION DISTRICTS

The Texas Legislature has established a process for local management of groundwater resources through groundwater conservation districts. The districts are charged with managing groundwater by providing for the conservation, preservation, protection, recharging and prevention of waste of groundwater within their jurisdictions. An elected or appointed board governs these districts and establishes rules, programs and activities specifically designed to address local problems and opportunities. Texas Water Code §36.0015 states, in part, "Groundwater Conservation Districts created as provided by this chapter are the state's preferred method of groundwater management." Five districts are currently in operation within the planning region.

6.4.1 Brewster County Groundwater Conservation District

The Brewster County Groundwater Conservation District was confirmed in 2001 and serves the all of Brewster County, the largest county in the State. The mission of the District is to manage, protect, and conserve the groundwater resources of Brewster County, while protecting private property rights and promoting constructive and sustainable development in the county. Management goals include:

- Improve the understanding of groundwater in the District
- Implement rules for drilling, completing, equipping, and operating of water wells
- Implement strategies that will provide for the most efficient use, long-term sustainability and conservation of groundwater
- Recommend strategies that will protect and enhance the quality and quantity of water by controlling and preventing waste

- Minimize the degradation of the aquifers by considering regulations for spacing of wells and production from wells
- Determine aquifer conditions to be used as trigger mechanisms to assist water suppliers in implementing emergency drought management plans
- Minimize the potential for contamination of groundwater by new or existing wells
- Prevent damage or degradation to the aquifers in the District by the export of water from the District

6.4.2 Culberson County Groundwater Conservation District

The Culberson County Groundwater Conservation District occupies the southwestern half of Culberson County and was confirmed in May 1998. Aquifers managed by the District primarily include the Wild Horse Flat, Michigan Flat, and Lobo Flat West Texas Bolsons, and the Capitan Reef aquifer. The District adopted a management plan in 2000, along with associated rules and regulations, and has established the following management goals:

- Improve the basic understanding of groundwater conditions in the District
- Implement management strategies that will provide for the most efficient use of groundwater
- Strive to prevent the waste of water
- Minimize the influence of pumping of wells on the degradation of the aquifers by regulating the spacing of wells and by use of a Production Use Measurement Area
- Minimize the potential for contamination of groundwater by new or existing wells
- Monitor water export out of the District

6.4.3 Hudspeth County Underground Water Conservation District #1

The Hudspeth County Underground Water Conservation District #1 was created in 1956 and is located in the Dell Valley irrigation area of northeast Hudspeth County, with the Community of Dell City lying approximately in the center of the District. The principal aquifer in the District is the Bone Spring-Victoria Peak. The District recently installed eight continuous water-level recorders and has placed flow gauges on irrigation wells. The latest District management plan adopted in 2002 includes the following management goals and activities:

- Provide for the most efficient use of groundwater
- Control and prevent the waste of groundwater
- Address natural-resource issues
- Curtail permitted withdrawals from the aquifer during periods of extreme drought
- Promote the efficient application of irrigation water to field crops

6.4.4 Jeff Davis County Underground Water Conservation District

The Jeff Davis County Underground Water Conservation District was formed in August 1994 (HB 2866) and includes all of Jeff Davis County and portions of Brewster, Pecos and Presidio Counties within its jurisdiction. Primary aquifers managed by the District include the Ryan Flat and Lobo Flat West Texas Bolsons and the Igneous. District activities include the registration of all new wells and the permitting of wells that are capable of producing 25,000 gallons per day or more. State well construction standards are enforced and water levels are monitored in 28 observation wells located in high use areas. The District is involved in a wellhead protection program with the Fort Davis Water Supply Corp. and also provides educational programs for schools and the public. The following goals are included in the District's 2003 management plan:

- Provide for the most efficient use of groundwater
- Control and prevent waste of groundwater
- Implement management strategies that will address drought conditions
- Implement management strategies that will promote water conservation

6.4.5 Presidio County Underground Water Conservation District

Presidio County residents approved the formation of the Presidio County Underground Water Conservation District in an election held August 31, 1999. Primary aquifers to be managed in the District include the Presidio-Redford Bolson, the Ryan Flat West Texas Bolson, and the Igneous. District activities include well permitting, recharge enhancement, and public education. The District developed a management plan in 2000 (revised 2003) which includes the following goals:

- Provide for the most efficient use of groundwater
- Control and prevent waste of groundwater
- Implement strategies that will address drought conditions
- Implement strategies that will promote water conservation.

APPENDIX 6A

CITY OF EL PASO

WATER CONSERVATION PLAN

APPENDIX 6A

City of El Paso Water Conservation Program

In 1990, the Public Service Board (PSB) named a 40 member Citizens Advisory Committee to look at all areas of water use and make recommendations for a water conservation program. This was in response to seasonally high peak demands as well as a growing concern of meeting long-term goals. At the same time, El Paso's Water Resource Management Plan was being finalized. One of the proposed measures included in the management plan was water conservation as the most economical way to help achieve projected water use savings. In addition, the Committee reported wasteful water use practices needed to be eliminated in order to successfully accomplish the 160 gallons per capita per day (gpcd) goal. The practices identified were lawn and garden irrigation, high volume plumbing fixtures, evaporative cooling and at-home car washing.

This report became the basis for El Paso's Water Conservation Ordinance that the PSB presented to City Council for approval in 1991. Consequently, the EPWU-PSB initiated a comprehensive water conservation program that includes a range of voluntary and mandatory programs as well as utility policy changes designed to help reach long-term goals. By implementing innovative water conservation measures such as permanent changes in water use, strategic public education, changes in the plumbing code, the water conservation ordinance affecting new and existing homes and businesses, water system optimization and higher cost of water by establishing an increased block rate structure, the El Paso Water Utilities seek to reduce per capita use 20 percent, from the 200 gallons per capita per day (gpcd) used in 1989 to 160 gpcd by the year 2000.

TABLE 1. HISTORICAL TOTAL SYSTEM WATER CONSUMPTION DATA

Year	Population	Growth	Total Water*	GPPD**
1990	554,502	2.0%	37.87	187
1991	558,499	2.5%	35.21	170
1992	582,553	2.4%	36.59	172
1993	596,664	2.4%	38.61	177
1994	610,832	2.3%	40.40	181
1995	625,057	2.3%	40.34	177
1996	639,339	2.2%	40.11	172
1997	653,404	2.2%	39.72	167
1998	668,074	2.2%	39.95	164
1999	682,527	2.1%	40.70	163
2000	697,037	2.1%	40.43	159
2001	690,000	-1.0%	39.15	155
2002	690,000	0%	38.46	153
2003	682,637	-1.1%	36.99	148
2004	682,137	-0.1%	34.66	139

* Billion Gallons
** Gallons per Person per Day

MANDATORY RESTRICTIONS

Conservation Ordinance

The Water Conservation Ordinance contains mandatory, year-round restrictions on certain water use activities, prohibits water waste and applies to any person who uses water from the El Paso Water Utilities supply system. Mandatory restrictions included in the ordinance are:

Landscape Watering Days

Before 1991, customers of El Paso Water Utilities could water their yards any time, any day, the water distribution system was always catching up with demand; and then in June 1990, reservoir levels were alarmingly low, just before the evening irrigation peak of 6:00 - 8:00 P.M. Levels at some reservoirs were only three feet high, jeopardizing fire protection in some areas of the city. This experience resulted in the adoption of a three-day per week landscape watering schedule designed to reduce wasteful irrigation practices and to reduce peak demand on the system. The year around schedule allows EVEN numbered addresses to water Tuesday, Thursday and Saturday. ODD numbered addresses are allowed to water Wednesday, Friday and Sundays. There is no residential watering on Mondays. Schools, parks, cemeteries, golf courses and industrial sites are allowed to water Monday, Wednesday and Friday.

Watering Days Times Restrictions

To extend the conservation efforts, landscape irrigation restriction times were adopted in addition to the watering day's schedule. From April 1 through September 30, outdoor watering is allowed only before 10:00 a.m. or after 6:00 p.m.

Exceptions

If a customer desires a change in irrigation days and hours, it is the customer's responsibility to apply for a variance and demonstrate hardship. A Review Board can modify established schedules or approve requests for variances. Variances are based on the Review Board's recommendations and are usually granted to customers that, because of age or health or depend on someone else to do yard work, or for those out-dated irrigation systems that cannot irrigate within the allotted time.

Landscape Watering Permits are issued for thirty days for the establishment of new lawns and landscapes or for one day for the application of either chemicals or fertilizer.

Car Washing

Is only allowed using a bucket and/or a hand-held hose equipped with a positive shut-off nozzle. All "fund-raising" car wash events must be held at commercial establishments. During different drought management stages, washing of vehicles will only be permitted at commercial establishments approved by the El Paso Water Utilities.

Water Waste

Any activity that causes water to spray or flow into the street or public right-of-way is prohibited and considered a violation. Violations are class C misdemeanor in nature. Although El Paso Water Conservation Ordinance does not require written warnings before a citation is given, the Conservation Department introduced the ordinance via warnings as part of their public education campaign. Washing of sidewalks, driveways, patios and other non-porous surfaces with a hose is prohibited except to eliminate dangerous conditions.

Leak Repair

After Inspectors notification, leaks must be repaired within five working days. Failure to do so might result in a citation.

The enforcement of the conservation ordinance has been the responsibility of the El Paso Water Utilities since June of 1992 and allows for fines from $50 to $500 for each violation.

TABLE 2. WATER CONSERVATION ENFORCEMENT HISTORY

Year	Telephone	D-hanger	Verbal	Written	Citation	Conservation. Line
1991*	40	1,025	1,268	208	29	n/a
1992**	388	152	449	77	14	n/a
1993	508	198	619	1,025	100	2,164
1994	569	329	675	699	118	1,234
1995	576	289	534	322	121	2,756
FY 1996-97	925	355	1,145	410	192	1,634
FY 1997-98	450	549	554	478	400	2,179
FY 1998-99	505	594	727	279	227	11,882
FY 1999-00	595	671	924	253	269	12,091
FY 2000-01	610	2,697	4,447	141	210	21,409
FY 2001-02	509	3,000	1,646	400	300	18,500
FY 2002-03	669	777	1,409	143	1,054	14,830
FY 2003-04	509	1,731	1,604	291	804	11,292
FY 2004-05	284	478	759	131	309	19,991

* Figures for the months of Jun -Oct only.
** Figures for the months of Jun - Dec only

UTILITY POLICY CHANGES

Block Rate Structure

In 1991, the utilities adopted an aggressive conservation-oriented rate structure. The same year the conservation program was launched. These two factors along with an intense media campaign resulted in the initial 15.4 percent per capita reduction. For more information on the Utilities' rate structure, please log-on into our Website at http:\\www.epwu.org

Changes in the Plumbing Code

Another area identified for significant water savings was the elimination of the high volume plumbing fixtures. Toilets using 1.6 gallons per flush and ultra-conserving showerheads and faucets using 2.5 gallons per minute (gpm) are now required under the City's Plumbing Code, to be installed in new constructions and remodeling jobs. Because in El Paso, thirty percent of the water consumed during the summer is used for evaporative cooling, the Plumbing Code does not allow any continuous bleed-off lines to be installed at evaporative cooling systems, only automated evacuation pumps are permitted to drain the unit reservoir after so many hours of operation. Existing bleed-off lines should be directed to drain into the landscape if possible. The code also requires swimming pools to be equipped with filtration or recycling systems and to be covered when not in use to reduce water loss through evaporation.

Large and Very Large Water Users

In April 1992, the Ordinance established that *Large Water Users* (averaging 10,000 gallons or more per day) to submit a Water Conservation Plan. The plan contains water use projections; it identifies areas for reduction and the re-use of water, and specifies conservation goals as a condition for new or continued service. In addition to the water conservation plan, the Public Service Board requires *Very Large Water Users* (averaging 100,000 gallons or more per day) to submit a water use justification report with a re-use component as a condition for new or expanded service.

Because of their non-peak use pattern, *Very Large Users* were not contributing to the cost of serving their demands. The average cost per CCF paid by these customers was lower than the charges incurred by other customers. The established block structure for residential customers did not apply to them. The utility was not recovering resource-related costs from these significant users. A rate analysis study was commissioned to address this issue. In 1994, an increased block rate that provides economic incentives to recycle was adopted for the *Very Large Users*. Incentives for recycling are structured based on percent of potable water recycled.

Local Government Turf Irrigation Accounts

Due to their summer peak use pattern, turf irrigation accounts have a higher peak to average ratio, as evidenced by the concentration of water use in the summer months. The amount of water used by these accounts is relatively insignificant to the total system water use, approximately two- percent.

Under the increase block rate structure, irrigation accounts tend to have an extremely low Average Winter Consumption (AWC), which is used to calculate block thresholds. Accordingly, the vast majority of the water use in the summer by these accounts was billed at the higher block 2 and 3 rates. Some irrigation accounts were increasing their Average Winter Consumption (AWC) in order to avoid the summer excess rate. This situation was not encouraging conservation.

The Utilities established a “Local Government Turf Irrigation Accounts” rate that bills water use based on monthly allotment levels. These levels are based on evapotranspiration measurements and allows for enough watering to replenish evaporation loss. Water use within the allotment is charged at $.95 CCF, usage above such allotments is charged at block 3 rates. Agencies such as public schools, universities and colleges are included in this rate.

TABLE 4. MONTHLY ALLOTEMENT FOR LOCAL GOVERNMENT YARDMETER ACCOUNTS (PER ACRE)

Month	Maximum CCF Per Acre	Month	Maximum CCF Per Acre
January	40	July	280
February	40	August	200
March	50	September	180
April	180	October	120
May	200	November	50
June	280	December	40

Water Rights

In response to the Water Resource Management Plan goal of relying less on ground water sources, El Paso Water Utilities has developed an aggressive program to obtain water rights to increase the use of surface water. In 1997, surface water accounted for almost 50% of the total water used in El Paso, a sharp contrast from the 20% figure of 1989. For more information on water rights, call the El Paso Water Utilities Planning Department at (915) 594-5681

Reclaimed Use

The City of El Paso is effectively using reclaimed water help lessen demands on the potable water supply system. Over the past several years, a series of projects has been undertaken to increase the use of recycled water. Several purple distribution lines have been installed on the West Side. Large turf irrigators such as Coronado Country Club and city parks are using reclaimed water for irrigation. Other reclaimed programs such as golf course irrigation, aquifer recharge, power plant cooling and various industrial uses have been in-service since 1960. For more information regarding reclaimed water use, please call (915) 594-5730

Drought Management Plan

Due to the potential decrease in surface water allotments from the Irrigation District, the Utilities have a contingency plan to manage drought and emergency conditions. This means that the Utility can continue to deliver cost effective, adequate, safe and a reliable water supply during periods of critical water shortages as a result of either drought or emergency interruption to available water supplies.

Future Sources

The EPWU is pursuing several options for future water supply. The Hueco basin contains 3 to 4 million-acre feet of brackish ground water. Pilot plant studies have demonstrated that the salts can be removed, however further study is needed to define a feasible method for disposing of the salt. For more information on regional water planning, visit our Web site at http://www.epwu.org

VOLUNTARY PROGRAMS (Conservation Initiatives)

Education

El Paso Water Utilities is involved in many activities to increase public awareness. These include monthly conservation messages on the back of bills, periodic bill stuffers, billboards, TV, radio, newspaper and displays at citywide shows, fairs, and festivals as well as presentations to civic groups and other organizations. The Conservation Department also makes presentations to school groups and youth organizations that often include a visit by our "Willie" mascot. Development of the "Willie" character has allowed greater visibility in promoting water conservation.

The Utility is involved with "Drinking Water Week", a project of AWWA held every full week of May of every year. Different activities are planned for that time, with emphasis on tours of the different plants and a student poster contest.

TABLE 5. EDUCATIONAL EFFORTS BY THE CONSERVATION DEPARTMENT

	Presentations	Attendees	Media Contacts
FY 1996-97	106	40,094	27
FY 1997-98	126	40,900	42
FY 1998-99	299	56,234	60
FY 1999-00	602	51,223	64
FY 2000-01	380	40,000	45
FY 2001-02	149	132,993	13
FY 2002-03	331	25,703	225
FY 2003-04	257	102,049	252
FY 2004-05	216	67,060	247

INITIATIVES

The Utility funds several programs that enhance the goals of the conservation program while providing information on wise water use.

<u>"Cash for Your Commode"</u>

When the plumbing code changes became effective, (September 12, 1991) the Utility kicked off its "Cash for Your Commode" rebate program. A customer can receive a 75% rebate (up to $100 per toilet) for replacing an existing larger water-using toilet with an ultra-low-flow toilet. Since the beginning of the program, over 30,000 toilets have been replaced, saving an estimated 340 million gallons of water and wastewater a year.

<u>"Free Showerhead Distribution"</u>

During 2000, more than 160,000 low-flow showerheads were delivered to customers. An evaluation of this program showed a decrease of 1 Billion gallons of wastewater.

<u>"Refrigeration Units Rebate"</u>

In coordination with the El Paso Electric, a rebate of $300.00 is given to residential customers or homebuilders for the installation of central refrigeration units.

<u>"Horizontal Washing Machines Rebates"</u>

A rebate of $200 for the purchase and installation of horizontal washing machines is available to our residential and a $300 rebate for our commercial customers.

<u>"Evaporative Bleed-off Line Clamps"</u>

The Utility distributes free evaporative bleed-off line clamps for customers that have evaporative cooling systems. Water used for cooling purposes in El Paso accounts for 15% of residential use, restricting the bleed-off flow will save millions of gallons that usually are dumped into the sewer.

<u>"Desert Blooms CDROM"</u>

Since 1990, the Utility has been working with the Texas A&M Extension Service to promote water efficiency in urban landscapes. Workshops and seminars are provided to increase awareness of water issues in the region. The CDROM was developed to fill the need for regional plant selection information. "Desert Blooms", has information in both English and Spanish of more than 400 trees, shrubs, groundcovers, grasses and flowers that are adapted or native to the Chihuahuan Desert.

<u>"Turf Rebate Program"</u>

Living in the Chihuahuan Desert calls for beautiful, colorful and most importantly, water conserving landscapes. Because our desert receives an average of only 8 inches of rainfall a year, it makes sense to use native and watertight plants, which require little or no additional irrigation. Water is a precious commodity and living in harmony with our desert proves your commitment and respect for our region and its limited water resources.

This rebate program offers an incentive to convert established turf areas to water-efficient landscape designs that incorporate low water use plants and common sense horticulture practices. This program is for established residential customers (no-new homes are eligible) and established commercial and industrial customers. The Utility pays $1.00 per square foot of established grass that is replaced with an approved landscape.

“Hot Water on Demand”

This new program has been added to our conservation portfolio as a result of Public Working Committee recommendations. The average home wastes nearly 10,000 gallons of water every year as people wait for hot water. The How Water on Demand systems re-circulates hot water through the house so that hot water reaches the tap in a shorter time. This rebate offers direct retail customers of El Paso Water Utilities a $100 rebate check for each pump installed at the residential site, with a $300 rebate maximum per site.

“Waterless Urinals”

The Utility continues to promote the installation of waterless urinals as another efficient way to save water. A total of 100 units have been distributed to area school districts and city offices. Staff is conducting installation verification visits to gather information about maintenance and acceptance comments.

Report of Major Accomplishments for Water Conservation

1989-90

- Reduce Summer Peak Demand with implementation of water odd/even schedule program.
- Initiated demonstration project with Texas A&M Research Center and Keep El Paso Beautiful to demonstrate water conservation type landscaping. Several sites around El Paso were Xeriscaped as demonstration gardens.

1990-91

- Water Conservation Advisory Committee developed comprehensive water conservation plan and recommended to employ a water conservation manager.

1991-92

- Water Conservation Department is formed with a total of five full time employees. A Manager, two Conservation Technicians, one Graphics designer and a Clerk Typist.
- Initiated public education campaign to include monthly messages on the back of the water bill, printed brochures and inserts and television spots.

1992-93

- Assumed enforcement of the water conservation ordinance.
- Implemented "Cash for your Commode Toilet Rebate Program" 3,600 units the first year.
- Expanded water conservation public education campaign by participating in several community events.
- Initiation of a three-year grant "Water Smart" program in cooperation with the Texas Agricultural Extension Service to increase awareness of landscape water use and appreciation of the Chihuahuan desert.

1993-94

- Expanded conservation program to hire three additional full time employees. Two Enforcement Inspectors and one Clerk Typist.
- Water conservation programs submitted by large water users were reviewed and customers contacted for progress report.
- Initiated Plant "Water Smart" Program with the Nursery Association. Banner, ID tags and printed materials were distributed to area nurseries.
- Assisted in drafting the Landscape Ordinance with City Planning Department.
- Assisted in water use survey to determine water issues awareness level.

1994-95

- Continue enforce the city's conservation ordinance.
- Initiated free irrigation water audit program.
- Continue toilet rebate.
- Aggressive mass media education campaign.
- Education programs to schools. Willie mascot visits.

1995-96

- Identified local government yard meter accounts monthly allocation basis.
- Invited Municipal Court Judges for a conservation forum.
- A total of 72 Willie presentations to schools.
- Continue with education campaign.
- Continue toilet rebate

1996-97

- Presented Amy Vickers report to the Public Service Board.
- Organized Water Conservation and Reuse Committee to redirect the conservation program.
- Increase the number of toilet appointments from 50 to 56 a week.
- Conducted 28 Willie presentations reaching 2,736 students.
- Provided 72 additional conservation presentations reaching 5,413 customers.
- Participated in six citywide education programs reaching 31,945 attendees.
- Increase number of citations from 118 to 128 and reduced warnings from 699 to 309.

