Regional Water Plan – Panhandle Water Planning Area
VOLUME I

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Regional Water Plan
Panhandle Water Planning Area

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EXECUTIVE SUMMARY

In June 1997, Governor George W. Bush signed into law Senate Bill 1 (SB1), a comprehensive water planning and management bill enacted by the 75th Texas Legislature. With the passage of SB1, the Legislature put in place a "bottom up" water planning process designed to ensure that the water needs of all Texans are met as Texas enters the 21st Century. Individuals representing various interested groups served as members of Regional Water Planning Groups (RWPGs) to prepare regional water plans for their respective areas. These plans map out how to conserve water supplies, meet future water supply needs and respond to future droughts in the planning areas.

The Texas Water Development Board (TWDB) established 16 distinct planning areas that are directed by 16 different RWPGs. The Panhandle Water Planning Group (PWPG) was formed to develop a 50-year regional water plan for Region A, the Panhandle Water Planning Area (PWPA). The PWPA consists of a 21-county area of the Panhandle that includes: Armstrong, Carson, Childress, Collingsworth, Dallam, Donley, Gray, Hall, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Potter, Randall, Roberts, Sherman, and Wheeler Counties.

The Regional Water Plan was developed in accordance with the Regional Water Planning Guidelines set forth in the 31 Texas Administrative Code § 357.7 (a) (1). The project was divided into the following six tasks: Task 1, Description of the Region; Task 2, Current and Projected Population and Water Demand; Task 3, Evaluation of Adequacy of Current Water Supplies; Task 4, Comparison of Current Water Supplies to Demands; Task 5, Water Management Strategies; and Task 6, Regulatory, Administrative or Legislative Recommendations.

DESCRIPTION OF THE REGION

The current total population in the PWPA is estimated to be approximately 379,018 in 2000 and is projected to be 552,072 by year 2050. This represents an increase of 46 percent from 2000 to 2050. Essentially all the increase is in the larger communities, with a declining rural population projected. Counties with a projected population of 10,000 or greater in 2000 include Gray, Hutchinson, Moore, Potter, and Randall. These counties include the cities of Amarillo, Borger, Canyon, Dumas, and Pampa. The city of Amarillo is estimated to have a population of 177,644 in the year 2000, increasing to 286,692 by 2050, and accounts for much of the population increase, especially in northern Randall County.

The economy of the region may generally be divided into the following sectors: agriculture and agribusiness, oil and gas operations, wholesale and retail trade, various manufacturing, tourism, and institutional. Major water-using activities include irrigation, petroleum refining, agricultural production, food processing and kindred, chemical and allied products, and electric power generation.

The climate of the Panhandle is characterized by low and erratic precipitation, widely variable seasonal temperatures, moderately high wind speeds, and low humidity. Annual precipitation declines across the planning area from east to west. Precipitation ranges from a high of about 22 inches in the east to about 16 inches in the west.

The Major Water Providers identified and designated by the PWPG include the Canadian River Municipal Water Authority (CRMWA), Greenbelt Municipal and Industrial Water Authority (GMIWA), and the city of Amarillo. The CRMWA serves more than 450,000 urban residents and provides water in the PWPA to Borger, Pampa and Amarillo. The GMIWA is located in Donley County and provides water to local municipalities. The city of Amarillo currently services over 60,000 active water accounts with an average usage of 42 million gallons per day, 45% of which is from groundwater and 55% from surface water.

Water supplies in the PWPA include both surface and groundwater sources. In the PWPA there are two major aquifers, the Ogallala and Seymour, and four minor aquifers, the Blaine, Rita Blanca, Whitehorse, and Dockum, that serve as groundwater sources for the study area.

Groundwater

Parts or all of 18 counties in the PWPA study area are included in the following six groundwater districts:

- Collingsworth County Underground Water District,
- Dallam County Underground Water District,
- Hemphill County Underground Water District,
- High Plains Underground Water Conservation District,
- North Plains Groundwater District, and
- Panhandle Groundwater District.

The Ogallala is primary aquifer that supports the major irrigated agricultural production base, as well as municipal water needs in the PWPA. Water-table elevations approximately parallel the land surface and dip from the northwest to the southeast. The aquifer is recharged by precipitation and runoff that drains to lakes, rivers, and streams.

The Seymour is a major aquifer located in north central Texas and some Panhandle counties. This aquifer consists of isolated areas of alluvium that are erosional remnants of a larger area or areas.

The Dockum is a minor aquifer which underlies the Ogallala Aquifer and extends laterally into parts of West Texas and New Mexico. The primary water-bearing zone in the Dockum Group, commonly called the "Santa Rosa," consists of up to 700 feet of sand and conglomerate interbedded with layers of silt and shale. Aquifer permeability is typically low, and well yields normally do not exceed 300 gal/min.

The Rita Blanca is a minor aquifer which underlies the Ogallala Formation in western Dallam and Hartley counties in the northwest corner of the Texas Panhandle. The portion of the aquifer located in the PWPA makes up a small part of a large aquifer system that extends into Oklahoma, Colorado, and New Mexico.

The Blaine is a minor aquifer located in portions of Wheeler, Collingsworth, and Childress Counties of the RWPA and extends into western Oklahoma.

The Whitehorse is a Permian aquifer occurring in beds of shale, sand, gypsum, anhydrite, and dolomite. It is an important source of water in and near the outcrop area around Wheeler County.

Surface Water

The PWPA is located within portions of the Canadian River Basin and Red River Basin. These two river systems and associated impoundments provide surface water for municipal, agricultural, and industrial users in the area.

In 1996, only three percent of the total water use in the Canadian River Basin portion of the PWPA was from surface water sources. There are three major reservoirs in the Texas portion of the Basin: Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir. According to the TNRCC's 1996 State of Texas Water Quality Inventory, the principal water quality problems in the Canadian and Red River Basins are elevated dissolved solids, nutrients, and dissolved metals.

Important reservoirs in the Red River Basin include Greenbelt Reservoir, Bivens Lake, Baylor Lake and Lake Childress, Lake Tanglewood, Buffalo Lake and Lake McClellan. Surface water is used in a larger scale in the Red River Basin portion of the PWPA than in the Canadian River Basin.

Regional Water Uses

Water use in the PWPA may be divided into three major categories – municipal, industrial, and agricultural. Industrial water use includes mining, manufacturing, and power generation activities. Agricultural water use includes both irrigation and livestock watering.

The PWPA is among the largest water-consuming regions in the State with over 90 percent of water used in the region for agricultural purposes. Use of this water in the PWPA produces 35 percent of the wheat, 49 percent of the corn, and 14 percent of the grain sorghum, along with 33 percent of the cattle on feed, 74 percent of the swine, and 47 percent of the beef slaughter capacity in the state. In 1990, the region accounted for only 1.9 percent of the State's total population, but accounted for approximately 13 percent of the State's annual water use. Projections indicate that total water use in the region will increase approximately five percent during the planning period (PWPG, 1999).

Municipal water use is closely tied to population centers. The TWDB estimates that during 1990, the total municipal water use in the PWPA was 75,394 ac-ft. Potter and Randall Counties, comprised 61 percent of the total municipal water use in the PWPA.

Industrial water consumption reached approximately 46,207 ac-ft in 1997. Hutchinson, Potter and Moore counties are the largest industrial water consumers with a combined use of 36,370 ac-ft in 1997. This consumption represents 79 percent of the total industrial water use for the region.

Agricultural water use represents the most significant use of water within the PWPA. Productive activities include crop irrigation and livestock watering. Dallam, Hansford, Hartley, Moore, and Sherman counties, accounted for approximately 78 percent of the total irrigation water in PWPA in 1996.

Issues of concern for water supply in the PWPA include aquifer depletions due to pumping exceeding recharge; contamination of the resource; and drought related shortages. Another potential concern is the presence of endangered or threatened species in the PWPA. Restrictions for groundwater pumping and maintenance of stream flows may be implemented if an endangered or threatened species is found in the area. The recent Federal listing of the Arkansas River shiner as a threatened species has the potential to affect water resources projects in Hutchinson, Hemphill, Oldham, Potter and Roberts Counties.

Drought contingency plans are required to be developed by wholesale water suppliers, irrigation districts and retail water suppliers. Drought contingency plans prepared by various water providers in the planning area and submitted to the PWPG include the Canadian River Municipal Water Authority, Greenbelt Municipal and Industrial Water Authority, city of Gruver, city of Canyon, city of Borger, Pantex Water System, TCW Supply Inc., and Moortex Water Supply Corporation.

Federal regulations with a direct impact in the regional planning efforts include the Clean Water Act and the Safe Drinking Water Act. The Canadian River Compact is an interstate program that sets forth water allocation policies for Oklahoma, Texas and New Mexico. Under this program, Texas shall have free and unrestricted use of all water of the Canadian River in Texas, subject to water storage limitations. The Red River Compact is an interstate program that apportions water of the Red River and its tributaries between the states of Texas, Oklahoma, Arkansas and Louisiana.

State programs affecting the water planning in the region include: Surface Water Rights Regulations, the Texas Pollutant Discharge Elimination System (TPDES), and the Texas Clean Rivers Program. In 1997 the TWDB adopted the Water for Texas Plan. This comprehensive State water plan identifies current and prospective water uses, water supplies and water users, and identifies needed water-related management measures, facility needs and costs. The plan also offers recommendations to better manage the State's water resources through the year 2050. The Texas Natural Resource Conservation Commission (TNRCC) provides groundwater protection through different programs and offices including Water Resource Management, Waste Management, Compliance and Enforcement, Department of Licensing and Regulations and Groundwater Districts.

Local water supply studies and plans developed in the region include the CRMWA Regional Water Supply Study completed in 1993 and an evaluation of the City of Amarillo's water supply and distribution systems performed in 1996. In addition, groundwater districts have developed water management plans that detail each district's goals for managing groundwater withdrawal within its jurisdictional area.

CURRENT AND PROJECTED POPULATION AND WATER DEMANDS

This Regional Water Supply Plan documents historical and estimates of projected population and water demands of cities and counties in the PWPA, as well as the demands on designated major water providers. Prior to the development of these projections, the TWDB in coordination with the TNRCC and the Texas Parks Wildlife Department (TPWD) had prepared population and water demand projections for the Region.

Population Projections

The planning group developed revised population and water demand projections for the 50-year planning period of 2000 to 2050 based on new information made available to the PWPG. Revisions to projected water demands for municipal, agricultural, and industrial uses were developed based on available data provided by the TWDB and input by regional water users.

Recognizing the importance of a water plan that would meet the unique needs of the Panhandle Water Planning Area, the PWPG compiled a database containing municipal, industrial, and agricultural water demands for the region. Municipal and industrial demands were identified using a survey questionnaire that was distributed to 155 entities identified as stakeholders in the PWPA.

Total PWPA population is projected to increase from 379,018 in 2000 to 552,072 in 2050. The data indicate that a major portion of the projected increase occurs in larger communities, such as Amarillo, with lesser increases projected in rural populations.

Water use in the PWPA during 1996 totaled over 2 million ac-ft, or approximately 17 percent of the state total. Five counties in the PWPA, Dallam, Hansford, Hartley, Moore, and Sherman County, reported a combined water use of approximately 1.5 million acre-feet in 1996, representing approximately 74 percent of the total regional water use.

The revised total water demand projections for the 21-county region for 2000 is 1,718,402 ac-ft and steadily increases to 1,812,949 ac-ft for the year 2050. Dallam County has the highest projected annual demand of 394,935 acre-feet in 2000, increasing to 405,458 acre-feet by 2050. Counties with projected increases in demand during the planning period include Dallam, Gray, Hansford, Hartley, Hutchinson, Lipscomb, Moore, Potter, Ochiltree, Randall, and Sherman County.

Projections of municipal water demands are calculated based on estimated changes in populations for cities and rural areas and on estimates of per capita water use. Per capita water use is estimated to decrease for each decade of the planning period based on the assumption that conservation measures will be implemented and result in lower water use.

Revisions to previous TWDB projections for municipal water use were made for those cities and counties for which population projections were revised. The major portion of municipal water demand occurs in Potter and Randall Counties which, along with Carson and Moore County, are the only counties in the PWPA projected to have an increase in municipal water demand.

Most counties are estimated to observe decreases in municipal water use, due to anticipated conservation or decreasing populations. Total municipal water use for the PWPA is projected to increase from 84,814 ac-ft in 2000 to 105,268 ac-ft by 2050, primarily due to significant population growth in population centers such as Amarillo.

Industrial water demand projections were developed for manufacturing, steam power generation, and mining activities within PWPA. Total manufacturing water demand for the PWPA is projected to increase from 37,493 ac-ft in 2000 to 53,009 ac-ft by 2050.

Mining operations in the PWPA consist primarily of oil and gas extraction and removal of industrial minerals such as sand, gravel, and gypsum. It is estimated that mining water demand will decrease from 7,817 ac-ft in 2000 to 5,062 acre-feet by 2050. This decrease is driven primarily by projected decreases in mining activities for Carson, Gray, Hansford, and Moore Counties.

Projections for agricultural water demand were also developed for the 21 counties included in PWPA. Agricultural use is divided into crop irrigation and livestock water demand.

According to the TWDB (1998), water used for irrigation totaled 1,850,192 ac-ft in 1996. As part of the regional water planning process, representatives of commodity groups, producers, and underground water districts expressed concerns that TWDB projections for irrigation demand tended to over estimate irrigation water use.

The Texas Agricultural Experiment Station and Texas Agricultural Extension Service (TAES/TAEX) developed a model to estimate the amount of irrigation water pumped in a county during a given year. Projections of annual future water use were made using planted irrigated acreage (pia) and the long-term averages for rainfall and potential evapotranspiration (PET) by county. The crop mix and acreage was assumed to remain unchanged from what was reported in 1997. Where available, demonstration data and well depletion data were used to verify the model estimates.

The current annual projections are 15 percent less than previous TWDB values in 2000, but only 2 percent different by 2050. The revised regional projected irrigation water demand is approximately 1.5 million acre-feet per year. The irrigation water use projections should be re-evaluated as more data becomes available to accurately reflect changes in the farming community due to new technologies, economic considerations, or crop acreages.

Revised livestock water use projections were developed which include the most recent inventories of various livestock species for each county, estimates of annual industry growth rates, and regional species-level water use estimates. Livestock water use projections indicate a total water demand of 46,793 acre-feet in 2000, gradually increasing to reach 96,414 acre-feet in 2050.

EVALUATION OF ADEQUACY OF CURRENT WATER SUPPLIES

This regional water plan includes an evaluation of current groundwater and surface water supplies available to the Region for use during the drought of record. Evaluation of groundwater sources include the Ogallala, Seymour, Blaine, Dockum, Rita Blanca, and Whitehorse aquifers.

The volume of water available from the Ogallala aquifer was determined using a numerical model developed by the Bureau of Economic Geology (BEG). Available supplies of water from the remaining aquifers was determined using estimates of saturated thickness, specific yield, and recharge rates from historical studies and published reports. For some of the minor aquifers, this detailed information was not available. Therefore, maximum historical pumpage was used as the available supply. Table 1 includes the estimated annual available groundwater supply for aquifers within PWPA.

Table 1 Estimated available water supply in aquifers underlying PWPA

Aquifer	***Estimated Available Water Supply (ac-ft/year)***
Ogallala	129,120,000
Seymour	40,189
Blaine	94,782
Dockum	7,862
Rita Blanca	5,250
Whitehorse	566

The evaluation of surface water resources included an estimation of annual water availability from Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir. Water supply from these sources was determined using historical yield studies, estimated sedimentation, assessments of existing infrastructure and contractual provisions. The firm yield for Lake Meredith is 76,000 acre-feet per year. The firm yield of Palo Duro Reservoir is expected to decrease from 6,543 ac-ft in 2000 to 6,092 ac-ft by 2050. The firm yield of Greenbelt Reservoir expected to decrease from 7,699 ac-ft in 2000 to 6,942 ac-ft by 2050.

Information provided in the existing yield studies of Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir should be updated as new information and studies become available, specifically, the determination of critical periods, net evaporation rates, and sedimentation surveys. Changes in these parameters may significantly change the estimates of available surface water supply in the PWPA

Ten minor reservoirs in the PWPA have been identified as other potential sources of surface water. These include Lake McClellan, Buffalo Lake, Lake Tanglewood, Rita Blanca Lake, Lake Marvin, Lake Baylor, Lake Childress, Lake Fryer, Club Lake, and Bivens Lake. The historical or current supply of these water bodies has not been quantified through yield studies. In addition, there are regulatory constraints currently in place that do not permit the use of these surface water bodies for water supply.

COMPARISON OF CURRENT WATER SUPPLIES TO DEMANDS

A comparison of current water supply resources in the Panhandle Water Planning Area (PWPA) to the projected demands was performed. Results from this analysis indicate that available water supply in the PWPA exceeds the demands by nearly 380,000 acre-feet per year in the year 2000. Total regional water demand begins to surpass the available resources in year 2020. Projections for 2050 indicate a total regional need of 777,406 acre-feet per year. Irrigation represents 86 percent of this amount with a total projected need of 668,579 acre-feet per year.

Irrigation needs for 2020 are projected to be 505,682 acre-feet per year increasing to 668,579 acre-feet per year in the year 2050. The largest needs are attributed to high irrigation use and limited groundwater resources in Dallam, Moore, Oldham, Potter, and Randall counties. The numerical groundwater model developed by BEG indicates that there may be other counties in the PWPA with localized shortages.

Municipal needs are typically associated with growth and limited development of existing groundwater rights. Projected municipal water needs begin in 2010 with a deficit of 1,844 acre-feet per year, gradually increasing to 51,092 acre-feet per year in 2050. Cities showing needs are Amarillo, Cactus, Canadian, Canyon, Claude, Dumas, Groom, Gruver, Lake Tanglewood, Lefors, McLean, Panhandle, Perryton, Shamrock, Skellytown, Sunray, Vega, White Deer and Wheeler. In addition, there are county-other municipal needs in Moore, Oldham, Potter, and Randall counties. There may be other municipalities in the PWPA which are not listed, but may develop needs as the yields of existing wells decline, and additional wells will be installed to maintain adequate supply capacity. In addition, groundwater quality may supersede quantity as a need to develop additional supplies. The cities of Perryton and Wheeler are experiencing localized groundwater contamination in some of their supply wells.

Livestock needs are projected for Dallam, Moore, and Randall counties and are primarily due to competition for Ogallala water. Livestock needs are estimated to be 7,459 acre-feet per year in 2030 and increase to 29,989 acre-feet per year by 2050.

Manufacturing needs are relatively small in the PWPA. Identified needs in 2020 in Dallam, Lipscomb and Moore counties and total just under 1,500 acre-feet per year. By 2050 the manufacturing needs are projected to be in Dallam Gray, Hansford, Hemphill, Hutchinson, Lipscomb, Moore, Potter and Randall counties and total 14,451 acre-feet per year.

Mining needs of 367 acre-feet-per year begin in 2040 in Potter County. By 2050 the total mining needs are 741 acre-feet per year and occur in Hall, Oldham, Potter, and Randall counties.

Steam electric needs occur in Moore and Potter County. The Moore County need of 200 acre-feet per year begins in 2030. Potter County needs are 12,294 acre-feet per year beginning in 2040. The total regional mining needs by 2050 are 16,060 acre-feet per year.

WATER MANAGMEMENT STRATEGIES

Water management strategies were developed to meet the water needs greater than 10 acre-feet per year for municipal, manufacturing, livestock and steam electric power. Since the irrigation needs cannot be met by developing additional supplies, the water management strategies for irrigation needs are directed toward reducing demands. The potentially feasible strategies for each individual water use were evaluated with respect to:

- Quantity, reliability and cost;
- Environmental factors;
- Impacts on water resources and other water management strategies;
- Impacts on agriculture and natural resources; and
- Other factors including, regulatory requirements, political and local issues, implementation time, recreational impacts and socioeconomic benefits or impacts.

Municipal

As discussed previously, there are 18 cities in PWPA that will need to develop additional municipal water supply sources during the planning period. Only the city of Amarillo and the city of Canyon have sufficient undeveloped water rights to supply the projected demand through 2050.

Groundwater is the main source for most of the cities in the Region. The Ogallala aquifer supplies the majority of the current municipal water demand in the PWPA. The Dockum aquifer supplies a small amount to county-other water users in Randall County. The Palo Duro River Authority (PDRA) plans to supply surface water to six cities in the area once a transmission system is completed in 2030.

Water management strategies for cities with water needs include the purchasing of additional water rights in the Ogallala aquifer. A total of 519,505 additional acre-feet of water rights will be needed to supply the total municipal demand in the PWPA for the planning period. The reliability of the resource is considered to be moderate; however, the increased demand on the aquifer will continue to deplete the Ogallala storage capacity. Other groundwater uses, particularly irrigation, have a direct impact on the long term sustainability of current water demands.

The development of additional groundwater rights to provide additional water supplies will have a different cost for each city, depending on the number of wells needed, the depth to water, and the transmission pipeline size and distance. In addition, there are additional costs developed for member cities of the Palo Duro River Authority to obtain water from Palo Duro Reservoir. In general, environmental impacts will be minimal during the projects' implementation, if water delivery systems are routed around environmental sensitive areas. However, detailed environmental reviews will be needed prior to building any infrastructure associated with water supply projects. Water management strategies may reduce the irrigated acreage for farming as additional water rights are purchased.

Manufacturing

Manufacturing needs were identified in Dallam, Gray, Hemphill, Moore, Potter, and Randall counties. The small manufacturing need in Gray County can most likely be met with supply from the city of Pampa. The needs identified for Dallam, Moore, Potter and Randall counties are due to competition for Ogallala water with other users in the county. To provide for manufacturing demands in these counties, additional water rights will need to be purchased or alternative supplies developed. In most cases, municipal water will supply a portion of the water needs. The city of Cactus in Moore County is assumed to provide water for manufacturing needs when the Palo Duro Reservoir pipeline is completed.

The development of additional water supplies for manufacturing needs ranging from $95.00 per acre-foot per year in Potter County to $155.00 per acre-foot per year in Randall County. Reliability will be high in all cases. Environmental impacts will need to be reviewed in detail prior to project implementation. The number of irrigated acres in production may be reduced as additional water rights are purchased.

Steam Electric Power

There are two needs identified for steam electric power, including a small need in Moore County (200 ac-ft/yr) and a significant need in Potter County by 2050 (15,860 ac-ft/yr). Currently, groundwater from Ogallala supplies Moore County steam electric power demand. In Potter County, supply is obtained from the city of Amarillo, Ogallala, and wastewater reuse. The projected demands in Potter County increase from 18,300 to 30,000 acre-feet per year by 2050. Additional supply could be obtained from groundwater resources for the needs in both counties, and the city of Amarillo could possibly sell additional treated wastewater effluent for steam electric demands in Potter County.

Reliability of the resource will be moderate for both cases. Development of additional sources will cost $159.00 and $122.00 per ac-ft/yr for Moore and Potter counties, respectively. Minimal environmental impacts are expected during project implementation in Potter County. This strategy will impact the irrigated acreage when additional water rights are purchased.

Mining

There are small mining needs identified with counties with limited supplies from the Ogallala: Oldham and Potter counties. To meet the mining needs, local supplies will need to be developed or non-potable water could be used. This may include local mining ponds, shallow groundwater, and local river diversions. Mining needs for Oldham and Potter counties are assumed to be supplied by additional wells in the Dockum aquifer.

Reliability of the resource will be moderate for the three cases. Development of additional sources will cost $154.00 and $188.00 per ac-ft/yr for Oldham and Potter counties, respectively. No environmental impacts are expected during project implementation. This strategy will impact the irrigated acreage when additional water rights are purchased. Historically, the Dockum Aquifer has not been used for mining needs in the Red Basin portion of the county. Further review of the groundwater availability from this formation in the demand areas is needed.

Irrigation

There are substantial irrigation needs identified in the PWPA due to limitations of the available supply from the Ogallala Aquifer and the minor aquifers. By 2050 these needs are projected to be 668,579 acre-feet per year. There is no readily available water supply in or near the high irrigation counties that could be developed to fully meet these needs. Therefore, water management strategies to reduce irrigation demands were examined. These strategies focus on Dallam, Moore, Oldham, Potter, Randall and Sherman Counties, where the projected demands cannot be met with projected supplies. According to the Texas Agricultural Statistics Service a total of 713,454 irrigated acres are located in these counties. Although, these are the only counties showing needs county wide, the numerical groundwater model simulations indicate that there may be other counties that will experience localized shortages. Therefore, the PWPG recommends that the water management strategies to reduce demands be adopted by irrigators in all 21 counties across the region.

The irrigation management strategies include the use of the North Plains Potential Evapotranspiration Network (NPPET) to schedule irrigation, changes in crop variety, irrigation equipment efficiency improvements, changes in crop types, convert irrigated acreage to dryland acreage, implement conservation tillage methods and implement precipitation enhancement projects. Table 2 includes the anticipated annual water savings in acre-feet per acre per year, and the expected percentage of acres by decade that would be shifted to these methods.