1997-98

- Finalize Water Conservation and Reuse Advisory Committee meetings and presented committees' overall recommendations to the Public Service Board.
- Obtained a $25,000 grant from the Bureau of Reclamation to develop a bilingual water smart landscape CD-ROM with information about plants for urban landscapes located in the Chihuahuan Desert along with conservation information, regional resources and efficient horticultural techniques for the El Paso, Las Cruces and Cd. Juárez area. The project was coordinated with NMSU, UTEP, Texas Agricultural Extension Service and the Texas Urban Forest Service.
- Develop program with local Car Wash Association to curtail water waste from fund-raising car wash events. The program is called "Let's Do It Right" and allows groups to collaborate with participating commercial car wash establishments to hold fund raising non-profit events.
- Coordinated a pilot program in cooperation with El Paso Electric Company. The program called "Be Water Wise and Energy Efficient" teaches middle school students the importance of energy and water conservation. A total of 600 middle school students participated in the first year.

- Launched effective television media campaign to increase awareness of conservation.
- Increase number of citations by 274% for violations to the conservation ordinance.
- A rate modification for yard meters other than local government accounts was implemented to eliminate AWC calculation and charging Block 2 rates for yard meter consumption.

1998-99

- Finalized development of the Desert Blooms CDROM, a project partially funded by the Bureau of Reclamation. Presented final product to the Public Service Board during their monthly meeting.
- Developed a marketing campaign for the preliminary introduction and distribution of the Desert Blooms project and continued implementation of conservation focused television campaign.
- Participated as speaker for:
  - Texas Water Conservation and Irrigation Conference in Houston, TX. With “El Paso’s Enforcement Program – Water Cops.”
  - 3rd. Annual Water Conservation Conference in Las Cruces, NM.
- Received the following awards:
  - 1998 AWWA Water Mark Award for Communication Excellence for the “Willie’s World Activity Book.”
  - Honorable mention from AWWA for the main lobby mural and new brochure depicting the “El Paso Water Utilities System” under the large utility miscellaneous category.
- Organized the first El Paso’s “Tree Conference” and landscape workshop for professional and homeowners for the most up-to-date information on tree care and water conservation in your landscape. Project done in cooperation with UTEP and the Texas Agricultural Extension and Research Center (300 attendees)
- Completed training of conservation staff in regards to irrigation systems water audits, educational presentations, ground water model demonstrations and vignettes with “Willie” the mascot.

1999-00

- Introduced “Desert Blooms” CDROM to the public through a comprehensive media and promotional campaign. Received the following awards for the project:
  - 1889-99 American Advertising Award “Best of Show” for the best interactive media category.
  - 1999 AWWA Water Mark award for the best use of technology.
  - 1999 AWWA Conservation and Reuse, under large utility indirect category.
  - 1999 Texas Urban Forestry “Community Forestry Award”

- Implemented the second "Be Water Wise and Energy Efficient" program in cooperation with El Paso Electric and additional sponsorship from "Partners in Education" was secured to underwrite an additional 600 students. Completed evaluation of program showed that 1,400 households program to date showed a 12% water use reduction.
- Continued implementation of television campaign aimed at reducing water use and increase awareness of regional water issues.
- Received recognition from the League of Women Voters during their 1999 Mission Possible conference for EPWU "Protection and Preservation of the Environment" educational efforts.
- Participated as speaker for:
    - Low Desert Xeriscape Conference in Tucson AZ. With "Desert Blooms, a SunScape Guide to Plants for a Water-scarce Region".
    - Spring and Fall SunScape series at UTEP, a seven-week comprehensive Xeriscape workshop.
    - Spring and Fall Texas Agricultural Extension Master Gardener program series.
- Secured a $10,000 grant from the Bureau of Reclamation to develop a SunScape Landscape printed brochure to be used in conjunction with "Desert Blooms".
- Organized the second annual "Tree Conference" in El Paso.
- Organized and completed the first ever Bi-national, Tri-state, Tri-city "Water Festival" in cooperation with NMSU, Bureau of Reclamation, EPA, WERC and other environmental agencies a total of 12,000 students from Cd. Juárez, Las Cruces and El Paso participated in the three day event.
- Participated in the EPWU's Public Working Committee (PWC) to gain insight and input into plans for phase II water conservation program initiatives. Participated in the preparation of the final report to the PSB.
- Obtained $20,000 from UTEP CERM program to work on a water sustainability information campaign to increase appreciation of the Chihuahuan desert.

2000-01

- Implemented PWC phase II recommendations:
    - "Showerhead Replacement Program". 200,000 showerheads were distributed to El Paso Water Utilities customers during FY 2000-01
    - Initiated the Join Water Conservation Initiative Program for Horizontal Axis Washing Machines and Refrigerated Air Conditioner program in cooperation with El Paso Electric and El Paso Water Utilities.
    - Hired temporary enforcement during the summer of 2000
    - Hired Water Conservation Education Specialist to help lead and coordinated all educational events.

- Participated as speaker for:
  - Nursery and Landscape Exposition in Dallas, TX. With "Effectiveness of El Paso's Water Conservation Program."
  - Water Conservation in Landscape Irrigation Conference in Houston, TX. With "A City Gets Tough with Water Wasters".
  - Conservation Forum in Salt Lake City, UT. With "El Paso Water Utilities Water Conservation Program in a Water Scarce Region."
  - Spring and Fall SunScape series at UTEP.
  - Spring and Fall Texas Agricultural Extension Master Gardener program series for Texas and New Mexico.
- Implemented 3rd. "Be Water Wise and Energy Efficient" program. Funds from El Paso's Independent School District were secured for an additional 300 middle school students.
- Organized and completed the second "Water Festival" and the 3rd. "Tree Conference" in El Paso. Both festival and conference are major educational events reaching more than 15,000 citizens.
- Received the following awards:
  - 2000 AWWA Water Mark award for the "Bi-national, Tri-state, Tri-city Water Festival" under the educational campaign.
  - 2000 AWWA Water Mark award for the "Willie's Bingo" an interactive board game for children.
- Continued implementation of television campaign aimed at reducing water use and increase awareness of regional water issues.

2001-02

- Implemented PWC phase III conservation initiatives:
  - "Turf Rebate Pilot Program" a PWC recommendation under conservation phase III initiatives. A total of 138 sites participated in the pilot program removing 269,343 sq. ft. of grass. An evaluation of the pilot program was conducted under a contract with the Stratus Company.
  - "Evaporative Bleed-off Clamp" program. More than 20,000 clamps were distributed to EPWU customers during FY 2001-02
  - Amended the Water Conservation Ordinance to allow fundraising carwash events only at commercial carwash establishments and to limit grass amount on new residential homes and commercial properties.
  - Initiated the "Waterless Urinals Pilot Program" with El Paso, Ysleta and Socorro school districts. A total of 30 units were installed at different school sites.
- Continued implementation of the JWCI with El Paso Electric. A total of 301 washing machines and 428 refrigeration unit rebates were processed.
- Participated as speaker for:
  - Conferencia Internacional de Conservación de Agua in Madrid Spain with "Programa de Conservación en la ciudad de El Paso, Texas."

- Organized and completed the 3rd. "Water Festival" (12,000 attendees) and the forth "Tree Conference" (500 attendees).
- Participated with educational booths at the Home and Garden Show (11,000 attendees) and the Generation 2000 (45,000 attendees) youth events at the Civic Center.
- Continued implementation of television campaign aimed at reducing water use and increase awareness of regional water issues.
- Received the following awards:
  - 2000 Public Relation Society of America (RIA) award for "Showerhead Program Campaign" and for the "Appreciation of the Chihuahuan Desert" television spots funded by UTEP-CERM.
- Worked with the El Paso International Airport in the design of water efficient landscape areas around the airport terminals.
- Remodeled EPWU main building landscape to reflect a more efficient design in a commercial setting utilizing plants that are adapted or native to our desert environment.

2002-03

- Continued implementation of all conservation initiatives: 350 turf sites, 674 refrigeration units, 759 washing machines, 2,708 toilet rebates. 10,000 clamps and 29,526 showerheads were distributed.
- Coordinated installation of landscape and plumbing fixtures on a Parade of Homes "Water Smart" home. Requested donations totaled more than $40,000 for this project. Donations included plants, gravel, irrigation system, landscape fabric, landscape design and volunteer hours from Master Gardeners who helped instruct the public regarding water efficiency in the landscape.
- Amended the Conservation Ordinance regarding drought conditions.
- Participated as speaker for:
  - 2002 American Planning Association Planning with Borders, not Boundaries conference in El Paso, TX. With "Water, a Diamond in the Desert".
  - Spring SunScape series at UTEP.
  - Fall Texas Agricultural Extension Master Gardener program.
- Organized and completed the 4th. "Water Festival" (8,000 attendees) and the 5th. "Tree Conference" (300 attendees).
- Participated in the Home and Garden Show.
- Coordinated, with El Paso Car Wash Association, the creation and airing of a television spot to promote the use of commercial car wash establishments.
- Coordinated Green Industry breakfast to initiate a public campaign promoting low-water use plants. Initiated Ms. Tree television campaign.

- Design and produced educational materials for Region XIX Head Start Program to be used at the Intellizeum. Materials included giant puzzles, memory card game, bags, coloring magnets and the water cycle interactive exhibit.
- Participated in the brainstorming session for the new Water Resource Learning Center at the planned Ft. Bliss/EPWU desalination plant.

2003-04

- Continued implementation of all conservation initiatives: 1,250 turf sites, 1,218 refrigeration units, 1,655 washing machines, 3,374 toilet rebates. 10,000 clamps and 30,101 showerheads were distributed.
- Successfully coordinated and implemented Stage One and Two of the EPWU drought and Water Emergency Management Response Plan approved by the PWC and City Council, including the supervision of the call-in center and additional temporary enforcement staff.
- Completed revision of educational materials to include drought information.
- Continue working with Region 19 Head Start Program to develop three giant lenticular murals depicting the Chihuahuan desert, regional water resources and water uses for the Intellizeum. Participated in the Head Start General Audit where the El Paso program received outstanding grades.
- Worked with the Junior League in the development of the Xeriscape demonstration garden for the Keystone Desert Botanical Garden. Active member of the educational committee for the park. Worked with Junior League members to request funds from the EPWU-PSB.
- Appointed to the Water Conservation Implementation Task force set for by the 78th Texas Legislature.
- Participated and implemented in the development of new EPWU/WIT project initiatives such as subsurface irrigation and hot water on demand pilot programs.
- Participated as speaker for:
    - 2004 Water Sources Conference in Austin, TX. With “Savings from a Turf Rebate Program in the Chihuahuan desert”.
    - 2004 Rotary International RYLA conference in Cd. Juárez, Mexico. With “El Paso’s Water Utilities Conservation Program.”
- Received the following award:
    - 2003 AWWA Water Mark award for the work done at the “Intellizeum Head Start Region 19.”

APPENDIX 6B

EL PASO COUNTY WATER IMPROVEMENT

DISTRICT NO.1

WATER CONSERVATION PLAN

APPENDIX 6B
El Paso County Water Improvement District No. 1

Mission, and General Description:

The El Paso County Water Improvement District No. 1 (EPCWID No.1) was organized in 1917 as part of the U.S. Bureau of Reclamation's Rio Grande Project. A five-member elected board governs the district. The EPCWID No.1 has ownership of all project works, easements, ditches, laterals, canals, drains, and rights-of-way associated with the project.

The Rio Grande Project provides full irrigation service to water-rights lands in the Elephant Butte Irrigation District and in the EPCWID No.1. The EPCWID No.1 has 69,010 water-rights acres, all located in the bottomlands of the river. Although the district does not provide wholesale public water supply, it supplies water to the City of El Paso for municipal and industrial purposes.

The principal focus of the EPCWID No.1 is to furnish high-quality irrigation water to El Paso County producers in amounts that allow for management flexibility and enhanced opportunity for increased farm revenue.

Water Resources and Supply:

The sources of water for the EPCWID No.1 are the headwaters and tributaries of the Rio Grande and the Elephant Butte and Caballo reservoirs. The amount of water available to Texas is specified by the Rio Grande Compact and is a percentage of the water in the Rio Grande passing the gauging station at Otowi, New Mexico. Since 1990, the annual allotment to the EPCWID No.1 has been 376,862 acre-ft. The district's board determines the individual allotments, which translates to 4 acre-ft per acre since 1990. The bulk of the water is available for use from March through September.

Water Use:

The principal use of surface water in the EPCWID No.1 is for field and vegetable crops and commercial orchard irrigation. Field crops are cotton (mostly Pima), alfalfa, corn, sorghum for silage, and wheat. The principal vegetable crops are peppers and onions. There are over 8,000 acres of commercial pecans in the valley. In addition to commercial agriculture production, irrigation water is distributed to numerous small tracts (less than 2 acres in size) that have the appropriate water rights.

Although the EPCWID No.1 is not a provider of potable water, the district furnishes water to the City of El Paso and to the Lower Valley Water District for subsequent treatment and municipal and industrial use.

Management of Water Supplies:

The EPCWID No.1 has little ability to manage the over-all supply of water to the district. This is determined largely by the Rio Grande Compact and various other contracts with the U.S. Bureau of Reclamation. However, once water reaches the first diversion structure for the district, the efficiency of use of the water is largely the responsibility of the district and individual water users. Loss of water during transport can represent a significant loss of water for agricultural producers. Since the district has ownership of all project works, ditches, laterals, canals, and drains, a loss minimization program is in effect. The district has a flow telemetry system in place to monitor major canals.

Actions, Procedures, Performance, and Goals:

Agricultural producers can order water, so as to be able to time water applications. The producer works with a dispatcher and a ditchrider to prevent unnecessary water losses. Water is metered to an individual producer, and producers are charged for water used. A new water allotment schedule is now in effect, such that:

- Allotment 1 represents the base allotment (currently 2 acre-ft) which producers are charged, whether or not the water is used.
- Allotment 2 represents an additional amount of water (currently 2 acre-ft, such that allotments 1+2 represent the total allotment) available to producers. Charges are based on the amount of water used.
- Allotment 3 represents water available from October through February. Producers are charged only for water that they use.
- Allotment 4 represents water that producers can use from a pool set aside by the district. This allotment is for emergency purposes to finish a crop, and will be charged accordingly at a higher rate.

The EPCWID No.1 monitors water levels in Elephant Butte Reservoir and snow pack levels of the headwaters of the Rio Grande. Reductions in potential allotments are forecast based on the amount of storage in Elephant Butte Reservoir. The district is prepared to issue warning forecasts to help agricultural producers plan cropping systems, back-up water supply systems, and arrange financing for potential water shortfalls.

The EPCWID No.1 recognizes that agricultural demand for water, along with increasing demands by the City of El Paso and the Lower Valley Water District, exceeds the available water supply to the district. As such, the district has developed a public/clientele information program that focuses on water conservation and irrigation and saline soil management through a newsletter and public meetings. The district cooperates with the Texas Agricultural Extension Service, Natural Resource Conservation Service, and other state agencies to educate clientele in improved water management practices.

Drought Contingency:

Drought conditions that impact the EPCWID No.1 are those that affect the headwaters of the Rio Grande and its tributaries, such that Rio Grande Compact water delivery requirements into Elephant Butte Reservoir are reduced. The district's board of directors determines when a drought exists. Generally, when water storage in Elephant Butte Reservoir is less than 0.9 million acre-ft during the irrigation season (March through September), drought conditions are declared.

During times of drought, the district will allot water to all water users on a pro rata basis. The extent of the water allotments will be dependent on the severity of the drought conditions, and will remain in effect until the conditions that triggered the drought contingency no longer exist. Under Section 11.083 of the Texas Water Code, noncompliance with the drought contingency plan is punishable by fine and/or incarceration.

(Source: "Operations Guide" of EPCWID No.1 dated July 9, 1998, U.S. Department of the Interior Bureau of Reclamation's "Legal and Institutional Framework for Rio Grande Project Water Supply and Use" dated October 1995, EPCWID No.1's Drought Contingency Plan (recent), and personal communication.)

APPENDIX 6C

HUDSPETH COUNTY CONSERVATION AND RECLAMATION DISTRICT NO.1

WATER CONSERVATION PLAN

APPENDIX 6C
Hudspeth County Conservation and Reclamation District No. 1

Mission, and General Description:

The irrigation district plan for the Hudspeth County Conservation and Reclamation District No. 1 (HCCRD No.1) was developed in November of 1991. The district occupies approximately 18,300 acres of Rio Grande River bottomlands from the El Paso/Hudspeth County line downstream to Fort Quitman. The district was created to provide adequate irrigation to those lands.

The HCCRD No.1 was organized in 1924 to consolidate water diversions from the Rio Grande. Under a Warren Act contract, the district has taken a direct diversion of the river since 1925. A board of directors governs the district, with headquarters in Fort Hancock, Texas.

Water Resources and Supply:

The district's primary source of water includes untreated water obtained from permitted Rio Grande diversions; drainage waters; return flows from farming operations; operational waste associated with the U.S. Bureau of Reclamation's Rio Grande Project; and return flows from El Paso water and sewage treatment plants. The district's operations are primarily recycling and reuse that further the use of the waters in the Rio Grande Basin. Because the water supply to the HCCRD No.1 is totally dependent on the water supply to the EPCWID No.1, the supply is erratic, and the optimal utilization of available water is difficult.

Water Use:

All water used in the district is for irrigation. The HCCRD No.1 does not supply potable water. When ample water is available, lands in the district are quite productive. Cotton, small grains, forages, and irrigated pasture represent the principal crops.

Management of Water Supplies:

The HCCRD No.1 has constructed a system of canals, drains, and regulating reservoirs to distribute irrigation water through the district. Over the last several years, the volume of the regulating reservoirs has been expanded by 3,200 acre-ft. A program to reduce canal losses is in place.

The HCCRD No.1 taxes water-use customers on a per acre basis of irrigable land. Additional assessments are made on acres watered under percentage water conditions, in order to equate the taxes with benefits delivered. The district meters water delivered to customers. When the supply of water exceeds customer demands, the district may sell water to out-of-district purchasers.

Actions, Procedures, Performance, and Goals:

The goal of the HCCRD No. 1 is to conserve the waters of the Rio Grande to the maximum extent possible. As such the district seeks the cooperation of all users. The district also holds regular public meetings. The public may have direct input during the meetings or through private contact with a district board member.

Currently, the district has an annual evaluation of the conservation program, and may make revisions to the program. If changes have been made to the plan, an annual report will be generated.

Between 1991 and 1995, the HCCRD No.1 in cooperation with the TWDB, Natural Resource Conservation Service, and the Texas Agricultural Extension Service provided water conservation brochures, conducted irrigation management workshops and field days, implemented a water metering program, and studied canal water losses.

Drought Contingency:

The HCCRD No.1 bases drought contingency planning on evaluation of the water supply projected and received by the EPCWID No.1, since all waters received by HCCRD No.1 are recyclable water from El Paso County. Since conditions, to a degree, can be predicted prior to a crop season, the drought mitigation plan largely affects agricultural producers cropping plan. When a mild or moderate predicted shortage occurs, the HCCRD No.1 will notify its clientele of the amount of the expected shortage. For a severe shortage, where the water supply will provide less than 50 percent of the expected demand, agricultural producers will be asked to prioritize their water requests based upon crop needs.

CHAPTER 7

PLAN CONSISTENCY

7.1 INTRODUCTION

The long-term protection of the Region's water resources, agricultural resources, and natural resources is an important component of this 2006 update to the *Far West Texas Water Plan*. Specific guidance was provided to insure that the plan reaches this goal. 31 TAC 357.14 (C) defines this requirement by the following consistency rules:

a) 31 TAC §358.3 relating to guidelines for state water planning,
b) 31 TAC §357.5 relating to guidelines for the development of Regional Water Plans,
c) 31 TAC §357.7 relating to Regional Water Plan development,
d) 31 TAC §357.8 relating to ecologically unique river and stream segments, and
e) 31 TAC §357.9 relating to unique sites for reservoir construction.

Chapter 7 identifies those considerations that provide for the long-term protection of water resources, agricultural resources, and natural resources that are important to Far West Texas; and describes how those resources are protected through the regional water planning process.

7.2 PROTECTION OF WATER RESOURCES

Water resources in Far West Texas as described in Chapter 3 include groundwater in numerous aquifers and surface water occurring in the Rio Grande and in the tributaries and main branch of the Pecos River. The numerous springs, which represent a transition point between groundwater and surface water, are also recognized in this plan for their major importance.

The first step in achieving long-term water resources protection was in the process of estimating each source's availability. Surface water estimates were developed through a water availability model process (WAM) and are based on the quantity of surface water available to meet existing water rights during a drought-of-record.

Groundwater availability estimates were based on acceptable levels of water-level decline or historical maximum pumping estimates. Where available, groundwater availability models (GAMs) were used as a tool to view various withdrawal rates in terms of water-level impacts. Establishing conservative levels of water source availability thus results in less potential of over exploiting the supply.

The next step in establishing the long-term protection of water resources occurs in the water management strategies developed in Chapter 4 to meet potential water supply shortages. Each strategy was evaluated for potential threats to water resources in terms of source depletion (reliability), quality degradation, and impact to environmental habitat.

Water conservation strategies are also recommended for each entity with a supply deficit. Conservation reduces the impact on water supplies by reducing the actual water demand for the supply. Table 4-2 in Chapter 4 provides an overview of these impact evaluations.

Chapters 6 and 8 contain information and recommendations pertaining to water conservation and drought management practices. When enacted, the conservation practices will diminish water demand, the drought management practices will extend supplies over the stress period, and the land management practices will potentially increase aquifer recharge.