Table 2 Water Management Strategies for Reducing Irrigation Demands

Water Management Strategy	Assumed Annual Regional Water Savings (ac-ft/ac/yr)	Assumed Baseline Use Year 2000	Goals for adoption per decade				
			2010	2020	2030	2040	2050
Use of NPPET	0.167	20%	70%	90%	90%	90%	90%
Change in Crop Variety	0.167	10%	40%	70%	70%	70%	70%
Irrigation Equipment Changes	0.25	55%	75%	95%	95%	95%	95%
Change in Crop Type	0.42	0%	20%	40%	40%	40%	40%
Convert irrigated acreage to dryland	1.2	0%	5%	10%	15%	15%	15%
Implement Conservation Tillage Methods	0.167	50%	60%	70%	70%	70%	70%
Precipitation Enhancement	0.08	0%	100%	100%	100%	100%	100%

Aggregate demand reductions by combining multiple strategies can significantly reduce the irrigation needs. Two different combinations of strategies for water demand reduction were evaluated. Both scenarios considered the use of NPPET, LEPA, conservation tillage, and precipitation enhancement. The first combination considered a change in crop variety, from long season to short season varieties, and the second combination considered a crop change from corn to sorghum. The first scenario resulted in a total irrigation demand reduction of 70,729 acre-feet per year in the region for the period from 2020 to 2050.

Revising the irrigation demands, using the aggregate reductions, results in four of the counties having enough supply to meet their needs during the 50-year planning period. Only two counties, Dallam and Moore, continue to show needs over the period. However, approximately 27 and 28 percent, respectively, of the total irrigation demands can be met by assuming the aggregate demand reductions.

In addition to evaluating the above irrigation demand reduction strategies, an economic analysis was conducted to determine the feasibility of importing irrigation water from counties with surplus availability to counties with identified needs. The analysis indicates that the cost of imported water needs to be lower than $120 acre-foot. Considering the distances between counties, it is unlikely that the associated cost of delivering imported water would be lower than $120 per acre-foot.

Livestock needs are proposed to be met by each producer by developing additional groundwater supplies. It may also be economically feasible to import water into the counties showing needs from nearby counting with available developable supplies. The water could be diverted to individual or clusters of concentrated animal feeding operations (CAFOs) to accommodate the projected growth.

REGULATORY, ADMINISTRATIVE OR LEGISLATIVE RECOMMENDATIONS

According to SB1 guidelines, regulatory, administrative, and legislative recommendations were developed for the PWPA Regional Water Supply Plan. The objective of these recommendations is to facilitate the orderly development, management, and conservation of water resources and preparation for and response to drought conditions in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of the state and regional water planning area. Following is a list of recommendations proposed by the PWPG for the TWDB to consider.

REGULATORY ISSUES

- TWDB should evaluate the notification requirements for amending the regional water supply plan.
- TNRCC should evaluate the rules governing reuse of wastewater effluent.
- TNRCC should encourage utilities to monitor unaccounted for water losses.
- TWDB should evaluate the definition of major water provider.
- TWDB should evaluate the methodology for developing irrigation demands.
- TWDB/TNRCC should evaluate the issue of groundwater rights vs. surface water rights.
- TWDB should submit plans for and results of reservoir feasibility studies to the appropriate Compact Commission (Red River Compact Commission or Canadian River Compact Commission) for review.

LEGISLATIVE ISSUES

- Provide interim funding for regional water planning.
- Prioritize state-sponsored water availability modeling, including groundwater availability modeling, especially as it relates to minor aquifers in the PWPA.
- Sponsor information gathering programs to improve the data on agricultural water use.
- Provide funding for implementation of water supply strategies.
- Create groundwater districts to manage groundwater resources through local districts across the State.
- Create a water conservation reserve program to make it economically feasible for farms to convert from irrigated acreage to dryland.
- Provide funding for utilities to replace/repair aging infrastructure.
- Provide funding for expansion of the NP-PET network and integration into a statewide network.
- Evaluate legislative barriers to using playa lakes for beneficial water supply.

- Provide funding for conducting feasibility studies of the Sweetwater Creek Reservoir project.
- Evaluate and clarify authority for reasonable and equitable export fees for groundwater districts.
- The PWPG requests that the Legislature requires coordination between Regional Water Planning Groups and State agencies regarding the development of the GAM and WAM models to ensure that the two models are not developed independently.

RECOMMENDATIONS FOR FUTURE STATE WATER PLANS

- TWDB should establish clear guidelines for eligibility for funding and needs assessment for very small cities and unincorporated areas.
- TNRCC should be made at least an ex-officio member of the RWPGs to provide input on known water quality/quantity problems.
- TWDB should provide clarification of the significance of designating unique reservoir sites and ecologically unique stream segments.
- TWDB should allow development of alternative near-term scenarios.
- TWDB should allow alternative definitions of the reliable supply from a reservoir.
- TWDB should continue to include potential PWPA reservoir sites in future water plans. These include, but are not limited to, Lelia Creek Reservoir site, Sweetwater Creek Reservoir site, and Red Deer Creek flood control/aquifer recharge structures.
- TWDB should separate water conservation from demand projections so conservation can be evaluated as a strategy.
- TWDB should provide clarification of the relationship between drought contingency planning and regional water supply planning.
- TWDB should simplify the format of required tables and provide better guidance for populating the tables.
- TWDB should allow complete access to TWDB and TNRCC database files by consultants.
- TWDB should include an economic impact analysis for the result of implementing water management strategies. The analysis should include impacts on water suppliers, users and major economic sectors.
- TWDB should include in future State Water Plans, salinity control projects for the Canadian River and/or Red River Basin.
- Water quality should play a more important role in future planning efforts.
- TWDB should include in future water plans, a detailed assessment for the interbasin/intrabasin water transfers in the PWPA.
- TWDB should provide guidance on how to account for brush control in the context of "new surface water supply."

DESCRIPTION OF REGION
- Panhandle Water Planning Area (PWPA) -

1.0 SENATE BILL 1

In June 1997, Governor George W. Bush signed into law Senate Bill 1 (SB1), a comprehensive water planning and management bill enacted by the 75th Texas Legislature. This comprehensive water legislation was an outgrowth of increased awareness of the vulnerability of Texas to drought and to the limits of existing water supplies to meet increasing demands as population grows. The state's population is expected to increase from its current level of about 19 million to more than 36 million by the year 2050, and many areas of the state are already suffering from water shortages.

With the passage of SB1, the Legislature put in place a "bottom up" water planning process designed to ensure that the water needs of all Texans are met as Texas enters the 21st Century. Individuals representing various interest groups serve as members of Regional Water Planning Groups (RWPGs) to prepare regional water plans for their respective areas. These plans map out how to conserve water supplies, meet future water supply needs and respond to future droughts in the planning areas. The Texas Water Development Board (TWDB) has established 16 distinct planning areas that are directed by 16 different RWPGs.

In accordance with SB-1 (as amended), the 16 regional water plans must be completed and adopted by January 5, 2001, and the TWDB must approve and incorporate the plans into a comprehensive state water plan. The water plans will be updated every five years.

This report describes Region A, the Panhandle Water Planning Area (PWPA). The PWPA consists of a 21-county area of the Panhandle that includes: Armstrong, Carson, Childress, Collingsworth, Dallam, Donley, Gray, Hall, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Potter, Randall, Roberts, Sherman, and Wheeler Counties (Figure 1-1).

Figure 1-1
PWPA Map

1.1 REGIONAL WATER PLANNING AREA

The Panhandle Water Planning Group (PWPG) is the regional water-planning group for the PWPA. This governing body of the region consists of 22 volunteer members (Table 1-1) representing the interests of the public, counties, municipalities, industry, agriculture, the environment, small business, electric generating utilities, river authorities, water districts, water utilities, and higher education. There are also 6 non-voting members that represent federal and state agencies and neighboring regional water planning regions.

The PWPG has designated three major water providers for the PWPA. These providers are the Canadian River Municipal Water Authority (CRMWA), Greenbelt Municipal and Industrial Water Authority (GM&IWA), and the City of Amarillo. The administrative contracting agency for the PWPA is the Panhandle Regional Planning Commission, Amarillo, Texas.

Table 1-1. Voting Membership of Panhandle Water Planning Group

Interest	Name	Entity	County (location of interest)
Public	Therese Abraham	Retired	Hemphill
Counties	Judge Vernon Cook	Roberts County	Roberts
Municipalities	Dan Coffey	City of Amarillo	Potter and Randall
	David Landis	City of Perryton	Ochiltree
Industries	Bill Hallerberg	IRI International (Retired)	Gray
	Mike Page	Phillips 66 Co.	Hutchinson
Agricultural	Frank Simms	Farmer/Cattle Feeder	Carson
	Rudie Tate	Farmer	Collingsworth
	Janet Tregellas	Farm/Ranch	Lipscomb
	B. A. Donelson	First State Bank	Sherman
Environmental	Grady Skaggs	Farmer	Oldham
	Nolan Clark	USDA-ARS	Potter
	Trish Neusch	Serious Texans Against Nuclear Dumping	Carson
Small Businesses	Rusty Gilmore	Water Well Driller	Dallam
Elec. Generation Utilities	Gale Henslee	Southwestern Public Service	Potter (serves entire region)
River Authorities	Jim Derington	Palo Duro RA	Hansford
Water Districts	Richard Bowers	North Plains Groundwater Conservation District	Moore and 7 other counties in the region
	Bobbie Kidd	Greenbelt M&I Water Authority	Donley and 2 other counties in the region
	C. E. Williams	Panhandle Groundwater Conservation District	Carson and 7 other counties in the region
	John C. Williams	Canadian River Municipal Water Authority	Hutchinson and 3 member cities in the region
Water Utilities	Charles Cooke	TCW Supply	Hutchinson
Higher Education	John Sweeten	Texas Agricultural Experiment Station	Entire Region

The PWPA is among the largest water-consuming regions in the State with over 90 percent of water used in the region for agricultural purposes. Use of this water in the PWPA produces 35 percent of the wheat, 49 percent of the corn, and 14 percent of the grain sorghum, along with 33 percent of the cattle on feed, 74 percent of the swine, and 47 percent of the beef slaughter capacity in the state. This accounts for $3.249 billion in direct benefit to the Region's economy. In 1990, the region accounted for only 1.9 percent of the State's total population, but accounted for approximately 13 percent of the State's annual water use. Projections indicate that total water use in the region will increase approximately five percent during the planning period (PWPG, 1999).

1.1.1 Population

The population of Texas was roughly 17 million in 1990. By 2000, it is estimated to be over 20 million. The PWPA accounted for just under two percent of the state total in 1990. Appendix A contains historical and projected population estimates for cities and counties in the PWPA.

Table 1-2 provides historical population estimates, summarized by county, in the PWPA for 1990 and projected estimates for each decade to 2050. Projected population estimates include TWDB projections and revised projections developed by the PWPG (1999). Rationale and methodologies for developing revised population projections are presented in detail in Chapter 2. Populations are presented for each city and smaller populated areas (County-Other) and totaled by county. The classification of County-Other includes rural and unincorporated areas within the county (Table 1-3).

The PWPA population is projected to increase from 323,766 in 1990 to 379,018 in 2000, 453,496 in 2020, and 552,072 by 2050. This represents an increase of 46 percent from 2000 to 2050. Essentially all the increase is in the larger communities, with a declining rural population projected.

Counties with a projected population of 10,000 or greater in 2000 include Gray, Hutchinson, Moore, Potter, and Randall. These counties include the cities of Amarillo, Borger, Canyon, Dumas, and Pampa. There are several cities with a projected population between 2,500 and 10,000 for the year 2000 including Cactus, Canadian, Childress, Dalhart, Fritch, Perryton, and Spearman. The city of Amarillo is projected to have a population of 177,644 by the year 2000 and accounts for much of the population increase, especially in northern Randall County (TWDB, 1998; PWPG, 1999).

Table 1-2. PWPA Projected Population by City, County and Rural Areas by Decade

COUNTY	CITY	1990	2000	2010	2020	2030	2040	2050
Armstrong	Claude	1,199	1,253	1,335	1,410	1,476	1,478	1,480
	County-Other	822	775	701	612	502	416	355
	TOTAL	2,021	2,028	2,036	2,022	1,978	1,894	1,835
Carson	Groom	613	655	658	648	600	545	501
	Panhandle *	2,353	2,469	3750	4104	4281	4401	4523
	Skellytown	664	666	667	650	572	564	556
	White Deer	1,125	1,231	1,341	1,391	1,445	1,477	1,510
	County-Other	1,821	1,783	1,776	1,676	1,773	1,780	1,705
	TOTAL	6,576	6,804	8,192	8,469	8,671	8,767	8,795
Childress	Childress *	5,055	6,000	6,500	6,750	7,000	7,250	7,500
	County-Other *	898	1,818	1,720	1,724	1,716	1,737	1,774
	TOTAL	5,953	7,818	8,220	8,474	8,716	8,987	9,274
Collingsworth	Wellington	2,456	2,482	2,508	2,577	2,588	2,583	2,569
	County-Other	1,117	1,062	1,119	1,149	1,155	1,152	1,146
	TOTAL	3,573	3,544	3,627	3,726	3,743	3,735	3,715
Dallam	Dalhart (P) *	4,001	4,543	4,766	4,891	4,828	4,695	4,566
	County-Other	1,460	1,477	1,634	1,727	1,764	1,816	1,824
	TOTAL	5,461	6,020	6,400	6,618	6,592	6,511	6,390
Donley	Clarendon	2,067	2,032	1,959	1,904	1,785	1,662	1,520
	County-Other	1,629	1,592	1,536	1,492	1,400	1,302	1,192
	TOTAL	3,696	3,624	3,495	3,396	3,185	2,964	2,712
Gray	LeFors	656	638	603	559	517	500	488
	McLean	849	891	931	970	868	850	832
	Pampa	19,959	20,778	21,723	22,698	20,395	19,992	19,597
	County-Other	2,503	2,637	2,814	2,919	2,527	2,441	2,374
	TOTAL	23,967	24,944	26,071	27,146	24,307	23,783	23,291
Hall	Memphis	2,465	2,338	2,306	2,264	2,190	2,117	2,057
	Turkey	507	569	578	588	597	615	632
	County-Other	933	809	782	747	695	634	581
	TOTAL	3,905	3,716	3,666	3,599	3,482	3,366	3,270
Hansford	Gruver	1,172	1,216	1,280	1,297	1,278	1,247	1,202
	Spearman	3,197	3,318	3,506	3,555	3,498	3,422	3,348
	County-Other	1,479	1,535	1,604	1,624	1,605	1,556	1,448
	TOTAL	5,848	6,069	6,390	6,476	6,381	6,225	5,998
Hartley	Channing	277	368	419	426	432	439	446
	Dalhart (P) *	2,245	2,998	3,412	3,468	3,514	3,584	3,655
	County-Other *	1,112	1,867	2,123	2,146	2,168	2,198	2,221
	TOTAL	3,634	5,233	5,954	6,040	6,114	6,221	6,322
Hemphill	Canadian	2,417	2,604	2,757	2,789	2,725	2,665	2,606
	County-Other	1,303	1,280	1,362	1,386	1,361	1,338	1,285
	TOTAL	3,720	3,884	4,119	4,175	4,086	4,003	3,891
Hutchinson	Borger	15,675	15,903	16,367	16,519	16,169	15,697	15,161
	Fritch	2,325	2,523	2,588	2,595	2,529	2,444	2,362
	Stinnett	2,166	2,303	2,371	2,396	2,347	2,281	2,217
	County-Other	5,523	5,372	5,536	5,602	5,493	5,341	5,143
	TOTAL	25,689	26,101	26,862	27,112	26,538	25,763	24,883

Table 1-2. PWPA Projected Population by City, County and Rural Areas by Decade (cont)

COUNTY	CITY	1990	2000	2010	2020	2030	2040	2050
Lipscomb	Booker (P)	1,231	1,255	1,310	1,323	1,319	1,298	1,255
	Lipscomb *	190	208	217	219	218	215	208
	County-Other	1,722	1,794	1,871	1,890	1,885	1,854	1,794
	TOTAL	3,143	3,257	3,398	3,432	3,422	3,367	3,257
Moore	Cactus *	1,529	2,500	2,871	3,279	3,921	4,717	5,673
	Dumas	12,871	14,620	16,451	18,312	19,942	21,443	23,057
	Sunray	1,729	1,902	2,271	2,678	3,022	3,267	3,532
	County-Other	1,736	1,879	1,969	2,017	1,996	1,991	2,053
	TOTAL	17,865	20,901	23,562	26,286	28,881	31,418	34,315
Ochiltree	Booker (P)	5	24	25	25	24	24	24
	Perryton	7,607	8,071	8,566	8,863	8,824	8,708	8,594
	County-Other	1,516	1,552	1,644	1,696	1,686	1,659	1,544
	TOTAL	9,128	9,647	10,235	10,584	10,534	10,391	10,162
Oldham	Vega	840	931	1,000	1,034	1,055	1,016	978
	County-Other	1,438	1,462	1,538	1,529	1,476	1,402	1,302
	TOTAL	2,278	2,393	2,538	2,563	2,531	2,418	2,280
Potter	Amarillo (P)	91,502	98,526	105,245	114,253	121,228	128,644	136,514
	County-Other *	6,372	15,516	16,293	17,378	18,784	20,283	20,303
	TOTAL	97,874	114,042	121,538	131,631	140,012	148,927	156,817
Randall	Amarillo (P)	66,113	79,118	92,341	105,281	117,927	133,079	150,178
	Canyon *	11,365	13,577	14,891	16,119	17,222	18,883	20,704
	Happy	588	567	552	527	503	500	503
	Lake Tanglewood *	637	1,085	1,177	1,254	1,311	1,344	1,351
	County-Other *	10,970	24,471	31,244	38,208	45,304	52,865	62,423
	TOTAL	89,673	118,818	140,205	161,389	182,267	206,671	235,159
Roberts	Miami	675	710	748	737	703	663	625
	County-Other	350	346	363	351	330	298	222
	TOTAL	1,025	1,056	1,111	1,088	1,033	961	847
Sherman	Stratford	1,781	1,904	2,027	2,104	2,036	1,962	1,891
	County-Other *	1,077	1,296	1,265	1,192	1,107	1,027	926
	TOTAL	2,858	3,200	3,292	3,296	3,143	2,989	2,817
Wheeler	Shamrock	2,286	2,312	2,338	2,356	2,389	2,399	2,409
	Wheeler	1,393	1,447	1,462	1,472	1,492	1,497	1,502
	County-Other	2,200	2,160	2,159	2,146	2,140	2,136	2,132
	TOTAL	5,879	5,919	5,959	5,974	6,021	6,032	6,043
REGION TOTAL		323,766	379,018	416,870	453,496	481,637	515,393	552,072

Source: TWDB, 1998; PWPG, 1999
(P) City is in more than one county. This represents only that portion of the city in this county.
* revised populations from PWPG, 1999

Table 1-3. Populated Areas included in *County-Other*

County	Populated Areas
Armstrong	Goodnight, Washburn, Wayside, and other unincorporated areas
Carson	Conway and other unincorporated areas
Childress	Kirkland, Tell, and other unincorporated areas
Collingsworth	Dodson, Quail, Samnorwood, and other unincorporated areas
Dallam	Texline and other unincorporated areas
Donley	Hedley and other unincorporated areas
Gray	Alanreed and other unincorporated areas
Hall	Estelline, Lakeview, and other unincorporated areas
Hansford	Morse and other unincorporated areas
Hartley	Hartley and other unincorporated areas
Hemphill	Glazier and other unincorporated areas
Hutchinson	Plemons, Sanford, and other unincorporated areas
Lipscomb	Darrouzett, Follett, Higgins, and other unincorporated areas
Moore	Masterson and other unincorporated areas
Ochiltree	Farnsworth and other unincorporated areas
Oldham	Adrian, Boys Ranch, Wildorado, and other unincorporated areas
Potter	Bushland and other unincorporated areas
Randall	Umbarger and other unincorporated areas
Roberts	Codman, Wayside, and other unincorporated areas
Sherman	Texhoma and other unincorporated areas
Wheeler	Mobeetie and other unincorporated areas

1.1.2 Economic Activities

The economy of the region may generally be divided into the following sectors: agriculture and agribusiness, oil and gas operations, wholesale and retail trade, various manufacturing, tourism, and institutional (Ramos, 1997). Major water-using activities include irrigation, petroleum refining, agricultural production, food processing and kindred, chemical and allied products, and electric power generation. Total economic values reported per county for 1996 to 1997 are shown in Table 1-4.

Table 1-4. Economic Activities of Counties in the PWPA

County	Total Wages (dollars)	Property Value (dollars)	Retail Sales (dollars)	Major Economic Activities: Agriculture	Manufacturing	Petroleum	Tourism *
Armstrong	6,130,662	146,555,650	5,026,257	X			X
Carson	164,501,213	649,452,072	20,670,087	X		X	X
Childress	37,225,273	174,348,806	55,091,977	X	X		X
Collingsworth	14,782,757	139,629,490	12,756,325	X	X		X
Dallam	44,681,269	392,241,529	54,439,676	X	X		X
Donley	14,245,669	183,076,002	17,591,050	X	X		X
Gray	209,031,209	1,121,570,019	209,820,860	X	X	X	X
Hall	13,691,830	161,391,542	21,708,170	X			X
Hansford	42,606,603	699,315,310	31,972,944	X			X
Hartley	11,263,676	297,891,810	20,766,507	X	X	X	X
Hemphill	29,880,638	844,057,785	20,120,107	X		X	X
Hutchinson	248,295,532	1,549,157,758	164,704,947	X	X	X	X
Lipscomb	15,841,806	419,600,730	9,698,442	X		X	X
Moore	165,952,501	571,096,030	115,763,486	X		X	X
Ochiltree	73,056,930	521,275,825	82,639,012	X		X	X
Oldham	14,578,067	167,222,421	10,466,677	X			X
Potter	1,408,573,746	3,586,125,502	1,669,654,206	X		X	X
Randall	363,599,684	2,737,669,603	609,500,515	X	X		X
Roberts	4,365,904	246,395,801	1,864,996	X		X	X
Sherman	14,554,677	518,596,296	12,132,428	X			X
Wheeler	26,461,883	591,428,936	32,699,595	X		X	X
TOTAL	**$2,923,324,000**	**$15,717,100,000**	**$3,179,088,000**				

Source: Ramos, 1997
* information from PWPG Municipal/Industrial Demands Subcommittee Meeting, October 21, 1999.

1.1.3 Climate

The climate of the Panhandle is characterized by low and erratic precipitation, widely variable seasonal temperatures, moderately high wind speeds, and low humidity. Annual precipitation declines across the planning area from east to west. Precipitation ranges from a high of about 22 inches in the east to about 16 inches in the west. The average annual precipitation measured at the National Weather Service (NWS) at Amarillo is 19.55 inches and is considered representative for the surrounding area (NWS, 1999). According to data collected at Bushland, Texas (Davis, 1997), rainfall occurs primarily in the summer months, with the months of May, June, July and August all averaging over 2.70 inches and the months of December, January and February averaging slightly more than 0.50 inches. Average wind speed is 12.9 miles per hour measured at 30 ft. and can become significant in the spring. The maximum average monthly high temperature measured at Bushland is 90.4 degrees Fahrenheit (July) and the minimum average monthly low temperature is 20.4 degrees Fahrenheit (January). Extremes of the monthly average temperatures measured by the NWS at Amarillo between 1961 and 1990 are: 92.5 degrees Fahrenheit measured in July; and 16.7 degrees Fahrenheit measured in January (NWS, 1999). The temperatures are usually slightly lower in the northwest, where the elevation is higher, and higher in the southeast where the elevation is about 1000 ft. lower. Temperatures often exceed 100 degrees Fahrenheit in the summer with up to 25 days in a single summer exceeding 100. The area can also experience several days of minimum temperatures below 0 degrees Fahrenheit. Record low temperatures across the area range from -10 to -20 degrees Fahrenheit. At Bushland, the average last freeze date in the spring is April 21 and the average first freeze date in the fall is October 22, giving that location an average growing season of 184 days. The southeastern counties have a slightly longer growing season relative to north western counties. Pan evaporation has been recorded at Bushland for 57 years for the months of April through September, with an average of 66.33 inches per year (Reneau, 1984). Estimates for annual evaporation are 94.98 inches from a 4 ft. Class A pan (Davis, 1997).

1.2 MAJOR WATER PROVIDERS

The term Major Water Provider (MWP) was established by SB-1 for the purpose of including major providers of water for municipal and manufacturing use into the regional planning process. A MWP is an entity which delivers and sells a significant amount of water on a wholesale and/or retail basis.

MWPs are identified and designated for each planning region by the regional planning group. Major water providers designated by the PWPG include the Canadian River Municipal Water Authority (CRMWA), Greenbelt Municipal and Industrial Water Authority (GM&IWA), and City of Amarillo.