7.3 PROTECTION OF AGRICULTURAL RESOURCES

Agriculture in Far West Texas, as described in Chapter 1 – Section 1.3.7, includes the raising of crops and livestock, as well as a multitude of businesses that support this industry. TWDB's socio-economic analysis (provided in Appendix 4A) reports that in 2000 irrigation farmers in the region produced about $124M worth of crops that generated $38M in regional income. The livestock industry contributed $33M in wages, salaries, and profits and supported an estimated 1,684 jobs. Water is an absolute necessity to maintaining this industry and its use represents over three-fourths of all the water used in the Region. Many of the communities in the Region depend on various forms of the agricultural industry for a significant portion of their economy. It is thus important to the economic health and way of life in these communities to protect water resources that have historically been used in the support of agricultural activities.

The *Far West Texas Water Plan* provides irrigation strategy recommendations in Chapter 4 that address water conservation best management practices. If implemented, these practices will result in reduced water application per acre irrigated. These strategies include:

- Irrigation water use management
- Land management systems
- On-farm water delivery systems
- Water district delivery systems
- Miscellaneous systems

Also, non-agricultural strategies provided in Chapter 4 include an analysis of potential impact to agricultural interests.

7.4 PROTECTION OF NATURAL RESOURCES

The Far West Texas Water Planning Group has adopted a stance toward the protection of natural resources. Natural resources are defined in Chapter 1, Section 1.3.8 as including terrestrial and aquatic habitats that support a diverse environmental community as well as provide recreational and economic opportunities. Rare, endangered, and threatened species found in the region are listed in Appendix 1A of Chapter 1. Environmental and recreational water needs are discussed in Chapter 2 – Section 2.5. In Chapter 8, Appendices 8B through 8I describe recommended ecologically unique river and stream segments, while Appendix 8I presents the Texas Parks and Wildlife Department recommended Ecologically Significant River and Stream Segments.

The protection of natural resources is closely linked with the protection of water resources as discussed in Section 7.2 above. Where possible, the methodology used to assess groundwater source availability is based on not significantly lowering water levels to a point where spring flows might be impacted. Thus, the intention to protect surface flows is directly related to those natural resources that are dependent on surface water sources or spring flows for their existence.

Environmental impacts were evaluated in the consideration of strategies to meet water-supply deficits. Table 4-4 in Chapter 4 provides a comparative analysis of all selected strategies. Of prime consideration was whether a strategy potentially could diminish the quantity of water currently existing in the natural environment and if a strategy could impact water quality to a level that would be detrimental to animals and plants that naturally inhabit the area under consideration.

The Far West Texas Water Planning Group recommends as "Ecologically Unique River and Stream Segments" (Chapter 8 – Section 8.4) three streams that lie within the boundaries of State-managed properties, three within National Park boundaries, and specified streams managed by the Texas Nature Conservancy. Although the Planning Group chooses to respect the privacy of private lands by not recommending stream segments on these properties, the Group recognizes and applauds the conservation work that is undertaken on a daily basis by the majority of these private landowners.

CHAPTER 8

RECOMMENDATIONS

8.1 INTRODUCTION

An important aspect of the regional water planning process is the opportunity to provide recommendations for the improvement of future water management planning in Texas. This chapter contains specific suggestions and decisions made by the Far West Texas Water Planning Group (FWTWPG). The recommendations 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. This chapter also addresses recommendations of "ecologically unique river and stream segments" and considerations of "unique sites for reservoir construction".

The FWTWPG approves of the legislative intent of the regional water planning process and supports the continuance of water planning at the regional level. However, the FWTWPG suggests that the Legislature and TWDB consider the following changes to the regional water planning process.

8.2 RECOMMENDATIONS

The following recommendations are intended to address regulatory, administrative and legislative issues related to water supply management planning. Some of the recommendations listed below may at first appear to be redundant, but each of them emphasizes a slightly different point. Several related points in the interest of specificity were intentionally refrained from being combined. The items that would involve a legislative change are marked with an asterisk.

- Need to allow for more local planning initiatives. The planning process seems to focus too heavily on meeting the technical requirements of the regional water planning process and the TAC rules, to the detriment of allowing for local planning initiatives. Providing for more local influence of the process and reducing the numerous, standardized checklists of the requirements of the Plan would help. *The planning process and the ultimate Plan must be flexible because of the unique characteristics of the border region. The FWTWPG cannot control the planning or water use of Mexico or New Mexico, with which it shares both its surface and groundwater resources. Despite this, it must recognize that the Hueco Bolson portion of El Paso County is a Priority Groundwater Management Area. The Plan should also recognize the legal, political and financial constraints of an area governed by three states and two nations. It should also recognize that El Paso has been designated the water and wastewater planner through Senate Bill 450 (74th Legislative Session) for the El Paso County region. Regional planning under Senate Bill 450 includes participation in water and wastewater planning with the adjacent Texas counties and the border states of New Mexico and Chihuahua, Mexico to address transboundary water quality issues. Senate Bill 450 is not applicable to El Paso County Water Improvement District No.1 and the Hudspeth County Conservation and Reclamation District No.1. The FWTWPG should have the legal ability to consider all water resources available to the Region, regardless of whether or not they are located within Texas.

- Provide for reimbursement of reasonable expenses incurred by planning group members. In other appointed State jobs the appointee's actual expenses are reimbursed, but although the planning group members were initially appointed by the TWDB by a mandate of the Legislature, their expenses are not reimbursed. Many of these members serve in a purely voluntary capacity, so that the donation of their time away from their businesses or jobs is a huge contribution to the process. To expect them to also cover their out of pocket expenses to travel sometimes over 400 miles and frequently over 200 miles, is so unreasonable that it limits those who can afford to participate in the process and negatively affects the attitude of all participants. A per diem amount could be payable to each regional member in lieu of actual reimbursement.

- *Ability to contract. Planning groups should have the ability to contract with those persons or entities with which they determine they should contract to further the purposes of the Plan. Presently they can contract only with their administrative entity. This will involve the Planning Group more directly in the process.

- *Eliminate the unfunded mandate. The current regulations of the TWDB require local entities to pay for 100 percent of the administrative costs of developing the plans. This is difficult to sell when a local government has to tell its constituents that they have to do with one less full-time deputy, a lower level of funding for the library, and no new fire truck – but that they can afford to pay for a water plan. Trying to force local "buy-in" by requiring local funding causes resentment of the process and antagonism toward the plan. In a time of record surpluses, the State should pay for what the State thinks is important. The current 100/100 Plan is an improvement over the original concept (pursuant to which the State was to pay for 75 percent of everything, including administration), but it is still an unfunded mandate, and is still a bad idea – no matter how good the idea being funded.

- Regional planning member training. The TWDB should have special training sessions for all planning group members before they become engaged in the water planning process, and these sessions should continue as the process proceeds. The complexity of water resource issues makes it unreasonable to expect members to draft a plan without appropriate preparatory training. Representatives must be appropriately trained in water planning and in the regional situation before they carry out their duties. There should be one or two education sessions during the planning process.

- <u>Modification of demand numbers</u>. 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. Demand tables should also show different numbers based on different growth and population scenarios. The manner in which the irrigation and livestock demand numbers increase during drought scenarios is inappropriate because other factors influence the demand. For example, during a drought in Far West Texas, livestock are sold, thus reducing the overall demand on groundwater. There needs to be a better understanding of the process of how livestock, drought and water demand interact, and this understanding needs to be reflected in the demand numbers.

- <u>*Needed funding for data collection in rural areas</u>. Rural areas need to be able to access State funding to gather the information needed to draft a substantive regional plan. This funding is needed for test wells, monitoring equipment, observation wells, modeling, and to obtain more data on the West Texas aquifers. Specific data-need recommendations for the rural areas are included in the "Data Needs" section. The FWTWPG should be allowed to request funding for the data needs and contract for the studies.

- <u>Make an Open Records exception for private water data.</u> The regional water planning process is predicated on the planning group's gathering thorough and complete data about water supplies within the planning area in order to inventory and evaluate the water resources. The problem with that predicate is that, given current law, most landowners are not going to give planning groups or groundwater conservation districts any information about their water. Under current law, if landowners give data about their water to the water planning groups, they are also giving it to anybody that wants it. The landowner's position will be that "My wells, my springs, and my tanks - where they are located, how deep they are, what their capacity is, the quality of the water - are my business. They are not the State's business, and they are not the public's business." This is counter-productive to the data collection that is necessary to effective water planning. The solution is an amendment to the Open Records Act that (1) excepts or exempts any water data from private lands without the landowner's prior written consent and (2) prohibits the TWDB and the TCEQ and all other state agencies from sharing any water data with any other person or agency without the landowner's prior written consent and (3) requires the TWDB and the TCEQ to treat all water data as confidential. The second and third need to have some teeth, such as criminal sanctions and/or personal liability for knowing or intentional violations without the need to prove damages. If we do not make this change, we are not going to get the data we need to plan effectively.

- <u>Plan Implementation</u>. Implementation of the plan's recommendations must be the responsibility of the local governments, entities, and individuals within the region. The Water Planning Group is not intended to assume a supervisory or command-and-control role. The Water Planning Group's function will be to monitor implementation and assist the local governments, entities, and individuals within the region as requested.

- <u>Groundwater Management Area Councils</u>. Groundwater Management Area Councils need to coordinate their efforts with regional water planning groups. It is counterproductive for the two separate entities to be establishing water-planning directives for the same area.

- Regional Planning Cycles. Conclusions of regional planning cycles should not overlap with legislative sessions. In the current water planning cycle, the Initially Prepared Plan is due one day after the regular session closes. This makes informed and current water planning extremely difficult, as numerous water bills (e.g. SB 3) are pending that could impact regional water planning and that likely will not be resolved until the 11th hour of the session.

  Regional water planners should not be put in the untenable position of either having to divine the future of water law or to rely upon statutes that may change literally the day after our plan is turned into the state.

  Additionally, many voting and non-voting members of the FWTWPG are involved with the legislative session. Every interest represented on the FWTWPG is affected by the session, and many voting and non-voting members (especially our legislative representatives) spend all or much of the session in Austin. As a result, several of our members have difficulty even attending meetings during the session due to their legislative commitments on water and other issues. If the State wants the best regional water plan possible, then structuring the bulk of regional water planning (the final 3-6 months per planning cycle) around legislative sessions will allow greater participation of our voting and non-voting members and also ensure that the current state of water law is known and can be applied effectively by the FWTWPG.

- Strategy economic analysis. Water project/strategy evaluation criteria need to be adopted for development of the State and regional plans such that consistent economic principles and benefit-cost analysis methods are applied. Such adopted evaluation procedures should follow the fundamentals of the federal planning document, "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies".

- Codification of in-stream flows. In-stream flows need to be codified in order to better manage surface water availability for holders of water rights and to meet environmental flow needs.

- Salt Cedar eradication. The FWTWPG joins with the Rio Grande Region (M) and the Plateau Region (J) in encouraging funding for projects aimed at the eradication and long-term suppression of salt cedar and other nuisance phreatophytes in the Rio Grande watershed.

- Data Needs.
  - Irrigators in the region believe the historical irrigation pumpage reported by the TWDB to be significantly low. The TWDB should continue its irrigation surveys and attempt to improve the estimates.
  - A study is needed to evaluate the potential contamination of the Rio Grande Alluvium aquifer below the confluence of the Acequias Madre with the Rio Grande.
  - A gain-loss study of the segment of the Pecos River between Girvin and Langtry is needed to quantify and identify the source of channel gains.
  - A study should be performed to evaluate the feasibility and potential benefits of rechanneling a segment of the Rio Grande below Fort Quitman.
  - A regional groundwater availability evaluation of the aquifer underlying the Diablo Plateau in Hudspeth County should be conducted. Presently, only water availability information in the Dell City area has been documented by the TWDB. Previous studies by the Bureau of Economic Geology indicated that there exists the potential for significant volumes of water underlying this area.
  - Other aquifers within the region that have limited knowledge of quantity of water in storage and recharge potential include the Edwards-Trinity (Plateau),

Capitan Reef, Marathon, and Rustler. Additional study is needed to quantify water availability in these aquifers.

- The TWDB is encouraged to complete its data gathering and model construction for the Presidio Bolson aquifer.
- A significant amount of groundwater is produced from Cretaceous limestone formations in southern Brewster County that exist outside the boundary of the Edwards-Trinity (Plateau) aquifer. The communities of Lajitas, Terlingua, and Study Butte, along with other rural users rely on this sole source of water to meet their daily needs. An aquifer characterization study is needed to estimate its vertical and lateral extend, sustainable yield, and water quality.

8.3 POLICY ISSUES

The TWDB provided regional planning groups with water issue discussion topics divided into the following categories:

- Agricultural and Rural Water
- Conservation
- Data
- Environmental
- Groundwater
- Innovative Strategies
- Providing and Financing Water/WW Services
- Surface Water
- Other Issues

The FWTWPG reviewed and discussed the topics during several meetings, and culminated the discussions by prioritizing the issue topics in each category (Appendix 8A). The priority order displayed in the survey provides a view of those issues that are of greatest concern in Far West Texas. The following issues held the highest level of interest.

- Environmental and economic impacts of conversion of agricultural and rural water
- Modifying the rule of capture while preserving it
- Protection of aquifers and springs
- Brush management and invasive species
- Codify land management and land stewardship
- Groundwater and surface water marketing and exportation, and their impact on water source sustainability
- Desalination of brackish water and concentrate management
- Funding for data collection, analysis, planning, supply projects, and support for groundwater conservation districts
- Consistency between water planning and drinking water system rules
- Emphasis on conjunctive use

8.4 ECOLOGICALLY UNIQUE RIVER AND STREAM SEGMENTS

As a part of the planning process, each regional planning group may include recommendations for the designation of ecologically unique river and stream segments in their adopted regional water plan (31 TAC 357.8). The Texas Legislature may designate a river or stream segment of unique ecological value following the recommendations of a regional water planning group. As per §16.051(f) of the Texas Water Code, this designation solely means that a state agency or political subdivision of the State may not finance the actual construction of a reservoir in a specific river or stream segment designated by the legislature under this subsection.

Stream segment designation is to be supported by a recommendation package that includes a physical description, maps, photographs, literature citations, and data pertaining to each candidate stream segment. In accordance with the TWDB's rules, the following criteria are to be used when recommending a river or stream segment as being of unique ecological value:

- **Biological Function:** Segments which display significant overall habitat value including both quantity and quality considering the degree of biodiversity, age, and uniqueness observed and including terrestrial, wetland, aquatic, or estuarine habitats;
- **Hydrologic Function:** Segments which are fringed by habitats that perform valuable hydrologic functions relating to water quality, flood attenuation, flow stabilization, or groundwater recharge and discharge;
- **Riparian Conservation Areas:** Segments which are fringed by significant areas in public ownership including state and federal refuges, wildlife management areas, preserves, parks, mitigation areas, or other areas held by governmental organizations for conservation purposes under a governmentally approved conservation plan;
- **High Water Quality/Exceptional Aquatic Life/High Aesthetic Value:** Segments and spring resources that are significant due to unique or critical habitats and exceptional aquatic life uses dependent on or associated with high water quality; or
- **Threatened or Endangered Species/Unique Communities:** Sites along segments where water development projects would have significant detrimental effects on state or federally listed threatened and endangered species, and sites along segments that are significant due to the presence of unique, exemplary, or unusually extensive natural communities.

The FWTWPG chooses to respect the privacy of private lands and therefore recommends as "Ecologically Unique River and Stream Segments" (Figure 8-1) three streams that lie within the boundaries of state-managed properties, three within National Park boundaries, and specified streams managed by the Texas Nature Conservancy. Notification was given to the general public that the FWTWPG would consider river and stream segments on private property only if requested by the landowner. No such requests were received. An evaluation of all recommended strategies in Chapter 4 indicated that there is no new negative impact to these stream segments resulting from their implementation.

8.4.1 Rio Grande Wild and Scenic River (Big Bend National Park)

The Rio Grande/Rio Bravo in Far West Texas is truly a national treasure with unique ecological and economic features. In 1978, Congress designated a 196-mile segment of the Rio Grande a National Wild and Scenic River. The designated Wild and Scenic stretch of the Rio Grande begins in Big Bend National Park, opposite the boundary between the Mexican states of Chihuahua and Coahuila. It then flows through Mariscal and Boquillas Canyons in the national park. Downstream from the park, it extends along the state-managed Black Gap Wildlife Management Area and several parcels of private land in the Lower Canyons. The wild and scenic river segment ends at the county line between Terrell and Val Verde Counties.

The Rio Grande Wild and Scenic River is significant as part of a valuable and largely intact ecological system representing major riparian and aquatic habitat associated with the Chihuahuan Desert. Spectacular river canyons, the primitive character of the river, and its international flavor combine to form a stimulating environment for high quality scenic and recreational experience.

The FWTWPG recognizes the significance of the 196-mile Rio Grande Wild and Scenic River segment and encourages the proper conservative management of this region. The upper 69-mile section of this corridor lies within the Big Bend National Park, however the National Park Service administers the entire 196-mile designated section. For purposes of the *2006 Far West Texas Water Plan*, the FWTWPG officially recommends that the part of the federally designated Rio Grande that is bordered by the Big Bend National Park and the Black Gap Wildlife Management Area be considered under the guidelines of "Ecologically Unique River and Stream Segments". A detailed information packet pertaining to this river segment is contained in Appendix 8B.

8.4.2 McKittrick Canyon and Choza Creek (Guadalupe Mountains National Park)

McKittrick Canyon and Choza Creek in the Guadalupe Mountains National Park are crucial for maintenance of ecological stability and wildlife health within this higher-elevation Chihuahuan Desert environment. Loss or failure of either of these waterways would cause significant environmental stress. Springs that create the flow in these streams are also historic areas used by pioneers, early ranchers, and settlers. Remains of their homesteads and structures used to manage spring outflow and direct water usage are still visible in and near the springs. The National Park Service is directed to preserve these historic elements and cultural landscapes against unnatural impacts from continued human use, as well as to protect the spring's water quality and quantity from human induced impairment. Those portions of McKittrick Canyon Creek and Choza Creek that flow within the Park boundary are recommended as ecologically unique stream segments, and are further described in Appendix 8C.

8.4.3 Cienega Creek (Chinati Mountains State Natural Area)

Cienega Creek flows downstream from the spring-fed spring, La Baviza, in the 38,187-acre Chinati Mountains State Natural Area in west-central Presidio County. The cienega forms a fresh to slightly saline marsh with waters that are slightly geothermal. The habitat supports a fairly intact, diverse marsh with saline grasses, rushes, sedges, and perennials. La Baviza Spring is also identified as a "Major Spring" in Chapter 1 of this plan. A high diversity of desert bats use the area for feeding and watering. The adjacent Cienega Creek has very good examples of saline marsh and cottonwood gallery woodlands. It is an important wildlife area and is located in the low Chihuahuan Desert where intact wetlands and riparian habitat are quite rare. A detailed information packet pertaining to this river segment is contained in Appendix 8D.

8.4.4 Alamito and Cienega Creeks (Big Bend Ranch State Park)

Alamito Creek extends from its confluence with the Rio Grande upstream to the FM 169 crossing in Presidio County. Cienega Creek extends from its confluence with Alamito Creek upstream to its headwaters also in Presidio County. Springs on private property north of the Big Bend Ranch Park form the headwaters of both creeks. The Far West Texas Water Planning Group recommends that only those stretches of these streams that lie within the boundaries of Big Bend State Park be considered as "Ecologically Unique River and Stream Segments". A detailed information packet pertaining to this river segment is contained in Appendix 8E.

Alamito Creek is recognized as a high quality ecoregional stream with exceptional aquatic life and high aesthetic value. The stream contains a diverse benthic community of macroinvertebrates and fishes (Bayer et al., 1992; Linam et al., 1999). Unique communities of threatened or endangered species include: Concho pupfish (Fed. SOS/St. T), Chihuahua shiner (Fed. SOC/St. T), Mexican stoneroller (Fed. SOC/St. T) (Bayer et al., 1992).

Cienega Creek is an intact desert spring ecosystem displaying overall habitat value (D. Riskind, 1999, pers. comm.). Unique communities of threatened or endangered species include: Big Bend mud turtle (St. E) and various endangered desert fishes (D. Riskind, 1999, pers. comm.).

8.4.5 Independence Creek (Texas Nature Conservancy - Independence Creek Preserve)

Independence Creek is a large spring-fed creek in northeastern Terrell County. It is the most important and one of the few remaining freshwater tributaries of the lower Pecos River. The Texas Nature Conservancy owns and manages the 19,740-acre Independence Creek Preserve. Caroline Spring, located at the Texas Nature Conservancy's Preserve headquarters, produces 3,000 to 5,000 gallons per minute and comprises about 25 percent of the creek's flow. Independence Creek's contribution increases the Pecos River water volume by 42 percent and reduces the total dissolved solids by 50 percent, thus improving water quantity and quality. The Preserve hosts a variety of bird and fish species, some of which are extremely rare. Caroline Spring, along with the entirety of the Independence Creek Preserve, is a significant piece of West Texas natural heritage. That portion of Independence Creek that flows through the Preserve is recommended as an ecologically unique stream segment. Additional information pertaining to Independence Creek is provided in Appendix 8F.