Canadian River Municipal Water Authority. - The CRMWA was created in 1953 by the Texas Legislature for the purpose of distributing water from the Canadian River Project. The Bureau of Reclamation began construction on the project in 1962 and completed Lake Meredith in 1965. The project also includes a 322-mile aquaduct system which transports water from Lake Meredith to CRMWA's eleven member cities. The CRMWA serves more than 450,000 urban residents and provides water to Borger and Pampa in the Canadian Basin; and Amarillo in the Canadian and Red River basins. The remaining eight member cities are located in the Llano Estacado Water Planning Region (Region O). The CRMWA is also currently involved in a salinity control project for the protection of water quality in Lake Meredith and a groundwater supply project being developed to supplement surface water supply.

Greenbelt Municipal and Industrial Water Authority (GM&IWA). - The GM&IWA provides water from Greenbelt Reservoir on the Salt Fork of the Red River. The GM&IWA is located in Donley County and provides water to local municipalities through an extensive delivery system, including a 121-mile aquaduct. There are five member cities, including Clarendon, Hedley, and Childress in the PWPA and Quanah and Crowell in the Region B planning area. The Red River Authority is a non-voting member of the GM&IWA.

City of Amarillo. – The City of Amarillo currently services over 60,000 active water accounts with an average production of 42 million gallons per day. The City gets its water from three active well fields and an allocation of surface water from CRMWA in Lake Meredith.

1.3 SOURCES OF WATER

Water supplies in the PWPA include both surface and groundwater sources. Statutes and regulations pertaining to the quantity and quality of water in Texas differ according to the type of water body (Table 1-5). Surface water is owned, held in trust, appropriated, and protected by the state on behalf of all citizens, while groundwater is subject only to right of capture by the surface landowner unless that right of capture is modified by the existence of a groundwater conservation district and the district has adopted rules to effect regulation. Except for such rules, legal restrictions are not imposed by the State of Texas on landowners regarding withdrawal that would bar them from exercising their right of capture of groundwater entering wells on and beneath their property.

Table 1-5. Summary of Policies and Agencies Affecting Texas Water Quality and Quantity

Type of Water	Water Quantity	Water Quality
Diffuse	Landowner control	Nonpoint source protection agencies: TNRCC (urban and industrial), TSSWCB (agriculture and silviculture)
Surface	State (TNRCC) Canadian River Interstate Compact Red River Compact	State (TNRCC) regulations Federal (EPA) regulations
Ground	Landowner right of capture; groundwater district rules (where applicable)	Groundwater District Rules State (TNRCC) Regulations

Source: TNRCC, 1997

1.3.1 Groundwater

1.3.1.1 Management and Classification

Management. The Texas Groundwater Protection Committee Rules (Title 30, Texas Administrative Code, Section 601.3) defines groundwater contamination as "the detrimental alteration of the naturally occurring physical, thermal, chemical, or biological quality of groundwater" (TNRCC, 1997). A comparison to naturally-occurring groundwater quality is often necessary to determine if contamination has occurred.

Senate Bill 1 altered several provisions of surface and groundwater law. One of the key new provisions will require TNRCC to determine areas that warrant special consideration. For those areas TNRCC is to encourage the formation of new groundwater districts or the incorporation of these areas into existing districts. Each groundwater district is required to submit a water management plan to the Texas Water Development Board for certification.

Undergroundwater conservation districts have played a major role in the management of water resources in the PWPA. While the State does not generally restrict withdrawal of groundwater, districts have been created to manage and protect groundwater. Parts or all of 18 counties in the PWPA study area are included in the six groundwater districts presented in Table 1-6. The counties of Childress, Hall, and Oldham are not included in any groundwater districts. Districts can regulate well spacing, well size, well construction, well closure, pumpage, and monitoring and protection of groundwater quality.

Table 1-6. Groundwater Districts in PWPA

Groundwater District	Counties Served in PWPA	Aquifer
Collingsworth County Underground Water District	Collingsworth	Seymour Blaine
Dallam County Underground Water District	Dallam	Ogallala Rita Blanca Dockum
Hemphill County Underground Water District	Hemphill	Ogallala
High Plains Underground Water Conservation District	Armstrong, Randall, Potter	Ogallala Dockum
North Plains Groundwater District	Dallam, Hansford, Hartley, Hutchinson, Lipscomb, Moore, Ochiltree, Sherman,	Ogallala Rita Blanca Dockum
Panhandle Groundwater District	Armstrong, Carson, Donley, Gray, Hutchinson, Potter, Roberts, Wheeler	Ogallala Dockum Blaine Seymour Whitehorse

Source: TNRCC, 1997

<u>Classification.</u> The TNRCC is the statutorily-designated state regulatory agency for water quality protection and water rights allocation. TNRCC has provided a recent summary of state groundwater policy and agencies participating in groundwater protection in Texas (TNRCC, 1997).

The State of Texas has established a groundwater classification system, established by the Texas Groundwater Protection Committee (created under Section 26.401 of the Texas Water Code), for use by state agencies. The groundwater classification system applies to all groundwaters of the state and has been incorporated into the rules of the TNRCC industrial solid waste program (TNRCC, 1997). The classification system was established for the criterion of total dissolved solids (TDS). Water bodies are considered fresh if the TDS concentration is less than 1,000 mg/L. Slightly saline water has TDS concentrations between 1,000 and 3,000 mg/L. Moderately saline water has TDS concentrations between 3,000 and 10,000 mg/L, and very saline to brine water has TDS concentrations greater than 10,000 mg/L.

The Texas Water Code stipulates the state groundwater protection policy of “nondegradation” which is based on the availability of groundwater for a particular use. The nondegradation policy obligates all state agencies’ programs and users to prevent degradation that would lower the classification of groundwater for present and subsequent uses. The policy states that discharges of pollutants, disposal of wastes, and other regulated activities must be conducted in a manner that will maintain present uses and not impair potential uses of groundwater or pose a public health hazard (TNRCC, 1997). The policy allows state agency officials to exercise best professional judgement in attaining the nondegradation goal.

1.3.1.2 Aquifers

In the PWPA there are two major aquifers, the Ogallala and Seymour (Figure 1-2), and four minor aquifers, Blaine, Rita Blanca, Whitehorse, and Dockum (Figure 1-3), that serve as water sources for the study area.

Ogallala Aquifer

The Ogallala is a major aquifer that contains approximately 417 million acre-feet of fresh groundwater within the State of Texas. It supports the major irrigated agricultural production base, as well as municipal water needs in the PWPA. Water-table elevations approximately parallel the land surface and dip from the northwest to the southeast. The aquifer is recharged by precipitation and runoff that drains to lakes, rivers, and streams (Mullican et al., 1994).

The TWDB (1993) reported that groundwater depletion in the Ogallala aquifer in the 18 counties underlain by this aquifer in PWPA is expected to average a total of 5.9 percent for the ten-year period between 1990 and 2000 (Table 1-7). The estimated water in storage in the Ogallala aquifer in the PWPA was about 265 million acre feet in 1990, and was projected to decline to 249 million acre feet in 2000 (TWDB, 1993).

The quality of Ogallala water is controlled by the composition of the recharge water and the geologic features and deposits above and within the aquifer. According to the results of a study of the Ogallala aquifer (Nativ, 1988) the TDS concentration of the Ogallala in the vicinity of the PWPA averaged 429 mg/L. The major constituent, bicarbonate, averaged 278 mg/L, while minor constituents such as sulfate, calcium, sodium, chloride, and potassium averaged from 8 mg/L to 66 mg/L (Nativ, 1988).

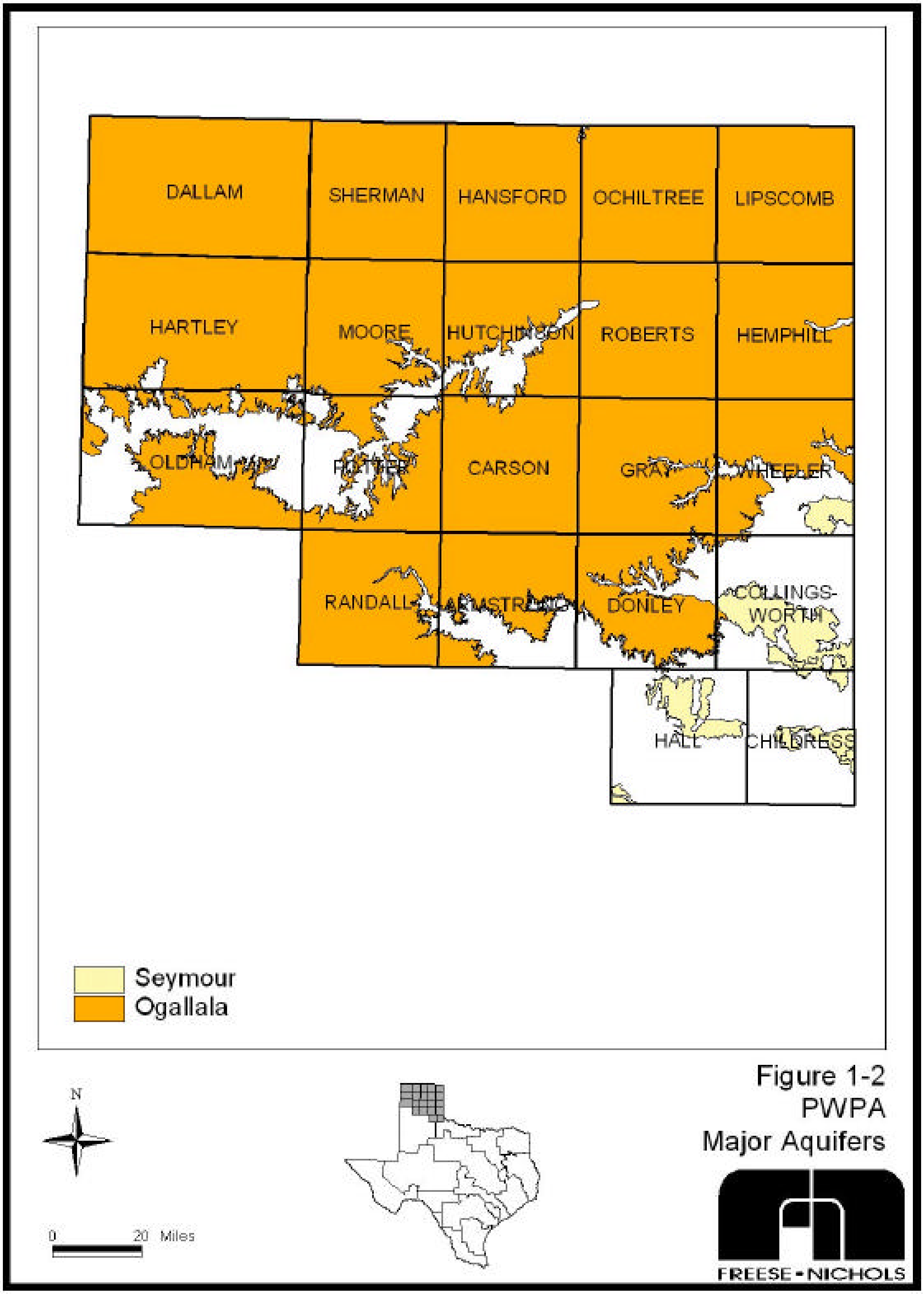


Figure 1-2
PWPA
Major Aquifers

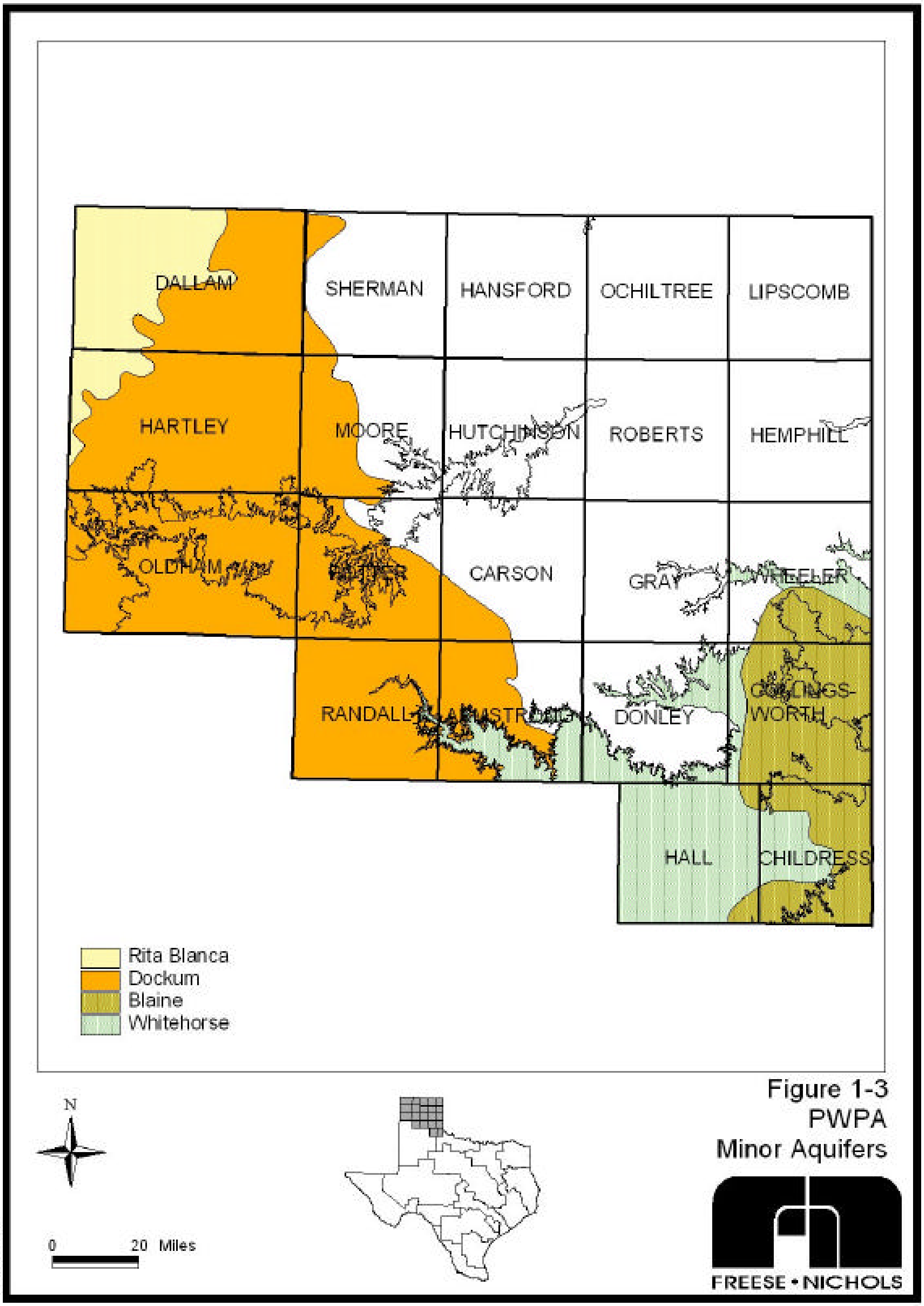


Figure 1-3
PWPA
Minor Aquifers

Table 1-7. Estimated Groundwater Storage of the Ogallala Aquifer in the PWPA (million acre-feet)

County	1990 Storage	2000 Storage	Percent Depletion
Armstrong	3.64	3.50	3.8 %
Carson	13.19	12.53	5 %
Childress	*NA*	*NA*	*NA*
Collingsworth	*NA*	*NA*	*NA*
Dallam	29.97	25.71	14.2 %
Donley	8.09	8.10	-0.1 %
Gray	12.96	12.30	5.1 %
Hall	*NA*	*NA*	*NA*
Hansford	23.27	21.36	8.2 %
Hartley	27.82	26.06	6.3 %
Hemphill	16.57	16.74	-1.0 %
Hutchinson	10.54	9.97	5.4 %
Lipscomb	20.82	20.74	0.4 %
Moore	13.20	11.11	15.8 %
Ochiltree	18.57	17.67	4.8 %
Oldham	1.14	1.07	6.1 %
Potter	3.07	2.76	10.1 %
Randall	4.51	4.00	11.3 %
Roberts	27.62	27.70	-0.3 %
Sherman	21.88	19.79	9.6 %
Wheeler	8.45	8.36	1.1 %
Total Storage	**265.31**	**249.47**	
Estimated Average 10-year Total Depletion			**5.9 %**

Source: Wyatt, 1996; TWDB, 1993
NA = the Ogallala aquifer does not occur in these counties.

Seymour Aquifer

The Seymour is a major aquifer located in north central Texas and some Panhandle counties. The aquifer consists of isolated areas of alluvium that are erosional remnants of a larger area or areas. Although most accumulations in the PWPA are less than 100 feet thick, a few isolated spots in Collingsworth County may exceed 300 feet. These thick accumulations overlie buried stream channels or sinkholes in underlying formations. This aquifer is under water-table conditions in most of its extent, but artesian conditions may occur where the water-bearing zone is overlain by clay.

Fresh to slightly saline groundwater recoverable from storage from these scattered alluvial aquifers is estimated to be 3.18 million acre-feet based on 75 percent of the total storage. Annual effective recharge to the aquifer is approximately 215,200 acre-feet, or 5 percent of the average annual precipitation that falls on the aquifer outcrop. No significant long-term water-level declines have occurred in areas supplied by groundwater from the Seymour aquifer. The lower, more permeable part of the aquifer produces the greatest amount of groundwater. Yields of wells average about 300 gal/min and range from less than 100 gal/min to as much as 1,300 gal/min (Ashworth & Hopkins, 1995).

Water quality in these alluvial remnants generally ranges from fresh to slightly saline, although a few higher salinity problems may occur. The salinity has increased in many heavily-pumped areas to the point where the water has become unsuitable for domestic uses. Brine pollution from oil-field activities has resulted in localized contamination of former fresh groundwater supplies. Nitrate concentrations in excess of primary drinking-water standards are widespread in the Seymour groundwater (Ashworth & Hopkins, 1995) .

<u>Dockum Aquifer</u>

The Dockum is a minor aquifer which underlies the Ogallala aquifer and extends laterally into parts of west Texas and New Mexico. The primary water-bearing zone in the Dockum Group, commonly called the "Santa Rosa," consists of up to 700 feet of sand and conglomerate interbedded with layers of silt and shale. Aquifer permeability is typically low, and well yields normally do not exceed 300 gal/min (Ashworth & Hopkins, 1995).

According to Bradley (1997), the base of the Dockum Group aquifer is mudstones at elevations ranging from 1,200 ft. MSL in the south (Crockett County) to 3,200 ft. MSL in Oldham County, and to 3,400 ft. MSL in Dallam County. Saturated thicknesses range from 100 ft. to 2,000 ft. The water table ranges from approximately 3,800-4,000 ft. MSL in Oldham, Hartley, and Dallam counties to 3,200 f. MSL or less in Potter, Carson, Armstrong, Moore and Sherman counties. Recharge to the Dockum aquifer is negligible except in the outcrop areas, where approximately 23,500 acre-feet is estimated to occur annually (Bradley, 1997).

Concentrations of TDS in the Dockum aquifer range from less than 1,000 mg/L in the eastern outcrop of the aquifer to more than 20,000 mg/L in the deeper parts of the formation to the west. The highest water quality in the Dockum occurs in the shallowest portions of the aquifer and along outcrops at the perimeter. The Dockum underlying Potter, Moore, Carson, Armstrong, and Randall Counties has a TDS content of around 1,000 mg/L (Bradley, 1997). The lowest water quality (highest salinity) occurs outside of the PWPA. Dockum water, used for municipal supply by several cities, often contains chloride, sulfate, and dissolved solids that are near or exceed EPA/State secondary drinking-water standards (Ashworth & Hopkins, 1995).

<u>Rita Blanca Aquifer</u>.

The Rita Blanca is a minor aquifer which underlies the Ogallala Formation in western Dallam and Hartley counties in the northwest corner of the Texas Panhandle. The portion of the aquifer located in the PWPA makes up a small part of a large aquifer system that extends into Oklahoma, Colorado, and New Mexico.

Recharge to the aquifer in Texas occurs by leakage from the Ogallala and by lateral flow from portions of the aquifer system in New Mexico and Oklahoma. Effective recharge and recoverable storage for the Rita Blanca have not been quantified but historically have been included with regional recharge and storage estimates for the Ogallala aquifer. Aquifer water-level declines in excess of 50 feet have occurred in some irrigated areas from the early 1970s to the middle 1980s. These declines were the result of pumpage which exceeded effective recharge. Evidence of aquifer declines included the disappearance of many springs in the northern part of Dallam County that once contributed to the constant flow in creeks that are now ephemeral. Since the middle 1980s, the rate of decline has generally slowed and, in some areas, water-level rises have occurred (Ashworth & Hopkins, 1995).

Blaine Aquifer

The Blaine is a minor aquifer located in portions of Wheeler, Collingsworth, and Childress counties of the RWPA and extends into western Oklahoma. Saturated thickness of the formation in its northern region varies from approximately 10 to 300 feet. Recharge to the aquifer travels along solution channels which contribute to its overall poor water quality. Dissolved solids concentrations increase with depth and in natural discharge areas at the surface, but TDS concentrations in the aquifer are less than 10,000 mg/L. The primary use is for irrigation of highly salt-tolerant crops, with well yields varying from a few gallons per minute (gpm) to more than 1,500 gpm (Ashworth & Hopkins, 1995).

Whitehorse Aquifer

The Whitehorse is a Permian aquifer occurring in beds of shale, sand, gypsum, anhydrite, and dolomite. It is an important source of water in and near the outcrop area around Wheeler county. Wells in the Whitehorse aquifer often pump large quantities of fine sand and require screens for larger yields. Water from the Whitehorse is generally used for irrigation, but other uses include domestic and livestock. Dissolved solids range from approximately 400 mg/L to just less than 2,700 mg/L, with better water quality generally occurring in the areas of recharge from the Ogallala (Maderak, 1973).

Springs

Springs are an important transition between groundwater and surface water bodies. A study by the TWDB (1973) identified 281 major and historically significant springs across the state of Texas, 16 of which were located in the PWPA. As observed throughout the state, spring flows in the PWPA have generally declined during the last century due to deforestation by early European settlers, grazing and cultivation, and the development of deep water wells. Springs identified by the TWDB study in Donley, Hartley, Oldham, Potter, and Wheeler counties were derived from the Ogallala Formation. The Blaine and Whitehorse Formations produced springs in Collingsworth and Wheeler counties, and one alluvial spring was identified in Collingsworth County.

1.3.2 Surface Water

The PWPA is located within portions of the Canadian River Basin and Red River Basin. These two river systems and associated impoundments shown in Figure 1-4 provide surface water for municipal, agricultural, and industrial users in the area.

1.3.2.1 Surface Water Management and Classification

The TNRCC is the agency charged with the management of surface water quality and quantity. Water quantity for the state is managed by a permitting system administered by the Water Quantity Section of TNRCC. Individual surface water rights greater than 1,000 acre-feet per year for both the Canadian River Basin and the Red River Basin and actual use, are shown in Table 1-8. The data show that permitted water rights total 183,090 acre-feet/year and reported use ranging from 73,915 acre-feet in 1994 to 79,029 acre-feet in 1996.

Table 1-8. Individual Water Rights in the PWPA: Permitted and Actual Use (Greater Than or Equal to 1,000 acre-feet)

County	Water Right Holder	Water Source	Reservoir Firm Yield	Use (1)	Use in 1994(2)	Use in 1995(2)	Use in 1996(2)	Permitted Amount
Canadian River Basin								
Hutchinson	Canadian River MWA	Lake Meredith	74,350	1	64,267	65,794	68,422	100,000
				2	5,213	4,894	6,103	51,200
Hansford	Palo Duro River Authority	Palo Duro Reservoir	7,290 *	1	0	0	0	10,460
Red River Basin								
Randall	City of Amarillo	Bivens Reservoir	N/A	8	0	0	0	5,400
Donley	Greenbelt M&I WA	Greenbelt Reservoir	9,400	1	4,435	4,238	4,504	14,530
				2	0	0	0	500
				3	0	0	0	250
				4	0	0	0	750
Totals					73,915	74,926	79,029	183,090

Source: TNRCC, 1999c: Note yield values reported by TNRCC in this table are not in agreement with the most recent yield studies, which are reported in Chapter 3.

1) Use Types: 1=Municipal (water delivered to municipalities); 2=Industrial (water delivered to industrial users); 3=Irrigation; 4=Mining; 8=Other

2) A "0" means that zero AF of water was reported as used. A blank means that no report was submitted.

Water rights known to include only saline water are not included in this table.

Inter-regional water transfers:

Approximately 50 percent of permitted amount of total water is authorized for use in Llano Estacado Planning Area from PWPA (Lake Meredith)

Additionally, there are 99 water rights of <1,000 AF each in the region totaling 8,053 AF of permitted water.

* initial estimated firm yield – Palo Duro Reservoir is in a new drought of record, therefore new yield will be less than the initial estimated yield.