8.4.6 Madera Creek, Canyon Headwaters of Limpia Creek, Little Aguja Creek, and Upper Cherry Creek (Texas Nature Conservancy - Davis Mountains Preserve)

The wild and remote Davis Mountains is considered one of the most scenic and biologically diverse areas in Texas. Rising above the Chihuahuan desert, the range forms a unique “sky island” surrounded by the lowland desert. Animals and plants living above 5,000 feet are isolated from other similar mountain ranges by vast distances. The Texas Nature Conservancy has established the 32,000-acre Davis Mountains Preserve (with conservation easements on 65,830 acres of adjoining property) in the heart of this region. Madera Creek, Canyon Headwaters of Limpia Creek, Little Aguja Creek, and Upper Cherry Creek form critical wetland habitat and establish base flow to the downstream creeks. The portion of these streams that flow through the Davis Mountains Preserve are recommended as ecologically unique stream segments. Additional information pertaining to these streams is provided in Appendix 8G.

8.5 TPWD RECOMMENDED ECOLOGICALLY SIGNIFICANT RIVER AND STREAM SEGMENTS

At the completion of the first round of regional water planning, the Texas Parks and Wildlife Department (TPWD) was asked to play a more active role in assisting the regional planning groups with environmental water needs assessment. In response, TPWD provided each of the 16 regional planning groups with their recommendation of “Ecologically Significant River and Stream Segments” along with supporting data for each segment. The FWTWPG greatly appreciates the efforts provided by the agency and used the information in formulating their recommendations pertaining to “Major Springs” (Chapter 1) and “Ecologically Unique River and Stream Segments” (this chapter).

The FWTWPG approved the inclusion in the Plan of three suggested stream segments that lie within the boundaries of state-managed properties. These stream segments include Cienega Creek in the Chinati Mountains State Natural Area and Alamito and Cienega Creeks in the Big Bend Ranch State Park. The entire TPWD recommendation document can be viewed in Appendix 8H.

8.6 CONSIDERATION OF UNIQUE SITES FROM RESERVOIR CONSTRUCTION

The regional water planning process gives each of the 16 regional water planning groups the opportunity to recommend stream locations for designation as “unique sites for reservoir construction.” The regional water planning process legislation and rules list many criteria to determine if a site is qualified for such designation.

The availability of water is one of the most important criteria in the selection of a reservoir site - if not the most important criterion. The low rainfall totals and the spotty nature of precipitation in Far West Texas limit the potential for sufficient runoff to maintain desired water levels in reservoirs.

Many canyons in the mountainous areas of Far West Texas might not retain large volumes of water because of the fractured and often highly-permeable bedrock that forms the walls and floors of these topographic features. Any attempt to develop a reservoir in Far West Texas will require extensive and costly geological, geotechnical, and hydrological investigations to determine whether a site is suitable. The program of work would also require detailed state and federal environmental impact assessments.

With regard to the Rio Grande, the 1944 International Treaty between the United States and Mexico specifies that a reservoir project considered by one country have the other country's permission. Furthermore, the treaty stipulates that international reservoirs are to be operated by both countries.

On watercourses other than the Rio Grande, the water use reported to the TCEQ by surface water right holders gives some clues as to which watercourses are the most reliably used and therefore could be investigated for potential reservoir sites. Reported water use data, provided by the Rio Grande Watermaster and by TCEQ, have been examined to identify holders of surface water rights who are able to divert water in amounts greater than 1,000 acre-feet per year. The analysis indicates that Musquiz and Maravillas Creeks in Brewster County are probably the most reliable surface water sources.

On Alamito Creek in Presidio County, there is an existing recreational reservoir authorized to impound 18,700 acre-feet, but diversions are not authorized and therefore no use amounts are reported. Whether this reservoir stays reliably full is unknown, and the reliability of Alamito Creek in general is unknown.

A feasibility study for a recreational lake site near Alpine was previously conducted and consideration was given to its municipal water supply potential. The project was abandoned because of its high cost-to-yield potential.

Additional off-channel reservoir sites, as well as flood protection dam sites on major arroyos have been studied by the Hudspeth County Conservation and Reclamation District #1, El Paso-Hudspeth County Soil Conservation District, and the Hudspeth County Commissioners Court. None of these sites have been selected for construction. Additional flood retention dams have been considered for the El Paso area. These retention dams would have the added benefit of increasing recharge of the local aquifer by increasing infiltration of the retained water into the bolson deposits.

The firm yield for any reservoirs constructed on even the most reliable Far West Texas watercourses is not likely to exceed 2,000 acre-feet per year. For this reason, the *2006 Far West Texas Water Plan* does not recommend any watercourse for designation as "unique sites for reservoir construction."

APPENDIX 8A

POLICY ISSUES SURVEY

APPENDIX 8A
FAR WEST TEXAS REGION POLICY ISSUES SURVEY

A.	Agricultural and Rural Water	Score
1	Quantification of impacts to rural Texans of water transfers (e.g. effects on income, employment, population)	40
2	Protecting agricultural and rural water supplies, considering economic constraints and competing uses	38
3	Conservation of agricultural water for additional agricultural use, urban uses or for environmental purposes (i.e. how to treat this "new" water)	38
4	Impacts on water supply and quality resulting from conversion of agricultural lands to urban lands	34
5	Improved water use information for irrigation and livestock watering categories	33
6	Effects of Safe Drinking Water Act on Small Water supply systems	24
7	Incentives for individual projects, including stock tanks	9
8	Use of playa lakes for recharge, considering impacts and constraints	9
9	Other topics in this category	5

B.	Conservation	Score
1	Relationship between drought contingency planning and regional water planning	37
2	Quantifying conserved water	37
3	Per capita water use analysis considering commercial and institutional use, income, hosting stock characteristics, and geographical location	36
4	Retail customer water pricing	32
5	Incentives (e.g. landscaping and plumbing rebates)	29
6	Other topics in this category	3

C.	Data	Score
1	Data for rural areas	42
2	Consistent analytical techniques	40
3	Compatibility of data from different sources	36
4	Linkages of databases	31
5	Access to data, including security constraints	30
6	Trends in data collection and availability	26
7	Other topics in this category	13

D.	Environmental	Score
1	Sustainable growth, including impacts of growth	38
2	Integrating water quality and water supply considerations	36
3	Watershed planning/source water protection	32
4	Springflow protection	28
5	Regional or statewide environmental mitigation system	28
6	Environmental criteria to measure and maintain a sound ecological environment	27
7	Instream flows	26
8	Invasive species	23
9	Wildlife resources, including threatened and endangered species	22
10	Environmental water permits	20
11	Unique stream segments	19
12	Bays and estuaries	8
13	Texas Water Trust	7
14	Other topics in this category	1

E.	Groundwater	Score
1	Sustainability and groundwater management	48
2	Groundwater export and potential equity issues (e.g. use of export fees)	46
3	Improving groundwater availability data	43
4	Coordination between Groundwater Conservation Districts and Regional Water Planning Groups	42
5	Water marketing (e.g. water rights leases, sales, transfers)	42
6	Conjunctive use of groundwater and surface water (see also surface water)	40
7	Rule of capture	40
8	Standardized methods/policy for determining groundwater availability	40
9	Clarifying state roles and district roles	38
10	Linking groundwater and surface water models (see also surface water)	37
11	Adequate financial resources for districts	37
12	Impacts of Texas Water Code §36.121, “Limitation on Rulemaking Power of Districts Over Wells in Certain Counties”	30
13	Variability of “historical water use” definition	30
14	Storm water runoff for groundwater recharge purpose (see also surface water)	27
15	Abandoned oil and gas wells, including waters supply and quality impacts	23
16	Other topics in this category	5

F.	Innovative Strategies	Score
1	Reuse (including basin-specific assessment of reuse potential and impacts)	**42**
2	Desalination of seawater and brackish water	**40**
3	Brush management, including potential impacts on water supply and wildlife	**28**
4	Groundwater banking	**24**
5	Planning beyond the current fifty-year time horizon	**15**
6	Climate change	**10**
7	Weather modification	**7**
8	Other topics in this category	**5**

G.	Providing and Financing Water/WW Services	Score
1	Potential funding sources for water supply	**32**
2	State participation	**31**
3	Regionalized water supply	**31**
4	Incentives for planning implementation	**28**
5	Ranking proposals as a component of financial assistance	**27**
6	Public-private partnerships	**19**
7	Other topics in this category	**5**

H.	Surface Water	Score
1	Water marketing (e.g. water right leases, sales, transfers)	**42**
2	Conjunctive use of groundwater and surface water (see also groundwater)	**36**
3	Linking groundwater and surface water models (see also groundwater)	**35**
4	International treaty compliance	**35**
5	Interbasin Transfer (IBTs)	**30**
6	Assessment of the current water resource regulatory system to meet water management needs of the 21st century	**30**
7	Reservoir storage reallocation (e.g. from flood storage to water supply storage)	**24**
8	Competing demands on reservoir operation (e.g. B&E flows, recreation, municipal supply, aesthetics, etc.)	**22**
9	System operation of water facilities (e.g. coordination of multiple reservoirs)	**18**
10	Subordination agreements (including basin-specific assessment of subordination agreements)	**17**
11	Watermaster program (e.g. expansion, funding, enforcement)	**14**
12	Cumulative effects on water availability of exempt water storage facilities (e.g. stock ponds)	**10**
13	Other topics in this category	**4**

I.	**Other Issues**	**Score**
1	Security of supply from potential disruptions	**36**
2	Education	**35**
3	Public involvement	**35**
4	Consistency between regional water planning and rules for drinking water systems regarding minimum requirements for water supply	**32**
5	Inter-regional cooperation / Inter-regional water sharing	**31**
6	Heritage / tourism / recreation / cultural resources	**31**
7	Other topics in this category	**5**

APPENDIX 8B

RIO GRANDE

WILD AND SCENIC RIVER

APPENDIX 8B
RIO GRANDE WILD AND SCENIC RIVER

The Rio Grande/Rio Bravo in Far West Texas is truly a national treasure with unique ecological and economic features. The Far West Texas Regional Water Planning Group recognizes the significance of the 196-mile Rio Grande Wild and Scenic River segment and encourages the proper conservative management of this region. The upper 69-mile section of this corridor lies within the Big Bend National Park, however the National Park Service administers the entire 196-mile designated section. For purposes of the Far West Texas Regional Water Plan, the Planning Group officially recommends that only the part of the federally designated Rio Grande that is bordered by the Big Bend National Park be considered under the guidelines of "Ecologically Unique River and Stream Segments". The following river segment characterization is principally contained with the National Parks Service / Rio Grande Wild and Scenic River Final General Management Plan and Environmental Impact Statement (http://www.nps.gov/rigr/pphtml/documents.html) and the Big Bend National Park / Rio Grande Wild and Scenic River web site (http://www.nps.gov/bibe/rgwsr.htm).

In 1978, Congress designated a 196-mile segment of the Rio Grande a National Wild and Scenic River (Figure 8.1). The Wild and Scenic River Act of 1968 directs that the designated rivers "… be preserved in free-flowing condition, and that they and their immediate environments be protected for the benefit and enjoyment of the present and future generations." Only 2% of America's rivers are "free flowing" and qualify for this designation. The Rio Grande Wild and Scenic River was designated for the following purposes:

- *To preserve the free-flowing condition and essentially primitive character of the river (except as provided by treaty)*
- *To protect the outstanding scenic, geologic, fish and wildlife, recreational, scientific, and other similar values of the river and its immediate environment*
- *To provide opportunities for river-oriented recreation that is dependent upon the free-flowing condition of the river and consistent with the primitive character of the surroundings.*

The Rio Grande Wild and Scenic River is significant as part of a valuable and largely intact ecological system representing major riparian and aquatic habitat associated with the Chihuahuan Desert. Spectacular river canyons, the primitive character of the river, and its international flavor combine to form a stimulating environment for high quality scenic and recreational experience. Protecting and managing this outstanding natural resource extends a valuable opportunity for international cooperation between the United States and Mexico.

Location

Under the Wild and Scenic River Act (16 USC 28 §1274), the following segment is designated:

The segment on the United States side of the river from river mile 842.3 above Mariscal Canyon downstream to river mile 641.1 at the Terrell-Val Verde County line,…
The International Boundary and Water Commission later revised the beginning and ending river miles to 853.2 and 657.5 respectively. The southern side of the river is not designated because it is owned by Mexico.

The designated Wild and Scenic stretch of the Rio Grande begins in Big Bend National Park, opposite the boundary between the Mexican states of Chihuahua and Coahuila. It then flows through Mariscal and Boquillas Canyons in the national park. Downstream from the park, it extends along the state-managed Black Gap Wildlife

Management Area and several parcels of private land in the Lower Canyons. The wild and scenic river segment ends at the county line between Terrell and Val Verde Counties. There are plans to introduce legislation that will extend the Wild and Scenic designation to the western National Parks boundary, extending the total distance by approximately 65 miles.

The National Park Service's jurisdiction on the Rio Grande Wild and Scenic River downstream from the park boundary includes only the river area from the United States/Mexico international boundary in the middle of the deepest channel to the gradient boundary at the edge of the river on the United States side. The gradient boundary, as recognized by the State of Texas, is defined as located midway between the lower level of the flowing water that just reaches the cut bank and the higher level of it that just does not overtop the cut bank. The riverbed of the Wild and Scenic River downstream from the park is the property of the State of Texas.

The stretch of river is classified as either wild or scenic. Wild sections are defines as "…those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watershed or shorelines essentially primitive and water unpolluted…these represent vestiges of primitive America…" Scenic sections pertain to "…those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds largely primitive and shorelines largely undeveloped, but accessible in places by roads…"

The following sections are classified as wild: Talley to Solis, which includes Mariscal Canyon; the entrance to Boquillas Canyon to the exit of Boquillas Canyon; and Reagan Canyon to San Francisco Canyon (the bulk of the "Lower Canyons"). The remainder of the Wild and Scenic River is classified as scenic.

Natural Resources

Scenic Value

The area encompassing the designated Rio Grade Wild and Scenic River contains views of the river and surrounding canyons with outstanding visual quality. Rugged, steep-walled canyons, scenic rapids, and unspoiled views contribute to the river and its surroundings, are important values for river visitors.

Geologic Features

Rock layers exposed by the Rio Grande were deposited about 100 million years ago. Subsequent uplifting, folding, faulting, and cutting of the river have produced the present topography. Near its upstream end, the Rio Grande has sliced through the surrounding rocks to form steep-walled, sometimes narrow canyons. Downstream from Boquillas Canyon, the river flows across a relatively broad and open floodplain, or *vega*. Near Reagan Canyon, the floodplain narrows abruptly, and the river flows in a continuous deeply cut canyon for almost 40 miles. In the Lower Canyons portion of this segment, the river and its tributaries lie 500 to 1,500 feet below the surrounding plateaus.

Fish and Wildlife

The area is an outstanding example of Chihuahuan Desert wildlife in Texas. This isolated area represents a rapidly dwindling, irreplaceable natural resource. The riparian corridor, containing more vegetative growth and a reliable water supply, attracts many wildlife species.

Forty-six known species of fish inhabit the Big Bend area; 34 of these are native. Shiners and daces are the most abundant fishes in the Rio Grande. Larger fish found here are the long-nose gar, channel catfish, blue catfish, and European carp. Six native fish species have been extirpated in recent decades because of the effects of dams, habitat modification, and competition from introduced species.

Numerous wildlife species are residents of the river corridor, and many others, especially birds, use the Rio Grande as a travel corridor. Mammals include skunks, rodents, squirrels, rabbits, raccoons, and ringtails. Mountain lions (locally called panthers) occupy the area, and black bears and desert bighorn sheep occasionally can be seen.

Birds are the most frequently seen animals along the river. Common resident species seen or heard along the river include yellow-breasted chat, black phoebe, white-winged dove, canyon wren, and roadrunner. Ravens, turkey vultures, and various raptors regularly soar overhead. Peregrine falcons (*Falco peregrinus*) use high cliff faces for nesting in Santa Elena, Mariscal, and Boquillas canyons. Reptiles include lizards, snakes, and both terrestrial and aquatic turtles. Several amphibian species also are present.

Native freshwater mussels have virtually disappeared from this area. Some historic species no longer can be found, and the more persistent Texas hornshell and Salina Mucket have not been found alive in recent years. Other aquatic species may be in danger of extirpation. Reductions in water quality and quantity adversely affect these and other aquatic species.

Many exotic or nonnative species are found in the Rio Grande. Twelve nonnative fish species compete with the remaining native species. Nutria, a large nonnative rodent, is no common, and the exotic Asian clam is abundant. At present there is insufficient information about the distribution and spread of exotic species.

Special Status Species

The following federally listed species may be found in the river corridor.

Fishes. The endangered ***Big Bend gambusia*** *(Gambusia gaigeii)* is known only from spring habitats near Boquillas Crossing and Rio Grande Village in Big Bend National Park, within the management area of the river. The population of this fish species at Boquillas Spring died when the spring stopped flowing in 1954. The population near Rio Grande Village drastically declined between 1954 and 1956, after the spring flow was altered to provide a fishing pool. By 1960, the Big Bend gambusia no longer could be found at the Rio

Grande Village location. The loss of this population probably was due to competition with the western mosquitofish and predation by the introduced green sunfish. All the present populations of the Big Bend gambusia are descendants of two males and one female taken from the declining Rio Grande Village population in 1956. The only known wild population exists in a protected pond in Big Bend national Park (Texas Parks and Wildlife Department Web site). A recovery plan is in effect for this species that calls for its reintroduction (USFWS 1984).

Other fish species of concern are as follows: Chihuahua shiners are know in the United States only in the park, where they inhabit the lower reaches of Tornillo and Terlingua Creeks. The Mexican stoneroller fish, the blue sucker, and the Conchos pupfish also are found in the area.

Black-Capped Vireos. Endangered ***black-capped vireos*** *(Vireo atricapillus)* nest in Texas during April through July and spend the winter on the western coast of Mexico. Their habitat is primarily rangelands with scattered clumps of shrubs separated by open grassland. They nest in shrubs such as hennery oak or sumac. They may occasionally use the river corridor. This species' listing as endangered is due to the dwindling population numbers from nesting habitat loss and cowbird parasitism.

Cactus Species. The threatened **bunched cory cactus** *(Coryphantha ramillosa)* is found on slopes and ledges of sparsely vegetated limestone rock outcrops (most commonly of the Boquillas or Santa Elena Formations) in the lechuguilla shrublands in Big Bend national Park and on large private ranches. This species is known from about 25 sites in southern Brewster County, many in Big Bend National Park. It also can be found in northern Coahuila, Mexico.

The ***Chisos Mountains hedgehog cactus*** *(Echinocereus chisoenis* var. *chisoenis),* also a threatened species, is known to occur in the river corridor. These cacti are found in low elevation desert grasslands or sparsely vegetated shrublands on gravelly flats and terraces in the Chihuahuan Desert. This species is known from about a dozen sites, all in Big Bend national Park. No federally designated critical habitat for this species exists in Terrell or Brewster County.

Vegetation

The Chihuahuan Desert, through which the Rio Grande Wild and Scenic River flows, exhibits a great diversity of vegetation types, which have been categorized according to topography. The vegetation adjacent to the river is adapted to flooding and wet soils. Willows, canes, reeds, seepwillows, acacias, and grasses are the major components of this association. Upslope, the vegetation becomes more desertlike, with lechugilla, blackbrush, catclaw acacia, candelilla, saltbush, mesquite, creosote bush, chino grama, and a variety of cacti predominating. Cracks in the cliff walls harbor a distinctive plan community of candelilla, rock nettle, and poison ivy.

The riparian zone varies from narrow intra-canyon banks to floodplains more than 0.5 mile wide. Early reports indicated that lance-leaf cottonwoods and willows were common, but by the early 1900s most of the trees had been harvested for use in mining operations, and their seedlings rarely survived grazing.

Tamarisk, giant river cane, Bermuda grass, and other invasive plant species have become established along the Rio Grande. In some places these exotic species have forced out native vegetation and form an impassable thicket.

Cultural Resources

The canyons and valleys of the Rio Grande have been a homeland to people for many centuries. The area contains a number of prehistoric and historic cultural resources that supply limited views into the lifestyle of various cultures over the last 10,500 years. Many sites along the wild and scenic river are undisturbed, which enhances their scientific value. Reconnaissance surveys have located a significant number of prehistoric sites on both sides of the river. These sites, which represent occupation and exploration activities by the prehistoric inhabitants, are found in caves, rock shelters, terraces, talus slopes, and canyon rims.

Throughout the prehistoric period, people found shelter and maintained open campsites throughout what is now Big Bend National Park. Archeological records reveal an Archaic-period desert culture whose inhabitants developed a nomadic hunting and gathering lifestyle that remained virtually unchanged for several thousand years. American Indian cultures represented are the Chisos, Mescalero Apache, Kickapoo, and Comanche. Sites containing ceramic artifacts suggest that some later indigenous peoples had a semisedentary lifestyle and practiced limited agriculture along the river.

The historic period began in 1535 with the explorations of Alvar Nuñez Cabeza de Vaca in the Texas Trans-Pecos region. During the late 1700s, Spanish presidios were established along the Rio Grande at San Vicente, Coahuila, and along the San Carlos River at San Carlos, Chihuahua.

Control of the area was passed to the United States after the Mexican-American War (1846-1848). A series of army posts was established along the Rio Grande in an attempt to stop Comanche and Apache raids. The first accurate maps of the Rio Grande canyon areas were completed by Army topographic engineers and the United States-Mexico Boundary Commission in the 1850s. Around that time, a wagon road was established to link San Antonio and El Paso. The road tied the region into the trade network that stretched from California to the Gulf of Mexico.

Grazing history along the Rio Grande dates back to the early Spanish missions established between 1670 and 1690. These missions had become major centers of livestock concentration by 1700.

Hispanic settlements existed near the Rio Grande in 1805. Mexicans farmed and ranched the area throughout the 1800s. Beginning in the 1880s, Anglo-Americans established ranches throughout the area and began farming in the early 20th century. Some farmers and ranchers left the area for a short hiatus during the Mexican Revolution. Cotton and food crops were grown around Castolon and what is now Rio Grande Village even after Big Bend National Park was established in 1944.