N/A - Not Available

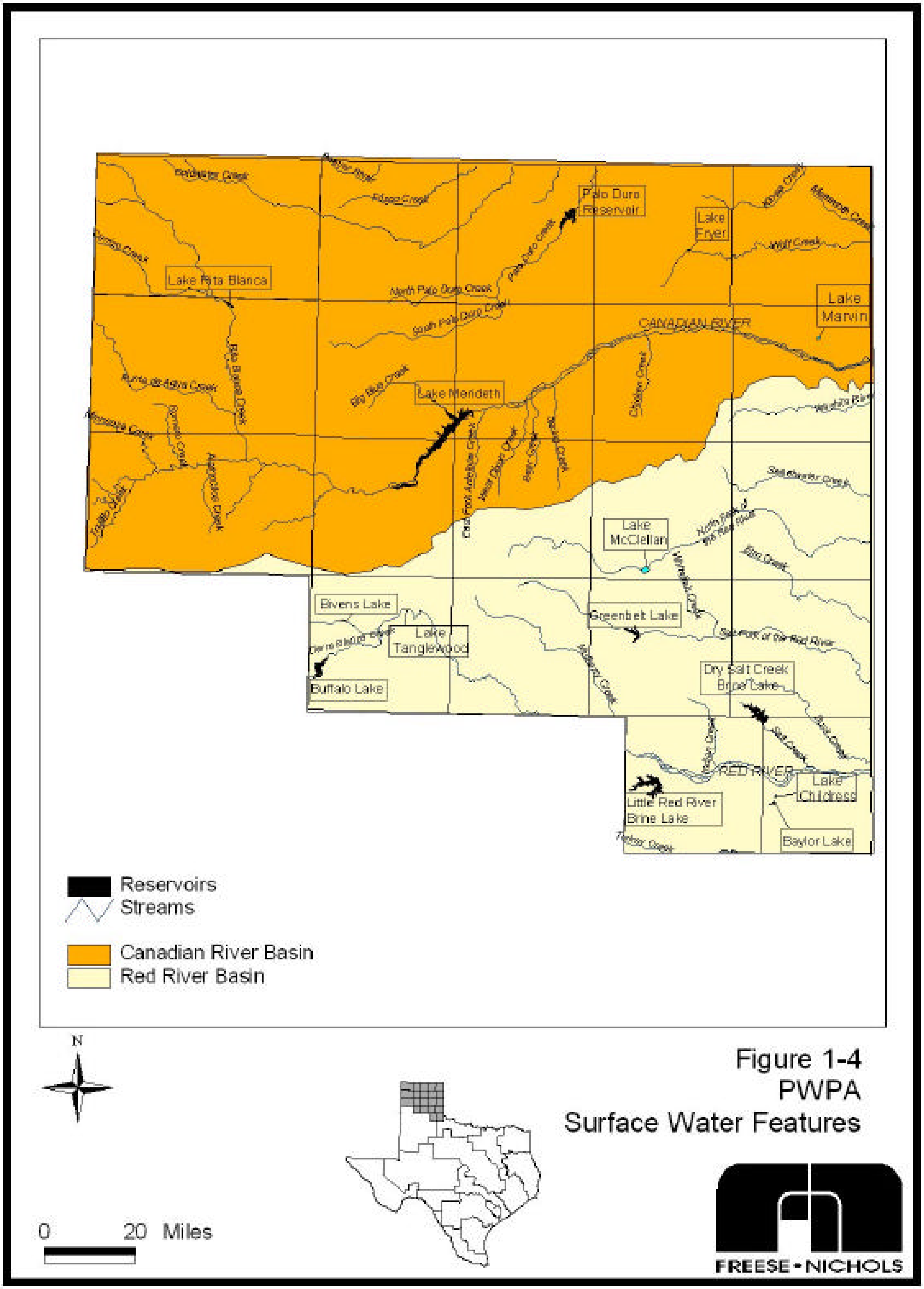


Figure 1-4
PWPA
Surface Water Features

Surface water quality is managed nationwide by the United States Environmental Protection Agency's (EPA) Clean Water Act (CWA), statewide through the Texas Clean Rivers Program (TCRP), and locally through TCRP partners such as the Canadian River Municipal Water Authority and Red River Authority. Federal drinking water standards under the Safe Drinking Water Act (SDWA) apply only to water bodies designated as drinking water supplies. Texas Surface Water Quality Standards apply to all perennial and many intermittent water bodies and are designed to protect water quality for all designated uses. According to the TNRCC's 1996 State of Texas Water Quality Inventory (TNRCC, 1996), the principal water quality problems in the Canadian River Basin are elevated dissolved solids, nutrients, and dissolved metals. Natural conditions including the presence of saline springs, seeps, and gypsum outcrops contribute to dissolved solids in most surface waters of the PWPA and elevated metals in localized areas. Elevated nutrients are most often associated with municipal discharge of treated wastewater to surface waters.

Under Section 303 of the Clean Water Act, water bodies which are determined by TNRCC as not meeting Texas Surface Water Quality Standards are included on the State of Texas Clean Water Act Section 303(d) list (TNRCC, 1999a). Water bodies which are placed on the 303(d) list are subject to the development of Total Maximum Daily Loads (TMDL) in an effort to improve water quality. Three segments in the PWPA were identified on the 1999 303(d) list. Water quality concerns and 303(d) listing of segments in the PWPA are shown in Table 1-9. All three segments are classified by TNRCC as low priority and are scheduled for TMDL development between 2001 and 2009.

Table 1-9 Surface Water Segments in the PWPA and Associated Water Quality Issues

		Constituents of Concern					**Potential Contaminant Sources**			
Water Body	**Segment Number**	**nutrients**	**fecal coliform**	**dissolved oxygen**	**dissolved minerals**	**dissolved metals**	**point source**	**storm water/ nonpoint source**	**geologic deposits**	**303(d) listed**
Canadian River Basin										
Canadian River below Lake Meredith	0101	X			X	X	X	X	X	
Lake Meredith	0102	X			X	X	X	X	X	
Canadian River above Lake Meredith	0103	X	X			X	X			X
Wolf Creek	0104	X					X		X	
Rita Blanca Lake	0105	X		X	X	X	X			
Red River Basin										
Lower Prairie Dog Town Fork of Red River	0207	X	X		X	X	X	X		X
Upper Prairie Dog Town Fork of Red River	0229	X	X		X	X				X
Greenbelt Lake	0223	X						X		
Salt Fork of Red River	0222	X					X	X		

Source: TNRCC, 1996 & 1999a

Agricultural and silvicultural nonpoint source water quality problems are managed statewide by the Texas State Soil and Water Conservation Board (TSSWCB) via local soil and water conservation districts. The TSSWCB has a regional office in Hale Center and a field office in Canyon. The Senate Bill 503 process established in 1993 authorizes TSSWCB to work individually with landowners on a volunteer basis to develop and implement site-specific water quality management plans. Conversely, urban and industrial nonpoint source water quality management plans are under the jurisdiction of the TNRCC.

1.3.2.1 Surface Water Bodies

Canadian River Basin

Basin Description. Approximately 13,000 square miles of the Canadian River Basin are located in the PWPA. There are three major reservoirs in the Texas portion of the Basin: Lake Meredith, Palo Duro Reservoir, and Rita Blanca Lake are used for municipal and recreation purposes. Other important reservoirs in the basin include Lake Marvin near the city of Canadian in Hemphill County, and Lake Fryer near Perryton in Ochiltree County.

From the Texas-New Mexico state line eastward, the Canadian River enters an area known as the Canadian River Breaks - a narrow strip of rough and broken land extensively dissected by tributaries of the Canadian River. Elevations in the northwestern portion of the basin extend to 4,400 feet MSL in Dallam County. Elevations in the eastern portion of the basin ranges from 2,175 feet MSL in the river bed at the Texas-Oklahoma border to 2,400 feet MSL in Lipscomb County. Land use in the Texas portion of the Canadian River watershed is predominantly irrigated, dryland farming, and cattle ranching.

Average annual precipitation of the Texas portion of the basin varies from 15 inches near the New Mexico border to 22 inches near the eastern state boundary with Oklahoma. Streamflow measured near Canadian, Texas, approximately 22 miles upstream of the Texas-Oklahoma state line, averages 89 cubic feet per second (CFS), or 64,700 acre-feet per annum (RRA, 1999)

Water Use. In 1996, total water use in the Canadian River Basin portion of the PWPA consisted largely of groundwater sources, with less than three percent contributed by surface water sources. The greatest surface water contribution to total water use by county were Potter and Oldham (42 percent from surface water, each), Hemphill (29 percent surface water), and Gray (23 percent surface water). The remaining counties in the PWPA utilize surface waters for less than 10 percent of their total water use (TWDB, 1998).

Future Water Supplies. Due to the scarcity of locally-developable surface water supplies, any additional water needed for the basin will likely come from reuse of present supplies, development of additional well fields in the Ogallala aquifer, and possible new development in minor aquifers present in the basin. A recent example of additional well field development is the planned Canadian River Municipal Water Authority well fields in Roberts County, which are expected to supplement and improve the quality of surface water from Lake Meredith. The

Authority is permitted to use a maximum of 40,000 acre-feet of groundwater per year from these wells, and up to 50,000 acre-feet under unusual or emergency conditions.

In order to maintain the continued suitability of water from Lake Meredith for municipal and manufacturing purposes, the Bureau of Reclamation, State of Texas and Canadian River Municipal Water Authority are jointly funding and developing an injection well salinity control project near Logan, New Mexico. The well will dispose of brine pumped from other wells along the Canadian River near Logan.

Red River Basin

Basin Description. The Red River Basin is bounded on the north by the Canadian River Basin and on the south by the Brazos, Trinity, and Sulphur river basins. The Red River extends from the northeast corner of the State along the Texas-Arkansas and Texas-Oklahoma state borders, across the Texas Panhandle to its headwaters in eastern New Mexico. The Red River Basin has a drainage area of 48,030 square miles, of which approximately 7,500 square miles occur within the PWPA. The watershed in Texas receives an average annual precipitation varying from 15 inches near the New Mexico border to 55 inches near the Arkansas border. (RRA, 1999).

Major reservoirs in the Red River basin of the PWPA include Greenbelt Reservoir and Bivens Lake, with a combined firm yield of more than 9,400 acre-feet. Other important reservoirs include Baylor Lake and Lake Childress in Childress County, Lake Tanglewood and Buffalo Lake near Canyon in Randall County, and Lake McClellan in southern Gray County.

Water Use. According to the TWDB estimates of water use during 1996, 273,289 acre-feet of water were used in the portion of the PWPA located in the Red River Basin. Water used for irrigated agriculture accounted for about 76 percent of the total water use, with municipal use accounting for approximately 15 percent, and industrial uses accounting for less than 10 percent (TWDB, 1998).

Although surface water supplies account for a larger percent of the total water use in the Red River portion of the PWPA than in the Canadian River portion of the PWPA, less than 15 percent of the total water use in the Red River portion of the PWPA was provided by surface water sources. The counties which relied most heavily on surface water sources in 1996 were Potter (46 percent surface water), Wheeler (36 percent surface water), Hemphill (30 percent surface water), Childress (29 percent surface water), and Randall (23 percent surface water) Counties. The remaining counties each used surface water sources to supply less than 20 percent of their water needs (TWDB, 1998).

1.4 CURRENT WATER USERS AND DEMAND CENTERS

Water use in the PWPA may be divided into three major categories – municipal, industrial, and agricultural. Industrial water use includes mining, manufacturing, and power generation activities. Agricultural water use includes both irrigation and livestock watering. Surface water sources for the PWPA include Lake Meredith and Greenbelt Reservoir. Although water rights exist for Palo Duro Reservoir (Palo Duro River Authority) and Bivens Reservoir (city of Amarillo), water use from these resources has not been developed. It is important to note that water which is not currently provided by the Canadian River Municipal Water Authority (CRMWA) from Lake Meredith or by Greenbelt Municipal and Industrial Water Authority (GM&IWA) from Greenbelt Reservoir is provided from groundwater sources. Appendix A contains historical and projected water demand totals for cities and counties in the PWPA.

CRMWA provides surface water from Lake Meredith to the cities of Amarillo, Borger, and Pampa in the PWPA. Approximately 57 percent of the water used by the CRMWA member cities was surface water, while the remaining 43 percent was groundwater. Water usage by CRMWA member cities in 1996 is summarized in Table 1-10.