Quicksilver (mercury) was discovered in the area in the late 19th century, and later finds of silver and fluorite attracted hundreds of miners and prospectors. A unique facet of the continuing Rio Grande history is the use of the candelilla plant to produce high-quality wax. This wax has been used in the manufacture of candles, waxes, gum, and phonograph records.

Sites of historical interest in the Lower Canyons are an abandoned candelilla operation, the Asa Jones Waterworks, Dryden Crossing, and Burro Bluff, the site of an old trail built by cattlemen for access to the Texas side of the river.

A review of the National Register of Historic Places reveals that four sites that are listed in the national register are in the river corridor in Big Bend National Park: Sublett Farm, Daniels Farm, the Castolon Historic District, and the Hot Springs District

The Texas Historical Commission conducted a reconnaissance survey of the river corridor from La Linda to Dryden Crossing in the 1970s (Mallouf and Tunnel 1977). The researchers recorded 83 prehistoric sites and 5 historic sites on that survey. Some of those are on the Mexican side of the river. The sites represented human occupation and use of the river area throughout the last 12,000 years. The potential for evidence of Paleo-Indian occupation exists in some of the more protected cave and rock shelter sites. Because they are on nonfederal land, no determination has been made about the eligibility of the prehistoric or historic sites in the Lower Canyons for the National Register of Historic Places.

Resource Concerns

Diminishing flows in the Rio Grande is an international, national, and regional concern. This concern is heightened by declining water quality and the presence of invasive species.

The Rio Grande, one of the longest rivers in the United States, is no longer a naturally flowing river along its entire length. Extensive diversion networks and dams control flows on the river to provide water for a variety of human needs. The high flows and periodic floods necessary to maintain the river channels have been reduced by 75% in the Rio Grande below El Paso and by 50% on the Rio Conchos over the years. Reduced flows below Fort Quitman have resulted in a long stretch of the river with no defined channel, and the river in that area has become a tamarisk thicket. The amount of water that reaches Big Bend National Park and the Wild and Scenic River has been reduced by more than half the historic level. Spring inflows and unregulated tributaries increase the average annual streamflow in the reaches of the Wild and Scenic River.

Current water quality in the Rio Grande is mitigated and freshened by groundwater (springs) inflows from the Langford Hot Springs Complex in Big Bend National Park and the Lower Canyon Thermal Springs Complex downstream. *(See additional discussion pertaining to these spring complexes in the "Major Springs" Section of Chapter 1)* The role of these springs in controlling water quality is so important that in discussions with the Texas Commission on Water Quality, it is recognized that water quality in the entire segment would not meet standards for recreational use or fish consumption without groundwater contributions from several spring systems.

The Rio Grande Wild and Scenic River has lost five species of fish and possibly could lose mussel species and a turtle. Inadequate river flows are compromising aquatic and terrestrial species and associated habitats. The Rio Grande corridor serves as important habitat for several state and federally listed threatened and endangered species. The river corridor could provide sufficient habitat to reintroduce or strengthen critical species.

Invasive or introduced species such as tamarisk (salt cedar) and nutria have been observed along the river corridor. There is concern about ways to control these species and the impact they could have on native plants and wildlife.

Cooperative Efforts

Big Bend National Park and the Rio Grande Wild and Scenic River have undertaken several tasks to define, protect, and better manage water resources. In partnership with the Comisión Nacional de Áreas Naturales Protegida, the World Wildlife Fund, the Rio Grande Institute, and Texas Parks and Wildlife, the Park is restoring the mouth of Boquillas Canyon by eradicating invasive species and planting natives. With projects such as this, a valuable opportunity exists for binational cooperation between the United States and Mexico to protect and manage this outstanding primitive resource.

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APPENDIX 8C

MCKITTRICK CANYON STREAM

CHOZA CREEK

(GUADALUPE MOUNTAINS NATIONAL PARK)

APPENDIX 8C

McKittrick Canyon Stream (Guadalupe Mountains National Park)

McKittrick Canyon stream consists of two headward branches in North and South McKittrick Canyon and a downstream reach formed by coalescing of the two headward branches. Both headward segments are fed by unnamed springs and the South McKittrick branch gains springwater at several points along its course. McKittrick Canyon stream is by far the largest of a very small number of perennially flowing streams in the Guadalupe Mountains in Texas and New Mexico. It supports substantial numbers and species of wildlife, as well as a riparian zone at the bottom of a steep canyon ranging up to 2000 feet deep. During the fall, scenic canyon walls are a backdrop to displays of brilliantly colored Bigtooth maples. The canyon is the only known habitat for an isolated population of a moss, *Venturiella sinensis* var. *angustiannulata,* whose closest relatives occur in China and within a small refugium in Oklahoma. Several areas in the canyon are breeding habitat for the Mexican Spotted Owl (*Strix occidentalis lucida*), officially list as a USF&WS Threatened species. There is one known nesting site for the recently de-listed Peregrine Falcon (*Falco peregrinus*) in the canyon cliffs. The headward branches flow through two areas officially designated as Research Natural Areas. The stream recharges an alluvial aquifer restricted to the canyon bottom, which supplies public drinking water at two park facilities.

North Branch - Guadalupe Peak 7 ½ min. Quadrangle

The flowing portion of the stream heads at a spring only a short distance into New Mexico and crosses into Texas three times. The state lines are also the boundaries between Guadalupe Mountains National Park and the Lincoln National Forest. The westernmost crossing into Texas occurs at:

UTM Coordinate N	3540258	Zone 13, Projection: NAD 1927 Conus
UTM Coordinate E	518792	

Continuing downstream generally southeast to the point where the northern branch joins the southern branch at:

UTM Coordinate N 3538348
UTM Coordinate E 520800

South Branch - Guadalupe Peak 7 ½ min. Quadrangle

The flowing part of the stream heads at a spring near:

UTM Coordinate N 3536021
UTM Coordinate E 518782

and continues to the junction with the north branch noted above.

Main Branch - Guadalupe Peak 7 ½ min. Quadrangle

Beginning at the junction noted above and continuing generally eastward to the point where the streambed exits the park at:

UTM Coordinate N 3537890
UTM Coordinate E 523616

Choza Stream (Guadalupe Mountains National Park)

The Choza Stream heads at Choza Spring and supports a narrow riparian habitat that extends for almost a mile to the southeast. It gains volume at one point immediately north of Highway 62-180 and, in wet years, another diffuse or multiple point area south of that highway. The latter area supports potentially classifiable wetland habitat. The stream provides critical habitat and a vital water source for desert wildlife. The heading spring discharges at:

UTM Coordinate N 3529837 Zone 13, Projection: NAD 1927 Conus
UTM Coordinate E 520309

and the stream exits the park at:

UTM Coordinate N 3529990
UTM Coordinate E 521158

APPENDIX 8D

CIENEGA CREEK

(CHINATI MOUNTAINS STATE NATURAL AREA)

APPENDIX 8D

Cienega Creek (Chinati Mountains State Natural Area)

Cienega Creek flows downstream from the spring-fed spring, La Baviza, in the 38,187-acre Chinati Mountains State Natural Area in west-central Presidio County. The spring (cienega) forms a fresh to slightly saline marsh with waters that are slightly geothermal. The habitat supports a fairly intact, diverse marsh with saline grasses, rushes, sedges, and perennials. A high diversity of desert bats also use the area for feeding and watering. The adjacent Cienega Creek has very good examples of saline marsh and cottonwood gallery woodlands. It is an important wildlife area and is located in the low Chihuahuan Desert where intact wetlands and riparian habitat are quite rare. La Baviza Spring (Cienega) is identified as a "Major Spring" in Chapter 1.

APPENDIX 8E

ALAMITO AND CIENEGA CREEKS

(BIG BEND RANCH STATE PARK)

APPENDIX 8E

Alamito and Cienega Creeks (Big Bend Ranch State Park)

Alamito creek extends from its confluence with the Rio Grande upstream to the FM 169 crossing in Presidio County. Cienega Creek extends from its confluence with Alamito Creek upstream to its headwaters also in Presidio County. Springs on private property north of the Big Bend Ranch Park form the headwaters of both creeks. The Far West Texas Water Planning Group recommends that only those stretches of these streams that lie within the boundaries of Big Bend State Park be considered as "Ecologically Unique River and Stream Segments". A detailed information packet pertaining to this river segment is contained in Appendix 8E.

Alamito Creek is recognized as a high quality ecoregional stream with exceptional aquatic life and high aesthetic value. The stream contains a diverse benthic community of macroinvertebrates and fishes (Bayer et al., 1992; Linam et al., 1999). Unique communities of threatened or endangered species include: Concho pupfish (Fed. SOS/St. T), Chihuahua shiner (Fed. SOC/St. T), Mexican stoneroller (Fed. SOC/St. T) (Bayer et al., 1992).

Cienega Creek is an intact desert spring ecosystem displaying overall habitat value (D. Riskind, 1999, pers. comm.). Unique communities of threatened or endangered species include: Big Bend mud turtle (St. E) and various endangered desert fishes (D. Riskind, 1999, pers. comm.).

APPENDIX 8F

INDEPENDENCE CREEK

(TEXAS NATURE CONSERVANCY PRESERVE)

APPENDIX 8F

Independence Creek (Texas Nature Conservancy Preserve)

The Texas Nature Conservancy's Independence Creek Preserve is located near the downstream terminus of Independence Creek in northeastern Terrell County. Caroline Spring, located at the Preserve headquarters, produces 3,000 to 5,000 gallons per minute and comprises about 25 percent of the creek's flow. Downstream, Independence Creek's contribution increases the Pecos River water volume by 42 percent and reduces the total dissolved solids by 50 percent, thus improving water quantity and quality. The preserve hosts a variety of bird and fish species, some of which are extremely rare. Caroline Spring, along with the entirety of the Independence Creek Preserve (19,740 acres), is a significant piece of West Texas natural heritage. Caroline Spring is identified as a "Major Spring" in Chapter 1.

APPENDIX 8G

DAVIS MOUNTAINS STREAMS

(TEXAS NATURE CONSERVANCY PRESERVE)

APPENDIX 8G

Davis Mountains Streams (Texas Nature Conservancy Preserve)

The wild and remote Davis Mountains is considered one of the most scenic and biologically diverse areas in Texas. Rising above the Chihuahuan desert, the range forms a unique "sky island" surrounded by the lowland desert. Animals and plants living above 5,000 feet are isolated from other similar mountain ranges by vast distances. The Texas Nature Conservancy has established the 32,000-acre Davis Mountains Preserve (with conservation easements on 65,830 acres of adjoining property) in the heart of this region. The headwaters of Madera, Limpia, Little Aguja and Upper Cherry Creeks originate within the boundaries of the Preserve. Tobe, Bridge, Pine and Limpia Springs (identified as "Major Springs in Chapter 1) contribute to these headwaters and form critical wetland habitat and establish base flow to the downstream creeks.

APPENDIX 8H

TEXAS PARKS AND WILDLIFE

RECOMMENDED ECOLOGICALLY

SIGNIFICANT RIVER AND STREAM SEGMENTS

APPENDIX 8H

Texas Parks and Wildlife Recommended Ecologically Significant River and Stream Segments

Alamito Creek - From the confluence with the Rio Grande in Presidio County upstream to the FM 169 crossing in Presidio County.

High water quality/exceptional aquatic life/high aesthetic value: ecoregion stream; diverse benthic macroinvertebrate and fish communities (Bayer et al., 1992; Linam et al., 1999)

Threatened or endangered species/unique communities: Conchos pupfish (Fed.SOC/St.T), Chihuahua shiner (Fed. SOC/St.T), Mexican stoneroller (Fed.SOC/St.T) (Bayer et al., 1992)

Cienega Creek - From the confluence with Alamito Creek upstream to its headwaters in Presidio County.

Biological function: intact desert spring ecosystem displays significant overall habitat value (D. Riskind, 1999, pers. comm.)

Riparian conservation area: Big Bend Ranch State Park

Threatened or endangered species/unique communities: Big Bend mud turtle (St.E) and endangered desert fishes (D. Riskind, 1999, pers. comm.)

Independence Creek - From the confluence with the Pecos River 15 miles south of Old Fort Lancaster and Sheffield in Terrell County upstream to its headwaters located 18 miles southwest of Sheffield in Terrell County.

Riparian conservation area: Chandler Ranch

High water quality/exceptional aquatic life/high aesthetic value: ecoregion stream; high water quality, diverse benthic macroinvertebrate community (Bayer et al., 1992)

Threatened or endangered species/unique communities: proserpine shiner (SOC/St.T), Rio Grande darter (SOC/St.T) (Linam and Kleinsasser, 1996; Linam et al., 1999)

Little Aguja Creek - From the confluence with Toyah Creek 2.5 miles southwest of Toyahvale at the Jeff Davis/Reeves County line upstream to its headwaters in the Davis Mountains 10 miles northwest of Fort Davis in Jeff Davis County.

Threatened or endangered species/unique communities: Rio Grande chub (SOC/St.T) (Hubbs et al., 1991); only known location of Little Aguja pondweed (D. Sullivan, 1998, pers. comm.)

Pecos River - From the Val Verde/Terrell County line upstream to the Terrell/Crockett/Pecos County line (within TNRCC classified stream segment 2311).

Biological function: Texas Natural Rivers System nominee for outstandingly remarkable fish and wildlife values (NPS, 1995)

High water quality/exceptional aquatic life/high aesthetic value: exceptional aesthetic value (NPS, 1995)

Threatened or endangered species/unique communities: proserpine shiner (SOC/St.T) (Hubbs et al., 1991; Linam and Kleinsasser, 1996)

Phantom Springs (Jeff Davis County)

Riparian conservation area: Managed by the Texas Parks and Wildlife Department through an agreement with the Bureau of Land Management

Threatened or endangered species/unique communities: Comanche Springs pupfish (Fed.E/St.E), Pecos gambusia (SOC/St.T) (Hubbs et al., 1991)

Rio Grande - From a point 1.1 miles downstream of the confluence of Ramsey Canyon in Val Verde County to the confluence of the Rio Conchos (Mexico) in Presidio County (TNRCC stream segment 2306).

Riparian conservation area: Big Bend National Park; Big Bend Ranch State Natural Area; National Wild and Scenic River

High water quality/exceptional aquatic life/high aesthetic value: diverse benthic macroinvertebrate community (J. Davis, 1998, pers. comm.)

Threatened or endangered species/unique communities: Occurrence of species or habitat insufficient to merit designation.

Terlingua Creek - From the confluence with the Rio Grande two miles south of Terlingua Abaja in Brewster County upstream to the FM 170 crossing in Brewster County

Riparian conservation area: Big Bend National Park

High water quality/exceptional aquatic life/high aesthetic value: ecoregion stream (Linam et al., 1999); exceptional aesthetic value (NPS, 1995)

Threatened or endangered species/unique communities: proserpine shiner (SOC/St.T) (Linam et al., 1999)

CHAPTER 9

WATER INFRASTRUCTURE FUNDING

9.1 INTRODUCTION

Between November 7 and November 30, 2005, 3 wholesale water providers, representing 10 water user groups, were surveyed by the Rio Grande Council of Governments on behalf of the Far West Texas Water Planning Group (FWTWPG). These entities have a projected water supply deficit and recommended strategies to meet that need in the *Far West Texas Water Plan (2006)*. Entities responding to individual surveys included the El Paso Water Utilities, Horizon Regional MUD and the El Paso County Tornillo WID. These entities were surveyed to determine their proposed method(s) for financing the estimated capital costs involved in implementing the water supply strategies recommended in the regional plan. Entities and water user groups with zero-capital-cost strategies were not surveyed.

Of the 3 entities surveyed, all submitted responses. In addition, the FWTWPG provided input on proposed methods of financing infrastructure needs for 4 county aggregate water user groups including El Paso County Other, El Paso County Irrigation, Hudspeth County Irrigation, and Presidio County Irrigation. The Water Planning Group also provided input on the policy statement required in TWC §16.053(q)2 that answers the question "What is the proper role(s) of the State in financing water supply projects identified in the approved regional water plans?"

Summary of Survey Results

Of the 3 entities with needs that were surveyed, only Horizon Regional MUD indicated that it could pay the entire $1,000,000 cost of its strategy of drilling additional wells. The capital costs will be met through a bond issue, which has already been approved. El Paso Water Utilities indicated that it plans to pay for 25% ($168,798,000) of its expected total of $675,192,000 in capital improvements through the use of cash reserves. And additional 72% ($486,138,240) will be financed through bond sales, with the final 3% ($20,255,760) expected to come from federal government programs. El Paso County Tornillo WID projects that it can afford to pay approximately 30% ($150,000) of its expected cost of $500,000 for drilling one additional well. It will apply to the state Office of Rural and Community Affairs (ORCA) for the additional $350,000 in projected infrastructure costs. These three political subdivisions indicated that they could afford to pay a total of $656,116,240 of their strategy costs using cash reserves or by issuing bonds. Of the three, only El Paso County Tornillo WID intends to access state financial programs, preferably grants, or low-interest loans if grants are not available.

El Paso County-Other is also expected to incur capital costs totaling $12,166,000 to finance additional wells to meet the supply deficit projected in the regional plan. However, much of this cost will be borne by the private sector, as it mainly pertains to the cost of installation of private wells on private land. An estimated 20% of the County-Other supply deficit will be supplied by private wells, financed by individual homeowners, at a total capital cost of $5,416,000. Within County-Other, 80% of the year 2060 water supply deficit will be supplied by small municipal utility districts (MUDs) and non-profit water supply corporations (WSCs), at a total capital cost of $6,750,000. Most, if not all, of these MUDs and WSCs are expected to access state as well as federal funding sources, primarily grants and low-interest loans. Several of these small entities were surveyed individually during the first planning cycle, and indicated that they would be unable to pay for any of the projected capital costs from cash reserves or system revenues.

In total, regional political subdivisions indicated that they will be unable to pay for approximately $27.4 million in projected water infrastructure costs.

9.2 THE INFRASTRUCTURE FINANCING SURVEY

The survey administered by the Rio Grande Council of Governments asked for a response to two questions required by the Texas Water Development Board. The surveys listed the recommended strategy, its implementation date, and the capital cost to be paid by the political subdivision. Following this basic data, the water user group or wholesale water provider was asked: 1) whether it planned to implement the recommended strategy; and if it answered yes to question 1, then 2) how it plans to finance the proposed total cost of the capital improvements, and the proposed percentage share of the total cost to be met by each of 6 potential funding sources. The FWTWPG did not add any additional, region-specific questions to the survey during this planning cycle. A copy of the survey is included in Appendix 9A. Additional input on County-Other and county aggregate strategies (irrigation) was received from the FWTWPG.

Political subdivisions of the state whose water supply strategies were noted in the regional plan as having zero capital costs were not surveyed. In the Far West Texas Water Planning Region, the communities of San Elizario, Socorro and Vinton, the supply entities of Homestead MUD and the Lower Valley Water District, and the county aggregate water user groups of El Paso County Manufacturing and Steam Electric Power Generation, have identified needs in the adopted regional water plan. However, the water management strategies recommended to meet those needs do not include capital costs. The recommended strategy for all of these entities is to purchase water from a wholesale water provider: either directly from El Paso Water Utilities, or from the Lower Valley Water District, which in turn purchases water from El Paso Water Utilities. Therefore, these communities and water user groups were not surveyed. Where a water user group with needs and strategies to meet those needs have multiple water management strategies, some of which have capital costs and others that have no capital costs, those water user groups were only surveyed for the strategies with a capital cost.

Surveys were either mailed first class through the U.S. Postal Service, or sent via e-mail on November 7, 2005, with a stated due date of November 28, 2005. Entities who had not responded to the survey by one week prior to the due date were contacted by phone or e-mail, and urged to submit their completed surveys. All of the surveys were completed and returned by December 6, 2005. The TWDB's suggested survey response reporting matrix is included as Appendix 9B. Copies of the completed and returned questionnaires are included in Appendix 9C.

The FWTWPG was asked to provide input on financing options for aggregate water user groups at a meeting of the group on November 17, 2005. Discussion was based on the recommendations for the aggregate water user groups developed for the 2001 infrastructure financing report. Additional suggestions were received from Planning Group members following posting of the draft of this report on the water planning group's web page in early December 2005.

At the November 17, 2005 FWTWPG meeting, members were also asked to develop a policy statement on the role of the State in financing water supply projects. Planning group members had considered the role of the state in funding various activities associated with the planning process, as well as funding necessary infrastructure improvements, when they developed the recommendations contained in Chapter 8 of the regional plan. Members were asked for their suggestions on specific, existing, or innovative methods for raising the funds necessary to pay the costs of the water supply strategies identified in the approved regional water plan. The policy statement is discussed separately below.

9.3 SUMMARY OF RESPONSES TO THE SURVEY

County Aggregate Strategies: El Paso, Hudspeth and Presidio County Irrigation

County aggregate water supply strategies generally apply to either entities such as irrigation districts or to individual private landowners. Three county aggregate irrigation water user groups in the planning region were projected to face a water supply deficit for which the recommended strategy includes a capital cost. Strategies to meet those needs were developed by an irrigation subcommittee of the water planning group, working from the Water Conservation Best Management Practices Guide (TWDB Report 362). Best Management Practices (BMPs) which were considered suitable for application to Far West Texas irrigation practices were selected and endorsed by the entire planning group.

While the cost considerations for each of these strategies are discussed in more detail in Chapter 4, Table 4-5 of the regional plan, it was not possible to develop total capital costs for their implementation. Implementation of these BMPs will be the responsibility of both the irrigation districts and individual landowners, and both will shoulder the burden of the costs for their implementation. Where irrigation districts are responsible, they have indicated that they could finance part of the cost through district fees and taxes. However, these financing strategies are not believed to be adequate to cover the entire cost of the recommended capital improvements. While the TWDB does have agricultural water conservation grant and loan programs available to political subdivisions of the state including irrigation districts, funding for these programs has been extremely limited. If funding is available, the irrigation districts have indicated that they would consider utilizing these state funding sources. The strategies pertaining to private entities or individual landowners would be privately financed by the affected private entity or private landowner.

El Paso County-Other Strategy

The County-Other strategy of drilling additional wells applies to individual landowners as well as to non-profit WSCs and small MUDs. Private landowners will pay the cost of domestic wells necessary in areas not served by community infrastructure. While it is estimated that only 20% of the County-Other water supply deficit in 2060 will be met by private domestic wells, the cost of those wells will amount to 45% of the total strategy cost. Small MUDs and WSCs are expected to cover 80% of the 2060 deficit, at 55% of the cost. These smaller public water suppliers have indicated that they will be able to pay very little, if any, of the cost of the additional wells needed to meet increased demand. They could not afford to pay the cost of their recommended water supply strategy without state or federal assistance, specifically grant assistance. The programs specified included Texas Office of Rural Community Affairs (ORCA) Community Development Block Grants (CDBG), and U.S. Department of Agriculture Rural Utilities Service (USDA RUS) grants. Frequent comments indicated that "any available" state grant assistance program would be accessed. Input from the water planning group corroborated these comments. Where state or federal grant funds are not available, state and federal loan assistance programs would be used, including the State Revolving Fund, Rural Water Assistance Fund and Economically Depressed Areas Program (EDAP) if appropriate. Where NADBank was mentioned as a possible funding source, it was considered to be the "lender of last resort" because of the length of the process and the difficulty in navigating the program's requirements.

Municipal Supply Strategies for Individual Political Subdivisions

In El Paso County, three entities were surveyed to determine the proposed method(s) of financing their recommended water management strategies. Of those political subdivisions surveyed, all responded: the El Paso Water Utilities, Horizon Regional MUD, and El Paso County Tornillo WID. El Paso Water Utilities indicated that it can pay 25% of the cost of their recommended strategies using cash reserves, an additional 72% of the cost by issuing bonds, and will look to federal government programs for the remaining 3% of the infrastructure costs.

Horizon Regional MUD can pay for 100% of the cost of their recommended strategy of drilling additional wells through the proceeds from bond sales. The bond issue has already been approved.

El Paso County Tornillo WID indicated that it could afford to pay approximately 30% of their strategy cost for drilling an additional well using cash reserves. The WID indicated that it would need to access state government programs, specifically naming ORCA programs, to finance the remaining 70% of their anticipated infrastructure costs.

9.4 PROPOSED ROLE OF THE STATE IN FINANCING WATER INFRASTRUCTURE COSTS

It is clear from the survey results that there will be a significant need to access both state and federal funding sources to pay for the cost of water infrastructure identified in the *2006 Far West Texas Water Plan.* Regional political subdivisions indicated that they will be unable to pay for approximately $27.4 million in projected water infrastructure costs. These figures do not include the costs associated with El Paso County Irrigation, Hudspeth County Irrigation, and Presidio County Irrigation. Where the costs of the recommended best management practice strategies will be the responsibility of irrigation districts, those districts have indicated that they would access state programs such as the water conservation fund, if such funding is available.

Increased demands on state and federal funding sources will heighten competition for limited available funds. Having started the regional planning process in motion, the state will need to identify the means to greatly expand its role in financing the needed water supply infrastructure. Without an expansion of state assistance programs, especially those programs focused on the needs of rural and agricultural communities, the needs identified in the regional planning process will not be addressed. For many of the communities surveyed, data indicate that they believe it simply will not be possible to pass the costs of necessary infrastructure onto their utility customers. For most of the smaller, rural communities, the customer base is too small and/or too poor to bear that burden alone.

Several of the smaller political subdivisions surveyed or represented on the water planning group indicated that they can not afford to pay any portion of their projected infrastructure costs using cash reserves or current utility revenue sources. For all of these entities, grant funding is the preferred option, whether those grants are from state or federal sources. Most of the entities seeking grants are small, rural communities with limited revenue sources, serving economically disadvantaged communities. For these entities, the first choice for state grant funding will probably be the Office of Rural Community Affairs' Community Development Fund or Colonia Fund. USDA Rural Utilities Service grants will also be an option. They will turn to loan funds only if grants are not available. State loan programs, which may be accessed, include the TWDB's Rural Water Assistance Fund, the Economically Distressed Areas Program (EDAP), and the State Revolving Fund. Federal lending sources include USDA Rural Utilities Service loan programs, and the North American Development Bank (NADBank). Most borrowers only turn to NADBank as a matter of last resort; however, because of the high administrative burden and the length of time it takes for project completion under the program. Small, rural, and disadvantaged communities will require access to low interest loan programs and grant funding, and funds for these resources need to be increased to match the expected demand.

The State Participation Program will probably be accessed by very few water suppliers in the region, predominantly those in El Paso County. For most of the Far West Texas Water Planning Region, the State Participation Program is simply unsuitable, because the distance between communities makes regionalization impractical. While the economies of scale that can be realized by regional systems is acknowledged, such regional systems require a density of population that only occurs within the planning region in El Paso County. The other six counties in the planning region are sparsely settled rural areas, characterized by small, widely separated communities. Within El Paso County, however, there are opportunities for regionalization in water supply infrastructure that would make the most cost-effective use of the limited funds available.

The increased role of the state in funding water infrastructure projects identified in the *2006 Far West Texas Water Plan* will require dedicated funding sources to support both grant and loan programs. The FWTWPG recommends that the following dedicated funding sources be considered to enhance the state's ability to assist local governments in implementing the recommended strategies to meet projected future water supply needs:

(a) general revenue;
(b) statewide bond issue;
(c) percentage of Texas Lottery proceeds;
(d) percentage of the fines imposed and collected from water-related violations of state environmental law;
(e) a bottled water fee; and
(f) expanded tax exemption for water conservation fixtures and equipment.

The Planning Group also considered other potential financing options, which it did not endorse. These include a per capita tax and a statewide sales tax on water and wastewater services. Both of these approaches were considered to be regressive taxes, which would place an unfair financial burden on economically disadvantaged residents.

The Planning Group recommends that more effort be made on the state level to attract federal money for needed water infrastructure projects, suggesting that the TWDB take a lead role in this effort. The group commented that less funding is being made available from federal sources at the same time that there are more regulations and duties being imposed on water suppliers, such as the new arsenic standards. They also recommend that efforts should be made by TWDB staff to assist smaller entities in identifying all available funding sources and putting together a “package” of complementary programs to cover the cost of needed infrastructure improvements. TWDB and other state agency programs that can be used to fund water infrastructure should be combined, their procedures simplified or streamlined, and their rules made more flexible. Many of the small communities that need to access state funds have limited staff for project proposals and management, and often feel lost in a maze of confusing program-specific rules and regulations.

APPENDIX 9A

WATER INFRASTRUCTURE FINANCING SURVEY

SAMPLE SURVEY TO OBTAIN INFRASTRUCTURE FINANCING INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

(Information to be completed before survey is sent)

Regional Water Planning Group ______________________________

Political Subdivision (WUG or WWP) __________________________

Recommended Project/Strategy	***Implementation Date***	***Capital Cost to be paid by Political Subdivision***	***ID# from DBO7***
TOTAL COST OF CAPITAL IMPROVEMENTS		$	

(Information to be provided by the Political Subdivision)

Are you planning to implement the recommended projects/strategies?

__YES ____NO

If 'no,' describe how you will meet your future water needs.

____

____

If 'yes', how do you plan to finance the proposed total cost of capital improvements identified by your Regional Water Planning Group?

Please indicate:

1) Funding source(s)[1] by checking the corresponding box(es) and

2) Percent share of the total cost to be met by each funding source.

☐ %__________ Cash Reserves
☐ %__________ Bonds
☐ %__________ Bank Loans
☐ %__________ Federal Government Programs
☐ %__________ State Government Programs
☐ %__________ Other____________________
% _________ TOTAL – (Sum should equal 100%)

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.

____

____

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

____________________	____________________	____________________
Name	Title	Phone

APPENDIX 9B

INFRASTRUCTURE FINANCING REPORT SURVEY
RESPONSE TRACKING MATRIX

APPENDIX 9B

INFRASTRUCTURE FINANCING REPORT SURVEY RESPONSE TRACKING MATRIX

RWPG	**Name of Political Subdivision**	**Recommended Project/Strategy**	**Implementa-tion Date**	**Capital Cost to be paid by Political Subdivision)**	**ID # from DB07**	**Planning on Implementing the recommended Strategy? (Y/N)**
E	City of El Paso	IWMS - Reuse	2010	$ 45,842,000	E-1	Y
E	City of El Paso	IWMS - Additional surface water	2020	$ 103,494,000	E-3	Y
E	City of El Paso	IWMS - Import from Diablo Farms	2040	$ 23,113,000	E-4	Y
E	City of El Paso	IWMS - Import from Dell Valley	2030	$ 502,743,000	E-5	Y
E	Horizon Regional MUD	2 New wells	2050	$ 1,000,000	E-7	Y
E	EP County Tornillo WID	1 new well	2040	$ 500,000	E-11	Y
				$ 676,692,000		

APPENDIX 9C

COPIES OF COMPLETED INFRASTRUCTURE FINANCING REPORT SURVEYS

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING
INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Far West Texas WPG
Political Subdivision (WUG or WWP): El Paso Water Utilities – PSB

Recommended Project/Strategy	*Implementa-tion Date*	*Capital Cost to be paid by Political Subdivision*	*ID# from DBO7*
IWMS – Reuse	2010	$ 45,842,000	E-1
IWMS - Additional surface water	2020	$ 103,494,000	E-3
IWMS – Import from Diablo Farms	2040	$ 23,113,000	E-4
IWMS – Import from Dell Valley	2030	$ 502,743,000	E-5
TOTAL COST OF CAPITAL IMPROVEMENTS		$ 675,192,000	

(Information to be provided by the Political Subdivision)
Are you planning to implement the recommended projects/strategies?
x YES NO

If 'no,' describe how you will meet your future water needs.
____
____

If 'yes', how do you plan to finance the proposed total cost of capital improvements identified by your Regional Water Planning Group?

Please indicate:
1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

%__25_____ Cash Reserves
%__72_____ Bonds
%_________ Bank Loans
%___3_____ Federal Government Programs
%_________ State Government Programs
%_________ Other________________
%_________ TOTAL – (Sum should equal 100%)

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.
____
____

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

Marcela Navarrete	Chief Finance Officer	915-594-5614
Name	Title	Phone

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING
INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Far West Texas WPG
Political Subdivision (WUG or WWP): Horizon Regional MUD

Recommended Project/Strategy	*Implementation Date*	*Capital Cost to be paid by Political Subdivision*	*ID# from DBO7*
2 additional wells	2050	$ 1,000,000	E-7
TOTAL COST OF CAPITAL IMPROVEMENTS		$ 1,000,000	

(Information to be provided by the Political Subdivision)
Are you planning to implement the recommended projects/strategies?
☒ ***YES*** ☐ ***NO***

If 'no,' describe how you will meet your future water needs.

If 'yes', how do you plan to finance the proposed total cost of capital improvements identified by your Regional Water Planning Group?

Please indicate:
1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

%______ Cash Reserves
% 100 Bonds
%______ Bank Loans
%______ Federal Government Programs
%______ State Government Programs
%______ Other______
% 100 *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.

N/A

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

[signature] G.M. 915-852-3917
Name Title Phone

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING
INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Far West Texas WPG

Political Subdivision (WUG or WWP):El Paso County Tornillo WID

Recommended Project/Strategy	*Implementation Date*	*Capital Cost to be paid by Political Subdivision*	*ID# from DBO7*
1 additional well	2040	$ 500,000	E-11
TOTAL COST OF CAPITAL IMPROVEMENTS		$ 500,000	

(Information to be provided by the Political Subdivision)

Are you planning to implement the recommended projects/strategies?
√ ***YES*** ☐ ***NO***

If 'no,' describe how you will meet your future water needs.

___

___

If 'yes', how do you plan to finance the proposed <u>total cost of capital improvements</u> identified by your Regional Water Planning Group?

Please indicate:
1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

- %__30__ Cash Reserves
- %____ Bonds
- %____ Bank Loans
- %____ Federal Government Programs
- %__70__ State Government Programs
- %____ Other____
- %__100__ *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.
ORCA

___

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

Name	Title	Phone
[illegible]	Business Manager	764-2966

CHAPTER 10

PUBLIC PARTICIPATION

AND

PLAN ADOPTION

10.1 INTRODUCTION

The Far West Texas Water Planning Group (FWTWPG) members recognized from the beginning the importance of involving the public in the planning process. Chapter 10, the final chapter of the plan, contains an overview of the Water Planning Group representation, the Group's commitment to public involvement, and specific activities that insured that the public was informed and involved in the planning process and the implementation of the plan.

10.2 REGIONAL WATER PLANNING GROUP

The TWDB appointed an initial coordinating body for Far West Texas, based on names submitted by the public for consideration. The Water Planning Group then expanded its membership based on familiarity with 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 water planning group: agriculture, counties, electric generating utilities, environment, industries, municipalities, river authorities, public, small business, water districts, and water utilities. Because there is no river authority in Far West Texas, this sector is not represented. In addition to these required interest groups, the FWTWPG added the following: travel and tourism, groundwater conservation districts, building and real estate, economic development, and other. The members of the FWTWPG have not been compensated for their participation in the planning process and have voluntarily devoted considerable amounts of their time to develop the regional water plan. Current committee members and their alternates are listed in the following table:

FAR WEST TEXAS WATER PLANNING GROUP

Water Use Category	Committee Member	County	Alternate Member	County
Agriculture	Tom Beard	Brewster	Rick Tate	Jeff Davis
Building/ Real Estate	David Etzold	El Paso	Ray Adauto	El Paso
Counties	Teresa Todd	Presidio	Val Beard	Brewster
Counties	Charles Stegall	Terrell	Ken Norris	Terrell
Counties	Jesse Acosta	El Paso	Dolores Briones	El Paso
Economic Development	Paige Waggoner	El Paso	Sylvia Firth	El Paso
Environment	Carl Lieb	El Paso		
Electric Generating Utilities	Jim Tom Voorhies	El Paso, Hudspeth, Culberson	Luis Ito	El Paso, Hudspeth, Culberson
Groundwater Conservation Districts	Randy Barker	Hudspeth	Talley Davis	Hudspeth
Groundwater Conservation Districts	Albert Miller	Jeff Davis	John Jones	Culberson
Industries	Howard Goldberg	El Paso	Jorge Uribe	El Paso
Municipalities	Becky Brewster	Culberson	Okey Lucas	Culberson
Municipalities	Ed Archuleta	El Paso	Bill Hutchison	El Paso
Municipalities	Ed Drusina	El Paso	Ray Caballero	El Paso
Other	Jerry Agan	Presidio	Pete Gallego	Brewster
Other	Loretta Akers	El Paso	Eliot Shapleigh	El Paso
Public	Elza Cushing	El Paso	Dave Hall	El Paso
Public	Teodora Trujillo	El Paso	Jose Escobedo	El Paso
Small Business	Ralph Meriwether	Brewster	Robert Stovell	Brewster
Travel/Tourism	Mike Davidson	Brewster	Tom Williams	Brewster
Water Districts	Jim Ed Miller	Hudspeth	Bill Skov	El Paso
Water Districts	Chuy Reyes	El Paso	Johnny Stubbs	El Paso
Water Utilities	Janet Adams	Jeff Davis	Casey Adams	Jeff Davis

In addition to the FWTWPG members, 13 non-voting members were appointed. Their function is to provide advice and guidance, based on their respective areas of expertise or geographic areas. Two non-voting liaisons were assigned from regions adjacent to Far West Texas (Region F and Region J). The non-voting members and their alternates are listed in the following table:

Non-Voting Member	**Agency/Organization**	**Alternate Member**	**Agency**
Raymond Bader	TCE		
Filiberto Cortez	USBR	Woody Jenkins	USBR
Robert Flores	TWDB		
Mary Helen Follingstad	NMISC		
Jeff Frank	GLO		
Ron Glover	Hunt NR, Ltd.		
Otila Gonzalez	Region J		
Mike Hobson	TPWD	Bobby Farquhar	TPWD
Ari Michelsen	TAMU Ag. Exp. Stn.	Zhuping Sheng	TAMU Ag. Exp. Stn.
Adriana Resendez	CILA Mexico	Aldo Garcia	CILA Mexico
Caroline Runge	Region F		
Jack Stallings	TDA		
Jim Stefanov	USGS		

10.3 PROJECT MANAGEMENT

During the first planning cycle, work on the *Far West Texas Water Plan* was divided along two parallel tracks; (1) an urban track representing the metropolitan portion of El Paso County, and (2) a rural track representing the other six rural counties and the eastern portion of El Paso County. Work developed along the two-track approach was integrated at appropriate intervals to ensure a unified, coherent regional plan. During the current planning cycle, this approach was abandoned, and the entire FWTWPG worked together on the regional plan from start to finish.

The planning decisions and recommendations made in the *Far West Texas Water Plan* will have far-reaching and long-lasting social, economic, and political repercussions on each community involved in this planning effort and on individuals throughout the Region. Therefore, involvement of the public was projected to be a key factor for the success and acceptance of the plan. Open discussion and citizen input was encouraged throughout the planning process and helped planners develop a plan that reflects community values and concerns. Some members of the public participated almost as non-voting members.

To insure public involvement, notice of all Planning Group and subcommittee meetings was posted in advance, mailed to a list of over 200 interested parties including mayors, county judges, water rights holders, public school superintendents, water districts, and concerned citizens, e-mailed to an additional 350 interested parties, and all meetings were held in publicly accessible locations with sites rotating among rural and urban locations throughout the counties in the region. Special public meetings were held to gather input on the development of the scope of work for the plan. Prior to submittal of the initially prepared plan to the TWDB, a copy of the *draft Far West Texas Water Plan* was provided for inspection in the county clerk's office and in at least one library in each county. Following public inspection of the initially prepared plan, two public meetings were conducted to present results of the planning process and gather public input and comments.

To provide a public access point, an internet web site (http://24.153.185.92/rio/rgcog/EnvSvcs/FWTWPG.htm) was developed that contains timely information that includes names of planning group members, bylaws, meeting schedules, agendas, minutes, meeting backup materials, and important documents, including groundwater conservation district management plans, technical reports, draft chapters for review, planning schedules and budgets, and links to water-related sites. Summaries of most of the planning group meetings were e-mailed to the full list of interested parties within 3 - 5 days of the meeting, to enable persons who were unable to attend to stay up to date on the planning process. Every document that was e-mailed or mailed to planning group members for their review was also e-mailed to the interested parties list, made available on the

FWTWPG website, and provided in hard copy at all public meetings. In addition, news stories concerning water planning-related issues were regularly distributed to all interested parties.

10.4 PRE-PLANNING MEETINGS

Prior to the development of a scope of work, two public meetings were conducted to identify a common long-range vision for the development of a regional water plan. The first regional public hearing was held in Marfa on January 10, 2002, with a second following in El Paso on February 7, 2002. The intent of the hearings was to explain the planning process, introduce the planning group members, and receive comments and recommendations regarding the proposed Scope of Work.

10.5 PUBLIC PRESENTATIONS AND FIELD TRIPS

Several presentations and four field trips were provided specifically to increase the awareness of the planning process and to engage public input where possible. Participation in these activities by both planning group members and the public served to broaden their knowledge of both regional issues and local conditions in a geographically diverse planning region.

- Public SOW meeting – Marfa, January 10, 2002
- Public SOW meeting – El Paso, February 7, 2002
- Field Trip – Dell Valley, October 25, 2001
- Field Trip – Ft. Quitman, October 31, 2002
- Field Trip – Presidio/Rio Conchos, April 17, 2003
- Field Trip – EPWU-PSB Jonathan Rogers WTP, September 18, 2003

10.6 PLANNING GROUP MEETINGS AND PUBLIC HEARINGS

All meetings of the FWTWPG, including committee meetings, were open to the public and visitors were encouraged to express their opinions and concerns, or to make suggestions regarding the planning process. The locations of the meetings were originally rotated between all seven counties so that all citizens within the region would have an equal opportunity to attend. The only county in the planning region that did not have an opportunity to host a planning group meeting during the current planning cycle was Terrell. Meetings were held in various locations in El Paso, as well as in Alpine, Marfa, Presidio, Ft. Hancock, Dell City, Van Horn, and at the McDonald Observatory and Guadalupe Mountains National Park. However, because of increased public attendance, the meetings were held predominantly in Alpine and El Paso, where adequate facilities could be arranged.

In accordance with the State Open Meetings Act, meeting notices were posted in the following newspapers and were reported by the following television and radio stations:

- El Paso Times
- El Paso Inc.
- West Texas County Courier
- Hudspeth County Herald
- Van Horn Advocate
- Alpine Observer
- Desert-Mountain Times
- Jeff Davis County News/Mountain Dispatch
- Presidio International
- Big Bend Sentinel
- Terrell County News Leader
- KALP FM (Alpine)
- KVLF AM (Alpine)

Two final public hearings were held to receive comments on the initially prepared plan, one in El Paso on July 14, 2005, and the other in Alpine on July 21, 2005. Responses to all comments (including TWDB, public hearing, and written) are provided in a separate document.

Copies of the plan were available by June 6, 2005 at the following locations:

- County Clerk's Office:
  Brewster County
  Culberson County
  El Paso County
  Hudspeth County
  Jeff Davis County
  Presidio County
  Terrell County
- Public libraries:
  Alpine Public Library, 203 N. 7th St., Alpine
  Van Horn City-County Library, 410 Crockett St., Van Horn
  El Paso Public Library, 501 N. Oregon, El Paso
  El Paso Public Library, Lower Valley Branch, 7915 San Jose, El Paso
  Grace/Grebing Public School, 110 N. Main, Dell City
  Ft. Hancock/Hudspeth County Public Library, 100 School Drive, Ft. Hancock
  Jeff Davis County Library, 3 Woodward, Ft. Davis
  Marfa Public Library, 115 E. Oak, Marfa
  City of Presidio Library, O'Reilly St., Presidio
  Terrell County Public Library, Courthouse Square, Sanderson
  U.S. Post Office, Terlingua

10.7 COORDINATION WITH OTHER REGIONS

The FWTWPG has exchanged liaisons with adjoining Region F and the Plateau Region (Region J). The responsibility of the liaisons is to report on any issues of common interest between adjoining regions. The Water Planning Group also coordinated with the Plateau Region (J) and the Rio Grande Region (M) in encouraging funding for projects aimed at the eradication and long-term suppression of salt cedar and other nuisance phreatophytes in the Rio Grande watershed.

10.8 PLAN IMPLEMENTATION

Following final adoption of the *Far West Texas 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, each city will be asked to review the Plan and to recommend needed improvements. Each community will also be asked to consider their specific short-range and long-range goals with those presented in the Plan. Based on the results of this input, the FWTWPG members may consider plan amendments prior to the conclusion of the next planning period.

FAR WEST TEXAS WATER PLAN

January 2006

Prepared by

Far West Texas Water Planning Group

Prepared for

Texas Water Development Board

CHAPTER 10 APPENDICES
RESPONSES TO COMMENTS

LBG-GUYTON ASSOCIATES

TABLE OF CONTENTS

APPENDIX 10A

RESPONSES TO TWDB COMMENTS

APPENDIX 10A

RESPONSES TO TWDB COMMENTS

LEVEL 1. Comments and questions must be satisfactorily addressed in order to meet statutory, agency rule, and/or contract requirements.

1. An Executive Summary documenting key findings and recommendations of the planning group is required. None is provided. *[Title 31, Texas Administrative Code (TAC) §357.10(a)(2)]* The Texas Water Development Board (TWDB) reserves the right to make additional comments for appropriate consideration and responses. Before providing the missing unit, please review its particular requirements and limitations and follow any appropriate guidelines contained in Exhibit "B" of the contract between the TWDB and the Rio Grande Council of Governments (the contractor).

Response: Executive summary is provided in the final plan.

2. Provide a summary of recommendations in the current (2002) State Water Plan for this area. *[Title 31, TAC §357.7(a)(1)(J)]*

Response: Summary added in Section 1.6.1.

3. Please provide information on the plan's impact to navigation. *[Title 31, TAC §357.5(e)(8)]*

Response: Statement added in Section 1.2.

4. Dissolved entities and name changes need to be reflected in the plan. Table 2-1 (page 2-7) and Table 2-2 (page 2-15) need to reflect changes in El Paso's retail water supplier situation to avoid confusion when applying projections. For example, it is presumed Horizon Regional Municipal Utility District replaces both Horizon City and the dissolved El Paso County Water Authority. *[Contract Exhibit "B," Sections 4.1 and 4.2]*

Response: Merged entities are explained in footnotes of Tables 2-1 and 2-2.

5. TWDB approved population and demand projections must be used. *[Title 31, TAC §357.5(d)(1) and (2)]* The following, listed by population or category of use and water user group, are not using approved numbers:

- Population for the City of El Paso and Horizon Regional Municipal Utility District.

TWDB APPROVED POPULATION	P2010	P2020	P2030	P2040	P2050	P2060
EL PASO	127,395	139,821	150,600	160,080	170,300	181,455
EL PASO COUNTY WCID – WESTWAY	601	877	1,119	1,322	1,536	1,750
EL PASO WCID #4	1,583	2,124	2,587	2,992	3,389	3,813
HORIZON CITY	1,457	2,155	2,786	3,306	3,846	4,387
EL PASO COUNTY WA	2,136	3,372	4,438	5,378	6,319	7,259
Subtotal	**133,172**	**148,349**	**161,530**	**173,078**	**185,390**	**198,664**

PLANNING GROUP POPULATION PROJECTIONS						
EL PASO	127,996	140,698	151,719	161,402	171,836	183,205
EL PASO WCID #4	1,583	2,124	2,587	2,992	3,389	3,813
HORIZON REGIONAL MUD	3,593	5,527	7,224	8,684	10,165	11,646
Subtotal	**133,172**	**148,349**	**161,530**	**173,078**	**185,390**	**198,664**

- Municipal demand for the City of El Paso and Horizon Regional Municipal Utility District.

TWDB APPROVED WATER DEMAND

Water User Group Name	2000	P2010	P2020	P2030	P2040	P2050	P2060
EL PASO	563,662	631,837	709,228	777,152	835,734	894,316	952,898
EL PASO COUNTY WCID – WESTWAY	3,196	5,644	8,423	10,862	12,965	15,068	17,171
EL PASO WCID #4	8,343	12,507	17,234	21,383	24,961	28,539	32,117
EL PASO COUNTY WA	6,633	13,817	21,973	29,131	35,304	41,477	47,650
HORIZON CITY	5,233	9,360	14,045	18,157	21,703	25,249	28,795
Subtotal	**587,067**	**673,165**	**770,903**	**856,685**	**930,667**	**1,004,649**	**1,078,631**

PLANNING GROUP WATER DEMAND PROJECTIONS

Water User Group Name	2000	P2010	P2020	P2030	P2040	P2050	P2060
EL PASO	566,858	637,481	717,651	788,014	848,699	909,384	970,069
EL PASO WCID #4	8,343	12,507	17,234	21,383	24,961	28,539	32,117
HORIZON REGIONAL MUD	11,866	23,177	36,018	47,288	57,007	66,726	76,445
Subtotal	**587,067**	**673,165**	**770,903**	**856,685**	**930,667**	**1,004,649**	**1,078,631**

- Irrigation demand in Jeff Davis and Presidio Counties as reflected in IPP Section 2.3.3, page 2-26. Below are the TWDB approved numbers.

County	Water User Group	2010	2020	2030	2040	2050	2060
TWDB - JEFF DAVIS	IRRIGATION	576	572	569	566	563	559
TWDB - PRESIDIO	IRRIGATION	20,068	19,670	19,279	18,896	18,521	18,154
IPP - JEFF DAVIS	IRRIGATION	3,119	3,057	2,995	2,935	2,875	2,816
IPP - PRESIDIO	IRRIGATION	25,156	24,646	24,145	23,655	23,175	22,705

- Livestock demand for Jeff Davis County as reflected in IPP Section 2.3.5, page 2-28. Below are the TWDB approved numbers.

COUNTY	Water User Group	2010	2020	2030	2040	2050	2060
TWDB -JEFF DAVIS	LIVESTOCK	508	508	508	508	508	508
IPP – JEFF DAVIS	LIVESTOCK	547	547	547	547	547	547

Response: **Population and water demand values are reversed in the above TWDB comment tables. Population and municipal demand values in Tables 2-1 and 2-2 incorporate entity changes discussed in comment #4 and are correct as reported in the IPP.**

Corrections are made to Table 2-2 to reflect TWDB approved irrigation and livestock demands. A Table 2-3 has been added to the plan to reflect demands the Regional Planning Group considers to be more accurate estimates of projections for irrigation and livestock in Jeff Davis County and irrigation in Presidio County.

6. Document all water supply sources and their availability using established guidelines and quantify them by county and river basin. *[Contract, Exhibit "B," Section 3.1 and 3.2]* Groundwater availability for many aquifers listed in Table 3-1, "Water Supply Source Availability" do not match TWDB approved estimates as follows:

Aquifer	Capitan Reef Complex	Edwards-Trinity Plateau	Hueco-Mesilla Bolson	Igneous	West Texas Bolsons
TWDB Availability Value	25,050	2,655	151,000	9,600	62,325
IPP Availability Value	25,000	1,650	136,000	8,100	61,325

Response: **The process of estimating groundwater source availability is described in Section 3.4. Methods used to estimate availability follow Exhibit B guidelines. The Planning Group considers the availability estimates reported in Table 3-1 to be appropriate, and do not know the origin of the TWDB amounts shown in the comment table. It is also not understood what is meant by "TWDB <u>approved</u> estimates".**

7. Identify and quantify water resources by county and river basin. *[Contract Exhibit "B," Section 3.1.1]*

Response: **Table 3-1 quantifies water sources by county. All of the planning area is within the Rio Grande Basin, which is now stated in the table.**

8. Identify both contractual and non-contractual demand obligations for each entity supplied by a wholesale water provider. *[Contract, Exhibit "B," Section 5.2.1]*

Response: **Table 2-4 is added to show demand obligations by wholesale water provider.**

9. Wholesale water provider information must be reported by category of use, by county, and by river basin. *[Title 31, TAC §357.7(a)(3)(B)]*

Response: **Wholesale water provider information by use category, county and basin is provided in Table 2-4. All wholesale water providers are in El Paso County and the Rio Grande Basin.**

10. TWDB's electronic database of wholesale water providers must be completed in accordance with established guidelines. *[Contract, Exhibit "B," Section 5.3]* Both IPP Sections 1.4.4 (page 1-33) and 3 (page 3-2) list five providers for the planning area; however, the database only lists four. Clarify the discrepancy or correct any error.

Response: TWDB's DB07 database has been corrected to show five providers.

11. Describe the process used to identify potentially feasible water management strategies approved by the planning group. *[Title 31, TAC §§357.5(e)(4)]*

Response: General process is explained in Sections 4.3 and the Integrated Strategy for EPWU is explained in Section 4.4.

12. Quantitatively report the *quantity, reliability, and cost* of water delivered and treated in the development and equitable comparison of all management strategies. *[Title 31, TAC §357.7(a)(8)(A)(i)]* Please address the following:

- TWDB received a separate, electronic document titled *Integrated Water Management Strategies for the City and County of El Paso.* Include these analyses for all six potentially feasible integrated strategies, along with their components, in the plan.

Response: Planning Group prefers for the comparison to remain in the attached report.

- IPP Section 4.3 and the *Integrated Water Management Strategies for the City and County of El Paso*, must present an assessment of the strategy's overall reliability as well as the reliability of individual components.

Response: Reliability assessment is documented in Table 4-2 and is discussed in Section 4.4.11.

13. Strategies must be presented in sufficient detail to allow agencies to make financial or regulatory decisions. *[Title 31, TAC §357.7(a)(9) and §358.3(b)(17)]* Detailed requirements (including time periods, interest rates, power costs and other supporting costs) are discussed in the contract. *[Contract Exhibit "B," Sections 1.2.5 and 4.2.9]* The IPP should present:

- Decadal construction periods (particularly for the *Integrated Water Management Strategies for the City and County of El Paso*).

Response: Detailed cost estimates and decadal construction is provided in Table 4-3 and in the appendices of the *Integrated Water Management Strategies for the City and County of El Paso* report.

- A description of the Automation and Telemetry (Section 4.4.16), and Regulatory Reservoirs (Section 4.4.17) strategies must be provided as they are recommended in the plan.

Response: Automation - Telemetry and Regulating Reservoir strategy descriptions have been added as Sections 4.6.16 and 4.6.17.

14. The conservation component of the Integrated Water Management Strategies for the City and County of El Paso must discuss conservation practices and drought measures at a water user group level. *[Title 31, TAC §357.7(a)(7)(A) & (B) and Contract Exhibit "B," Section 4.2.7a]*

Response: A detailed explanation of conservation is presented in a separate report entitled *Integrated Water Management strategies for the City and County of El Paso*. The portions of this report that explain the savings amount by water user groups, the total savings, and the main conservation activities are incorporated in Section 4.4.

15. Not all comparisons have the same level of analysis. *[Title 31, TAC §357.5(e)(4) and §357.7(a)(8)(E)]* IPP Section 4.4, beginning on page 4-21, recommends irrigation strategies based solely on TWDB's Report 362, Water Conservation Best Management Practices Guide. Evaluate or quantify water savings and costs and apply them to the appropriate water user group.

Response: Quantity savings and costs of the irrigation strategies are provided in Table 4-5.

16. Quantitatively report the integrated strategy's impact on environmental factors, including effects on environmental water needs, wildlife habitat, and cultural resources. *[Title 31, TAC §357.7(a)(8)(A)(ii)]* Broad statements of the types of impacts are currently provided, yet the integrated strategy involves pipeline construction, reduced streamflow, conjunctive use and groundwater drawdown.

Response: Strategy impacts on environmental factors are presented in Table 4-4.

17. Consolidate and list the planning group's water conservation and drought recommendations. *[Title 31, TAC §357.7(a)(11)]* The chapter currently restates Texas Commission on Environmental Quality's rules and plans, and describes existing plans. There is nothing region specific.

Response: Consolidated recommendations are presented in Section 6.1.

18. A model water conservation plan is required for each user group to which Texas Water Code §11.1271, dealing with water right permits applies. Please include plans for *both municipal and agricultural (irrigation)* users. *[Title 31, TAC §357.7(a)(7)(A)(i)]*

Response: A link to TCEQ conservation and drought contingency model plans is provided in Chapter 6. Appendices 6A, 6B and 6C contain the required conservation plans.

19. Provide discussion of how the plan is consistent with the long-term protection of the state's water, agricultural, and natural resources. *[Title 31, TAC §358.3(b) and Contract Exhibit "B," Section 1.1.7]*

Response: Chapter 7 now contains the protection discussion.

20. A complete stream segment package must accompany recommended unique river or stream segments. *[Title 31, TAC §358.3(b)(12) and Contract Exhibit "B," Section 1.1.8]* IPP Section 8.3 and Appendices 8B, 8C, and 8D must include descriptions characterizing physical qualities and cultural resources, maps and photos, and supporting literature and data.

Response: Available information has been provided in the appropriate Chapter 8 appendices.

21. Include an assessment of the impacts of the plan on the proposed unique stream segments. *[Title 31, TAC §357.8(c)]*

Response: Impacts of the plan on unique stream segments is discussed in Section 8.4.

22. The contractor must correctly populate the required database fields. *[Contract Exhibit "B," Sections 3.1, 3.2, 4 and 5]* Consequently the TWDB reserves the right to issue additional comments that must be addressed once that particular task is finished. As previously noted, additional review time could result in a delay in TWDB consideration of the plan for approval.

Response: The TWDB DB07 database will be fully populated.

LEVEL 2. Comments and suggestions that might be considered to clarify or help enhance the plan.

23. The public may benefit by providing a matrix table summarizing all potential and recommended water management strategies, perhaps cross indexed by water use category.

Response: Strategy summary discussion but no matrix table is provided in the Executive Summary.

24. The public may benefit from a summary table covering supply sources, availability, and yields in one location.

Response: Supply source summary discussion but no table is provided in the Executive Summary.

25. IPP Section 1.3.1 (page 1-9) claims Ciudad Juarez's population is 1.5 million while Section 1.8.1 (page 1-63) says it is 1.3 million. Please reconcile the population for Ciudad Juarez.

Response: Statement is corrected in Section 1.3.1.

26. Consider modifying Figure 1-13 to distinguish historically significant springs from others.

Response: No change made. Virtually all springs in the desert environment of Far West Texas can be considered historically significant.

27. The first paragraph on page 53 states this is the first state water plan to incorporate regional water planning. That is not accurate. Please correct the statement to reflect the current (2002) State Water Plan's efforts.

Response: Statement is clarified in Section 1.6.1.

28. Table 2-2, titled "Far West Texas Water Demand Projections," might indicate the unit of measurement (acre-feet) in the mainframe instead of an unlinked footnote.

Response: Correction is made in Table 2-2.

29. Reconcile conservation and reclaimed water availability numbers presented in Table 4-2 (page 4-11) and in Figure 4-2 (and correspond with the *Integrated Water Management Strategies for the City and County of El Paso*).

Response: Availability numbers have been reconciled.

30. Section 4.3.7 and Table 4-4 present the costs associated with the recommended integrated strategy for El Paso. It may be helpful to present the costs for all six of the integrated strategies considered in this summary.

Response: The Planning Group prefers to leave the cost of all six strategies in the stand-alone report.

31. In the same Table 4-4, consider expanding it to show the unit cost of water to a user on a per acre-foot and per thousand gallons basis.

Response: Table 4-4 Is expanded to show unit cost per acre-foot but not for 1,000 gallons.

32. Appendix 6A contains confusing references to time periods of three and five days while discussing capacity and drought triggers. Often, one number is spelled out and its accompanying numeric (in parenthesis) is a different value. Consider correcting these conflicts for consistency.

Response: Appendix 6A provides entity plans in their original form. The Planning Group chooses not to alter the looks of an entity's written plan.

33. Consider completing the "Plan Section" of Appendix 7A, titled "Plan Consistency Cross Reference," by cross-referencing rule or contract obligations with their occurrence in the plan.

Response: Appendix 7A has been removed from the plan. Sections 7.2, 7.3, and 7.4 fulfill the requirement previously intended to be met by the Appendix table.

34. Consider expanding the appendices. Many have "sub" appendices that are stand-alone documents. This is confusing and some are hard to locate.

Response: Appendices are listed in the Table of Contents where appropriate and are reconfigured where practical in the text.

35. Regarding the "Table of Contents," consider:

- Most chapters are identified using the term "Introduction" rather than a title reflecting their content. Exhibit "B," Section 1.1, may be useful in determining chapter titles.

Response: Table of Contents numbering system is altered to identify chapter titles.

- Appendices are identified at the end of the Table of Contents though actually occurring at the end of each chapter. Consider merging the list with the rest of the Table of Contents.

Response: Appendices are moved to the end of appropriate chapters in the Table of Contents.

APPENDIX 10B

RESPONSES TO ORAL

PUBLIC HEARING COMMENTS

APPENDIX 10B

RESPONSES TO ORAL PUBLIC HEARING COMMENTS

EL PASO, TEXAS - JULY14, 2005

<u>Marvin Roth, Turner Ranch</u>

Mr. Roth asked if El Paso had a shortage of water and if El Paso was in need of water. He then asked from how far east did they anticipate importing water. Mr. Roth stated that last year the FWTWPG was in the process of negotiating with Dell City groups. Mr. Roth asked if El Paso was in the market for water or not. Mr. Roth stated that Turner Ranch could provide 22,500 acre feet of pure water on the El Paso-Hudspeth County line, but cannot seem to get a response.

Response: **It was suggested to Mr. Roth that this discussion be directed to the El Paso Water Utilities. The current regional water plan recommends an Integrated Water Management Strategy to obtain the water needed. This strategy includes increasing conjunctive use of surface and groundwater in El Paso County by 20,000 acre-feet per year, importing 50,000 acre-feet per year from Dell City area, and importing 10,000 acre-feet per year from Capitan Reef. The proposed strategy is in the very preliminary planning stages. Please keep participating in the planning process as this strategy unfolds.**

No data or previous feasibility studies were available to the Planning Group or the Region E consultants about Turner Ranch at the time of elaborating the regional water plan. Mr. Roth is welcome to provide technical data to the Planning Group for consideration in future versions of the plan.

No changes will be made to the initial report based on these comments.

<u>Hector Aguilar, Dell City Water Rights Holder</u>

Mr. Aguilar stated that he was seeking advice on making the best use of his land. Again he stated that he is seeking concrete advice on what he should do. Mr. Aguilar expressed his interest in working together and doing what's best for everyone.

Response: **The Planning Group appreciates your participation in and support of the regional water planning process. The proposed strategy of acquiring water from Dell City to serve El Paso County is in the very preliminary planning stages. Please keep participating in the planning process as this strategy unfolds.**

No changes will be made to the initial report based on these comments.

ALPINE, TEXAS - JULY 21, 2005

<u>Beverly English Evans</u>

Ms. English Evans asked if car washes were considered a municipal use. She also asked
if it was addressed in the plan under conservation.

Response: **Car wash use is not broken out separately in the plan, but is considered as a part of the total water use of each municipal entity.**

<u>Jeff Bennett, Big Bend National Park</u>

Mr. Bennett asked if environment could be included as a demand category.

Response: **Environment is not a separate water use category in the current planning process. However, environmental water needs, environmental water flows, and environmental impacts are evaluated within the plan.**

<u>Dr. Kevin Urbanczyk, Sul Ross State University</u>

Dr. Urbanczyk pointed out a possible typographical error in the discussion on the igneous aquifer in Chapter 3, where the text refers to the old map, with a graphic of the new map. He then asked if the map in the plan illustrates the new delineation.

Response: **Text is revised to reflect new aquifer boundary.**

Dr. Urbanczyk mentioned the concept of converting irrigation water rights in El Paso to municipal and asked who exactly would be paying for this.

Response: **EPWU will be paying for the conversion through acquisition of land, leases, or forbearance agreements.**

Dr. Urbanczyk asked if the WPG was in communication with Mexico and if there was an international focus in the planning efforts to encourage conservation in Mexico.

Response: **Although the Far West Texas Plan does not specifically address planning issues of Mexican water-use categories, it does recognize the impact that Mexican water use may have on water sources used on the United States side of the border.**

Dr. Urbanczyk asked if the Igneous Bolson GAM was incorporated or used in the WPG decision-making and the possibility of suggesting targeted areas to improve resolution in certain areas. He also asked what the scientific community could do to improve the models for better data control.

Response: **The Igneous/Salt Bolson GAM was used to evaluate source availability. The GAM was also used to evaluate potential impacts of withdrawals based on an IWMS scenario that was not chosen by the planning group.**

APPENDIX 10C

RESPONSES TO WRITTEN

PUBLIC HEARING COMMENTS

APPENDIX 10C

RESPONSES TO WRITTEN PUBLIC HEARING COMMENTS

Letter to Tom Beard, Chairman, Far West Texas Water Planning Group from Myron Hess (National Wildlife Federation), Mary Kelly (Environmental Defense) and Ken Kramer (Sierra Club, Lone Star Chapter)

The **Executive Summary and Chapter 7** are not complete in the IPP version dated June 1, 2005. We request that a mechanism be established to accept comments on these sections once they are finalized in draft form. Both of these plan components are critically important to the plan and should be afforded the same opportunity for public review and comment.

Maximize Water Efficiency
We strongly believe that improved efficiency in the use of water must be pursued to the maximum extent reasonable. Damaging and expensive new supply sources simply should not be considered unless, and until, all reasonable efforts to improve efficiency have been exhausted. Consistent with TWDB's rules for water planning, we consider water conservation measures that improve efficiency to be separate and distinct from reuse projects. We do agree reuse projects merit consideration. However, the implications of those projects are significantly different than for water efficiency measures and must be evaluated separately

Section 16.053(h)(7)(B) prohibits TWDB from approving any regional plan that doesn't include water conservation and drought management measures at least as stringent as those required pursuant to Sections 11.1271 and 11.1272 of the Water Code. In other words, the regional plan must incorporate at least the amount of water savings that are mandated by other law. In addition, the Board's guidelines require the consideration of more stringent conservation and drought management measures for all other water user groups with water needs. Consistent with the TWDB rules, our comments treat water conservation and drought management as separate issues from reuse.

We acknowledge the City and County of El Paso for their past and present efforts to incorporate both reuse and conservation efforts in their water management efforts. However, the initially prepared plan seems to be lacking the required information about future conservation and reuse efforts for those entities or other water user groups. Without that information, it is not possible to comment in any detail about those aspects of the plan.

Limit Nonessential Use during Drought
Senate Bill 2 and TWDB rules mandate consideration and inclusion in regional plans of reasonable levels of drought management as water management strategies. It just makes sense to limit some nonessential uses of water during times of serious shortage instead of

spending vast sums of money to develop new supply sources simply to meeting those nonessential demands. Because drought management measures are not included as water management strategies, the initially prepared plan does not comply with applicable requirements.

Plan to Ensure Environmental Flows

New rules applicable to this round of planning require a quantitative analysis of environmental impacts of water management strategies in order to ensure a more careful consideration of those additional impacts. However, if existing water rights, when fully used, would cause serious disruption of environmental flows resulting in harm to natural resources, merely minimizing additional harm from new strategies would not produce a water plan that is consistent with long-term protection of natural resources or that would protect the economic activities that rely on those natural resources.

Accordingly, environmental flows should be recognized as a water demand and plans should seek to provide reasonable levels of environmental flows. Environmental flows provide critical economic and ecological services that must be maintained to ensure consistency with long-term protection of water resources and natural resources.

We comment (sic) the group for the strong acknowledgement of the importance of those flows to the region and the policy recommendation for a codification of instream flows.

Manage Groundwater Sustainably (sic)

Wherever possible, groundwater resources should be managed on a sustainable basis.
We commend the planning group for it recognition of the value of sustainable management of groundwater. We encourage the planning group to adopt a clear definition of "sustainable management" and of the concept of "near sustainable management" that is proposed for some aquifers.

Facilitate Short-Term Transfers

Senate Bill 1 directs consideration of voluntary and emergency transfers of water as a key mechanism for meeting water demands. Those approaches seem to have received little attention in the planning process to date. There is a clear legislative directive that the regional planning process must include strong consideration of mechanisms for facilitating voluntary transfers of existing water rights within the region, particularly on a short-term basis as a way to meet drought demands.

Emergency transfers are intended as a way to address serious water shortages for municipal purposes. They are a way to address short-term problems without the expense and natural resource damage associated with development of new water supplies. Water Code Section 16.053 (e)(5)(I), as added by S.B. 1, specifically directs that emergency transfers of water, pursuant to Section 11.139 of the Water Code, are to be considered, including by providing information on the portion of each nonmunicipal water right that could be transferred without causing undue damage to the holder of the water right. Thus, the water planning process is intended as a mechanism to facilitate voluntary transfers, particularly as a means to address drought situations, by colleting specific information on rights that might be transferred on such a basis and by encouraging a dialogue between willing sellers and willing buyers on that approach.

Without a detailed description of how the proposed integrated strategy of El Paso County will be implemented, it is impossible to tell if this recommendation to facilitate short-term transfers is heeded by Region E.

Response: **The final Plan incorporates significantly more detail, particularly in terms of strategy analysis. The Far West Texas Water Planning Group acknowledges the comments and concerns as stated above and will continue to refine the manner in which these issues are addressed.**

Executive Summary

In many cases, the executive summary is the only portion of the water plan that the public will read. For this reason, it is important that it be available for public comment prior to the finalization of the plan.

Response: **An Executive Summary is included in the final Plan.**

Chapter 1, Section 1.2.1

Page 1-2. It would be helpful to have definitions for the terms "sustainable groundwater management" and "near sustainable groundwater management."

Response: **These terms differ from one water source to another. Therefore, it is difficult to provide a single definition that can include all sources equitably.**

Chapter 1, Section 1.3

Page 1-9. This section is missing a description of the region's native vegetation, ecology and agricultural and natural resources. It is important to include these topics in the description portion of the plan, in addition to outline any potential threats these resources may experience in relation to water quantity and/or quality problems. It is also important for the plan to include a reasonably detailed discussion of the various types of habitats present in the region (i.e. spring-fed aquatic and terrestrial, riparian, etc.), and the individual species dependent on them. This information is needed to assess long-term impacts on natural resources and to perform a meaningful quantitative evaluation of potentially feasible water management strategies.

Response: Descriptions occur in Chapter 1 Sections 1.3.6, 1.3.7, 1.3.8, and 1.5.3. Habitat descriptions are available in Major Springs descriptions in Appendix 1B and in the Ecologically Unique Stream Segments in Chapter 8 Appendices 8B through 8H.

Chapter 1, Section 1.5.3
Page 1-47. The inclusion of Figure 1-13 is helpful for an overall perspective on the prevalence of springs in the region. It would also be helpful to include descriptions and estimations of their general nature, i.e. relative flow rates, associated aquatic and wildlife habitats, etc. We acknowledge that this level of information if probably not know for each spring shown on Figure 1-13, but a generalized overview of the range of these qualities for the springs identified would still be useful. This is especially important for use in evaluating the proposed water management strategies for impact on springflow in the region and for assessing potential threats to water resources and natural resources.

Response: The 19 "Major Springs" described in Section 1.5.3 and Appendix 1B range in size from very small to large, and their characteristics are similar to all springs in the Region.

Chapter 1, Section 1.4.6
Page 1-36. We commend the group for including this section on environmental and recreational water needs in the discussion of regional water demands. This information provides a valuable perspective on the importance of maintaining environmental flows to the region's environment, economy, and populace.

Response: Thank you.

Chapter 2, Section 2.3
Page 2-13, last paragraph; page 2-21, second paragraph. The plan needs to state what rate of plumbing fixture replacement was chosen. The discussion notes that the expected savings as a result of the installation of water-efficient devices in compliance with the state plumbing code are included in municipal demand projections. We request that information about the assumed savings from those fixtures, in the form of per capita reductions in water use, be included in the plan. We believe that is valuable information to help the public understand those savings. The inclusion of information about per capita water use rates also would be helpful in identifying potential for additional water efficiency savings.

Response: The amount of savings resulting from the state plumbing code for El Paso County is provided in Chapter 4 Table 4-6.

Chapter 2, Section 2.3.4
This demand appears to be potentially overstated. Water demand for steam electric power generation is projected to increase 353% during the planning period. By contrast, water demand for municipal use is projected to increase only about 80% to support a 116%

increase in population. Water demand for manufacturing water use in only projected to increase about 66%. Given the likelihood that municipal and manufacturing activities are the categories that would drive demand for electrical power, some additional explanation is needed for what seems to be a very disproportionate increase in projected water demand for steam-electric power generation.

We recognize that these projections come from the Board. The planning group may not be able to change them, but it could provide further explanation for this seemingly anomalous projected growth in water demand. We also note that the TWDB projects, as we understand them, include a projected .5% increase per year in per capita energy demand. Given advances in energy efficiency and escalating fuel prices, we question the reasonableness of the assumption of such continued escalation in per person use of electricity.

Response: The Far West Texas Water Planning Group accepted the steam electric power generation demand number provided by the TWDB with the understanding that this number was not necessarily representative of this particular entity in El Paso County, but rather that it is based on a statewide trend. It is also understood that not all the power is used locally, but is supplied to a grid.

Chapter 2, Section 2.4
Page 2-31. This section gives a good overview of the environmental and recreational water needs of the region. We acknowledge and commend the planning group's recognition of the importance of this issue.

Response: Thank you.

Chapter 3, Section 3.0
Page 3-1, last bullet. The plan states that the availability of groundwater is based on "acceptable levels of water level decline." These decline levels should be discussed in the water availability write-up as they may affect future availability of both surface and groundwater resources in the region.

Response: The Far West Texas Water Planning Group considers "acceptable levels" to mean groundwater levels that would allow the aquifer to continue to be used in an economically reasonable manner and that would not have a significant impact on surface water or spring flows.

Chapter 3, Table 3-1, Page 3-3. It would be helpful if the planning group provided some explanation of how the indicated availability amounts were determined for each of the listed aquifers. We were not able to find specific information about the determinations here or in Section 3.3.

Response: **A more detailed documentation of availability analysis will be performed in the next planning session.**

Chapter 3, Section 3.1

Page 3-11, second paragraph, last line. The plan states that "from Presidio downstream through the Big Bend Region, the Rio Grande generally contains sufficient flow to support recreational use at almost any time of the year." It is important to qualify this statement because while it is generally true, the flows often vary seasonally, and recreational use such as rafting suffers if there is low runoff and a reduction in irrigation return flows upstream. This is especially important to note given the June 2003 incident were (sic) the river dried up through parts of Big Bend National Park.

Response: **This statement is revised in the third paragraph of Section 3.2.**

Chapter 4, Table 4-2.

Page 4-11. As shown in Table 4-1, savings from conservation and reuse are calculated and incorporated prior to the assessment of project needs. Both are actual water management strategies and should be subject to the same level of discussion and evaluation as the proposed integrated strategy. If this level of information is included under separate cover, we request that the pertinent information be incorporated into this section of the plan.

Response: **Chapter 4 has been significantly revised. A separate report (*Integrated Water Management Strategies for the City and County of El Paso*) provides backup material for this chapter.**

The conservation program information included in Appendix 6A for the City of El Paso is an overview of conservation efforts from 1990 to date. As a result, there isn't a description of the actual conservation measures that will be relied upon to achieve the projected conservation savings. In addition, it isn't clear which water user groups would implement water conservation strategies. Information also is needed on how the proposed increase in use of reclaimed water will be achieved over the planning period. See Section 357.7 (a)(7)(C).

Response: **The City of El Paso will continue the current conservation efforts described in Chapters 4 and 6. Reuse build out is described in Chapter 4.**

Drought Management Measures

As required by 357.7(a)(7)(B) of TWDB's rules, drought management is a water management strategy that must be evaluated. That provision, along with Section 16.053 (h)(7)(B) also requires that drought management be included as a water management strategy for each entity required to prepare a drought management plan pursuant to Section 11.1272 of the Water Code. Although the planning group may decide, provided it documents the basis for that decision, not to include drought manageme4nt as a water management strategy beyond those measures specifically required by Section 11.1272, it must include at least the

Section 11.1272 level of drought management as a water management strategy. The initially prepared plan does not comply with that requirement. For each entity required to prepare a drought contingency plan pursuant to Section 11.1272, the water plan must include a water management strategy reflecting the drought period savings from that drought plan.

Response: Required water conservation plans for three entities are discussed in Section 6.1 and are provided in Appendices 6A, 6B and 6C.

Section 4.3.3
Page 4-14. Please clarify in this section the source aquifer for the groundwater in the Dell City area.

Response: Aquifer name is provided in the revised Del City Section 4.4.6.

Section 4.3.1
Page 4-14, first paragraph. Please define "nearly sustainable" as used in the text. The definition could be included here or in Section 1.2.1.

Response: The term has been changed to "sustainable" in the last paragraph of Section 4.4.4.

Section 4.3.4
Page 4-16. TWDB rules require a quantitative evaluation of the environmental factors including effects on environmental water needs, wildlife habitat, cultural resources, and effect of upstream development on bays, estuaries, and arms of the Gulf of Mexico. This section should include a discussion of the potential impacts from withdrawing and/or transferring water from the Capitan Reef aquifer and the Dell City area to El Paso County including any potential impacts to springflow in the region.

Response: Environmental factors are quantified in Table 4-4 and in discussions of individual strategies.

Chapter 5
Consideration of impacts of water management strategies on water quality is a key issue, especially in west Texas. In particular, we believe discussion is needed about the potential impacts on water quality from the discharge of effluent resulting from the various groundwater sources proposed for use by El Paso County. Similarly, if desalination is likely, some discussion is needed about the disposal of concentrate water from the desalination process and potential water quality and other impacts associated with that disposal.

Response: **Water quality impacts are now provided in Chapter 4 and in Section 5.6 of Chapter 5. Desalination concentrate disposal in El Paso County has undergone stringent analysis and has met TCEQ/EPA permit requirements for non-degradation of USDWs. Desalination concentrate disposal of other groundwater sources (Dell Valley) will also have to meet the same stringent guidelines; see Section 4.4.7.**

Section 5.3
Page 5-15. Please include an overview of the water quality of reuse water.

Response: **Reuse quality characteristics are not included in this plan, but will be considered in the next planning period.**

Section 5.5
Page 5-25. Please explain if the removal of groundwater from the Dell Valley area will impact the water quality of the remaining groundwater in storage.

Response: **Aquifer water quality may improve or stabilize as irrigation return flows are reduced.**

Section 5.5
Page 5-25. Please explain if the removal of groundwater from the Capitan Reef aquifer will impact the water quality of the remaining groundwater in storage.

Response: **Capitan Reef aquifer water quality impact is discussed in Section 4.4.5.**

Section 5.5
Page 5-25. Please explain how the reallocation of surface waters from agricultural use to municipal use may affect the water quality of the Rio Grande, i.e. due to a reduction in agricultural return flows to the river and surrounding alluvium, etc.

Response: **Section 5.6 states that there is no anticipated change in quality; however, it will take a more detailed water balance evaluation to fully analyze the quality question.**

Section 5.6
Page 5-17. Please address the potential impact that moving groundwater from rural agricultural areas may have on local soils and groundcover, through loss of soil moisture content and erosion.

Response: **This issue is not addressed in this Plan, but will be considered during the next planning period.**

Chapter 6, Section 6.4
Page 6-11. As drafted, the purpose of this section is unclear. The text doesn't appear to contain any actual water conservation recommendations. In fact, the overall initially prepared plans seems to be lacking in discussion of water conservation strategies for the various water user groups identified in Table 4-1 as having water needs. As noted above, there isn't sufficient information provided about the anticipated savings through water conservation to identify which water user groups would be implementing the conservation practices. TWDB rules require that water conservation strategies be <u>considered</u> for each water user group with an identified need for water and that water conservations recommendations be <u>included</u> for user groups required, pursuant to Section 11.272 of the Water Code, to have water conservation plans.

Response: Water conservation as a strategy is discussed in Chapter 4. Chapter 6 has been reformatted and regional water conservation recommendations are discussed in Section 6.1.1.

Section 6.5
Page 6-13. Please include the website address for these sample forms. We assume that the "Word Perfect"/"PDF" references were originally hyperlinks to the forms.
The documents included here appear to be water conservation plan forms rather than model conservation plans. We believe that a model plan must include examples of the water conservation measures the planning group considers to be appropriate. For example, the model plan should reflect the best features of the various example plans included in Appendix 6A.

Response: Web sites have been fixed. TWDB instructions for model plans were not clearly stated and, therefore, reference was made to state-provided models.

Section 6.6
Page 6-15. Please include the website address for these sample plans. We assume that the "Word Perfect"/"PDF" references were originally hyperlinks to the forms.

Response: Web sites have been fixed.

Appendix 6A
It appears that most of the example plans included here have not been updated to include the specific, quantified targets for water savings currently required pursuant to Sections 11.1271(c) and 11.1272 of the Water Code and TCEQ rules. If updated plans are available, we would encourage the inclusion of those updated versions.

Response: Chapter 6 has been revised to only include plans of the three required entities.

Chapter 7
It is impossible to review this chapter in its incomplete form. Given that this chapter is critically important for the protection of natural resources in the region, we request that a mechanism be established to accept comments on this chapter once a completed draft is available.

As you know, the Texas Legislature, in recognition of the key importance of this information, specifically provided that TWDB may not approve a regional water plan absent an affirmative finding that the plan is consistent with long-term protection of the state's water resources.

Response: Chapter 7 has been totally rewritten to conform to TWDB requirements.

Chapter 8
We commend the planning group for the recommendation of three segments for designation as Ecologically Unique. We would encourage the group to provide some discussion on why only segments within state and federal lands were recommended. This could help to avoid any potential false impression that those are the only segments in the region that have special characteristics deserving of protection.

Response: Basis for not selecting stream segments on private properties is discussed in Section 8.4. Stream segments within Texas Nature Conservancy Preserve properties were added to the list.

<u>Letter to Tom Beard, Chairman of the Far West Texas Water Planning Group from Bruce E. Puckett for Rio Nuevo, Ltd. (Sept.23,2005)</u>

Letter advises that additional information requested by the Far West Texas Water Planning Group in a letter dated March 17, 2005 has been included in a report, entitled *Business Plan for Assessment of Groundwater Resources, Permanent School Fund Lands, Far West Texas*, submitted to the General Land Office. The General Land Office plans to forward a copy of the report to the Water Planning Group. The Business Plan provides a more thorough description of Rio Nuevo's plan than has been previously available.

Response: **As of the final edit of this Plan, the Far West Texas Water Planning Group has not received a copy of the above-mentioned report and, therefore, no further action is being taken on this issue during this planning period. Further, although the Planning Group tried, unsuccessfully, to get a copy of the "Business Plan" from Rio Nuevo and from the Texas General Land Office, the Chairman and at least one other member of the Planning Group were able to examine a copy. The copy reveals that insufficient detail continues to prohibit including the so-called proposal as a strategy. With no proposed end-user, no defined source of water, no quantified amount of water, and no delineated delivery system, Rio Nuevo's proposal cannot be included.**

APPENDIX 10D

RESPONSES TO PARKS AND WILDLIFE COMMENTS

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RESPONSES TO PARKS AND WILDLIFE COMMENTS

Letter to Tom Beard, Chairman, Far West Texas Regional Water Planning Group from Larry D. McKinney, Ph.D., Director of Coastal Fisheries, Texas Parks and Wildlife Department

Chapter 1.3.2 of the Far West Texas Region IPP briefly describes the Physiography of the region. Environmental and recreational water needs are discussed in Chapters 1.46 and 2.4 and major springs occurring on state or federally managed lands are described in Chapter 1.53 and Appendix 1A. Threatened and endangered species are discussed only for ecologically significant stream segments in Appendix 8G. Environmental impacts associated with the El Paso County integrated strategy are briefly addressed in Chapter 4.3.4 but the IPP does not include a quantitative reporting of environmental factors for other strategies. TPWD concurs with the statement made on page 2-32 "The Far West Texas Regional Water Planning Group recognizes the importance of supply adequate environmental and recreational water fairly to all users, and the goal of better quantifying those needs in the next planning cycle."

Response: A listing of rare, threatened, and endangered species in all counties of the Region is provided in Appendix 1A of the final Plan. Environmental impacts have also been provided for all strategies in Chapter 4.

Threats to natural resources are briefly discussed in various sections of the report. However Section 7.3 "Natural Resources" is blank in the draft plan. Even though Section 7.0 says that Appendix 7A is provided to "assist the reader in locating specific required inclusions", the column in that appendix showing where the materials can be found is also blank.

Response: Section 7.4 (Protection of Natural Resources) is now complete.

The Far West Texas IPP relies heavily on conservation and reuse for meeting future water needs. The City of El Paso is to be commended for reducing its per capita consumption of water from 187 gallons per person per day in 1990 to 139 gallons per person per day in 2004. TPWD especially supports the Region's consideration of brush control/management as an additional means of conserving water if done in a manner that can also benefit wildlife habitat. The Forgotten River Segment Study discussed in Chapter 3.1.7 is a good example of this type of effort.

Response: Thank you.

TPWD is pleased to see that the plan recommends nomination of 6 stream segments within state or federally managed properties as ecologically unique. TPWD stands ready to provide any additional supporting information necessary to designate these segments as unique.

Response: Thank you.

The 2005 Far West Texas Region IPP recognizes that the region contains most of the federal public land in Texas and over half the land in the entire Texas State Park system and that "Providing sufficient water for recreation and habitat in West Texas is critical to the long-term economic health." TPWD certainly agrees with that statement. Staff also appreciates the fact that many of our earlier comments have been addressed in the plan. It would be beneficial if those areas of the plan that were lacking in the detail necessary to describe potential impacts and how to address them could be completed.

Response: Hopefully you will find that significantly more detail has been added in the final Plan.