Table 1-10. Water Used by CRMWA Member Cities in the PWPA during 1996 (acre-feet)

City	Wells Groundwater	Surface Water CRMWA	Total
Amarillo	21,719	29,981	51,700
Borger	2,868	2,695	5,563
Pampa	1,486	2,675	4,161
Total (acre-feet/yr)	26,073	35,351	61,424

Source: TWDB, 1998

The amount of water from Lake Meredith available to the three member cities by the CRMWA is based on the available supply in the lake. According to CRMWA, the city of Amarillo is entitled to approximately 37 percent, Borger to five percent, and Pampa to seven percent of the reservoir estimated yield. Just over 50 percent of the yield of Lake Meredith is contracted to cities in Region O.

GM & JWA provides surface water from Greenbelt Reservoir for municipal, industrial, mining and irrigation uses. In 1996 GM&IWA supplied just over 2,300 acre-feet of water to the cities of Childress, Clarendon, Hedley, Memphis, and to the Red River Authority for use in the PWPA. Over 1,200 acre-feet were provided to entities for use in Region B (TWDB, 1998).

1.4.1 Municipal Use

The amount of water used for municipal purposes is closely tied to population centers. The TWDB estimates that during 1990, the total municipal water use in the PWPA was 75,394 acre-feet (TWDB, 1998) (Table 1-11). Potter and Randall counties, which contain the city of Amarillo, comprised 61 percent of the municipal water use in the PWPA, while five counties (Armstrong, Donley, Hemphill, Roberts, and Sherman) each comprised less than one percent. Table 1-11 contains the 1990 and projected municipal water use for counties in the PWPA during the planning period. By 2050, Potter and Randall counties are projected to comprise over 70 percent of the municipal water use in the PWPA (TWDB, 1998).

Table 1-11. Historical and Projected Municipal Water Use for the PWPA, (acre-feet)

County	1990	2000	2010	2020	2030	2040	2050
Armstrong	353	357	344	328	324	308	300
Carson *	1,361	1,587	1,823	1,808	1,818	1,806	1,818
Childress *	1,191	1,551	1,536	1,506	1,509	1,523	1,562
Collingsworth	739	841	820	803	790	774	764
Dallam *	1,134	1,324	1,325	1,296	1,263	1,212	1,176
Donley	701	690	635	585	531	490	446
Gray	4,816	4,917	4,873	4,827	4,159	4,039	3,930
Hall	843	790	740	689	647	618	597
Hansford	1,413	1,443	1,452	1,411	1,364	1,301	1,260
Hartley *	756	1,181	1,276	1,231	1,227	1,223	1,236
Hemphill	729	845	852	822	785	750	731
Hutchinson	3,498	4,442	4,319	4,131	3,925	3,672	3,549
Lipscomb *	769	838	834	804	787	760	733
Moore *	3,810	4,223	4,510	4,782	5,139	5,475	5,923
Ochiltree	2,611	2,704	2,738	2,710	2,651	2,578	2,514
Oldham	2,753	2,761	2,765	2,748	2,737	2,705	2,684
Potter *	24,845	26,608	26,964	27,815	29,054	30,362	31,921
Randall *	21,321	25,752	28,488	30,884	34,076	37,831	42,514
Roberts	235	248	249	233	215	199	182
Sherman *	614	745	739	715	670	631	601
Wheeler	901	966	921	874	855	831	827
Total	**75,394**	**84,814**	**88,201**	**91,003**	**94,525**	**99,088**	**105,268**

Source: TWDB, 1998; PWPG, 1999
* revised projections from PWPG, 1999
See Appendix A for details.

The city of Amarillo has a target of providing 30% groundwater and 70% surface water to all its customers. Presently, the city is supplying 35% groundwater and 65% surface water for water supply, not including its major industrial customers. When major industrial customers (IBP, Southwestern Public Service Co., Asarco, etc.), are included, the city of Amarillo is currently providing 45% groundwater and 55% surface water (Freeman, 1999). The groundwater comes from well fields in Carson, Potter, Randall, and Deaf Smith counties.

1.4.2 Industrial Use

Industrial water use includes mining, manufacturing, and power generation, and accounted for approximately 46,207 acre-feet in 1997 (TWDB, 1998). The TWDB and PWPG historical and projected industrial water demands in the PWPA for the planning period are located in Table 1-12. The counties with the highest projected industrial water demand are Hutchinson and Potter counties with a combined demand of 43,766 acre-feet in 2000 and 66,325 acre-feet in 2050. This represents 69 percent of the projected total industrial water demand in 2000 and 75 percent of the projected total industrial water demand in 2050. There is no projected industrial water use for Collingsworth or Hartley counties (TWDB, 1998).

Table 1-12. Historical and Projected Industrial Water Use for the PWPA (acre-feet)

County	1997	2000	2010	2020	2030	2040	2050
Armstrong	19	25	24	25	26	26	26
Carson	2,268	3,008	2,685	2,659	2,772	2,951	3,178
Childress	20	25	24	25	26	27	28
Collingsworth	0	0	0	0	0	0	0
Dallam *	0	235	235	235	235	235	235
Donley	22	24	25	26	27	30	33
Gray	5,211	5,471	5,337	5,328	5,327	5,640	5,996
Hall	22	29	30	31	32	33	34
Hansford	800	1,377	1,265	1,241	1,135	1,138	1,145
Hartley	0	0	0	0	0	0	0
Hemphill	1	4	5	6	7	8	9
Hutchinson	16,584	20,422	22,485	23,747	24,755	27,027	29,298
Lipscomb	87	164	174	180	184	197	218
Moore *	8,979	8,248	8,491	8,568	8,682	9,219	9,788
Ochiltree	204	228	202	186	170	151	155
Oldham	548	502	517	532	548	565	582
Potter *	10,807	23,344	27,851	31,139	32,840	34,938	37,027
Randall	490	565	523	477	480	483	489
Roberts	9	11	11	9	8	8	8
Sherman	23	26	26	27	28	29	31
Wheeler	113	102	43	23	11	5	2
Total	**46,207**	**63,810**	**69,953**	**74,464**	**77,293**	**82,710**	**88,282**

Source: TWDB, 1998; PWPG, 1999
*revised projections from PWPG, 1999

Mining. According to the TWDB, mining water use for the region in 1997 totaled 8,415 acre-feet, or approximately 18 percent of the total industrial water use. Moore County had the highest mining water use with 2,167 acre-feet (TWDB, 1998).

Manufacturing. According to the TWDB, manufacturing water use totaled 33,061 acre-feet for the entire region in 1997, approximately 72 percent of the total industrial water used. Hutchinson County had the highest use with 16,177 acre-feet (TWDB, 1998).

Power Generation. Power generation use includes only water consumed during the power generation process (typically losses due to evaporation during cooling). Water that is diverted and not consumed (i.e., return flow) is not included in the power generation total. According to the TWDB (1998), Potter and Moore are the only counties to have reported water use for power generation activities in 1997, accounting for approximately 10 percent of the total industrial water use for that year.

Southwestern Public Service Company (SPS), the main supplier of electricity in the PWPA, estimates that total water use for power generation in 1997 was 16,679 acre-feet, or approximately 36 percent of the total industrial use in the PWPA as reported by the TWDB

(PWPG, 1999). SPS obtains water from groundwater (Ogallala aquifer), surface water (Lake Meredith), and municipal effluent (city of Amarillo). SPS currently uses most of the wastewater from Amarillo for cooling and is considering investigation into reuse of wastewater from Plainview and Pampa, as well as cities outside of the PWPA to meet the increasing demand of water for power generation.

1.4.3 Agricultural Use

Land Use. Agricultural land use in the PWPA includes irrigated cropland, dryland cropland, and pastureland. Major crops include corn, cotton, hay, peanuts, sorghum, sunflower, soybeans, and wheat. According to 1997 Census of Agriculture estimates presented in Table 1-13, although the number of farms has decreased in the period between 1978 and 1997, the acres of harvested cropland actually increased by approximately 3.6 percent (USDOC, 1998). By 1997, total harvested cropland in the PWPA approximated 2,407,185 acres and was distributed between 3,397 farms. In 1997, approximately 54 percent of the harvested cropland was contained in six counties (Carson, Dallam, Hansford, Moore, Ochiltree, and Sherman) on 1,224 farms.

Table 1-13. Number of Farms and Acres of Harvested Cropland in the PWPA, 1978 through 1997

	1978		1982		1987		1992		1997	
County Name	**Farms**	**Acres**	**Farms**	**Acres**	**Farms**	**Acres**	**Farms**	**Acres**	**Farms**	**Acres**
Armstrong	189	73,120	194	100,434	173	81,576	148	74,910	129	70,345
Carson	293	146,423	295	191,154	266	154,361	242	172,506	217	171,917
Childress	304	76,960	259	93,197	199	66,295	179	86,806	157	92,646
Collingsworth	363	105,762	296	86,337	248	78,250	258	83,752	275	90,581
Dallam	308	250,252	295	261,412	293	203,239	272	230,710	255	297,475
Donley	274	59,083	243	57,784	190	32,035	160	30,073	161	37,735
Gray	241	102,060	217	105,053	193	77,615	164	92,719	161	95,851
Hall	364	122,739	286	105,052	216	78,598	200	86,363	168	88,430
Hansford	275	203,143	260	203,607	259	169,195	221	203,150	188	212,399
Hartley	157	132,816	157	157,962	178	115,245	159	140,626	140	152,776
Hemphill	131	34,926	133	44,703	125	33,748	105	29,505	102	26,881
Hutchinson	100	61,551	82	60,335	87	55,412	94	74,740	67	87,425
Lipscomb	240	81,877	229	89,262	206	74,940*	177	75,212	143	68,003
Moore	204	148,631	205	169,202	224	133,869	203	162,528	156	177,071
Ochiltree	334	212,118	339	267,989	334	214,199	301	233,663	229	233,892
Oldham	113	58,713	109	72,739	94	57,818	82	60,996	73	46,500
Potter	66	27,491	58	21,878	68	25,900*	50	21,925	52	24,288
Randall	363	112,746	380	161,471	364	130,238	315	120,833	266	130,451
Roberts	58	29,309	47	24,906	58	23,399	47	25,999	38	23,958
Sherman	252	207,680	226	194,465	241	168,821	194	181,527	179	218,933
Wheeler	348	75,685	360	91,421	291	65,477	265	62,249	241	59,628
Totals	4,977	2,323,085	4,670	2,560,363	4,307	2,040,220	3,836	2,250,792	3,397	2,407,185

Source: USDOC, 1998
* estimated county average

Irrigation. Irrigation for crop production represents the most significant use of water and accounts for approximately 90 percent of crop receipts within the PWPA. According to TWDB data, use of irrigation water totaled approximately 1,850,192 acre-feet in 1996. Five counties, Dallam, Hansford, Hartley, Moore, and Sherman, accounted for approximately 78 percent of the total irrigation water applied in 1996 (TWDB, 1998).

Concerns have been expressed by commodity groups, producers, and undergroundwater district officials that TWDB projections tended to overestimate agricultural water use. A task in the development of the PWPA regional water plan evaluated the TWDB irrigation and livestock water use projections and provided new projections where necessary. The revised irrigation water use projections from the study are discussed in detail in Chapter 2. Historical and projected irrigation water demands are summarized in Table 1-14. All projected demands in Table 1-14 are revised from the original TWDB projections.

Table 1-14. Projected Irrigation Water Use for the PWPA (acre-feet)

County	1996	2000	2010	2020	2030	2040	2050
Armstrong	9,654	6,753	6,753	6,753	6,753	6,753	6,753
Carson	76,190	93,020	93,020	93,020	93,020	93,020	93,020
Childress	4,703	3,819	3,819	3,819	3,819	3,819	3,819
Collingsworth	32,707	17,811	17,811	17,811	17,811	17,811	17,811
Dallam	393,795	386,403	386,403	386,403	386,403	386,403	386,403
Donley	9,338	17,031	17,031	17,031	17,031	17,031	17,031
Gray	17,863	22,270	22,270	22,270	22,270	22,270	22,270
Hall	11,764	8,077	8,077	8,077	8,077	8,077	8,077
Hansford	211,978	121,492	121,492	121,492	121,492	121,492	121,492
Hartley	224,642	202,232	202,232	202,232	202,232	202,232	202,232
Hemphill	1,815	4,377	4,377	4,377	4,377	4,377	4,377
Hutchinson	50,023	41,758	41,758	41,758	41,758	41,758	41,758
Lipscomb	14,767	35,122	35,122	35,122	35,122	35,122	35,122
Moore	358,509	200,579	200,579	200,579	200,579	200,579	200,579
Ochiltree	85,237	47,300	47,300	47,300	47,300	47,300	47,300
Oldham	7,618	26,497	26,497	26,497	26,497	26,497	26,497
Potter	23,615	24,303	24,303	24,303	24,303	24,303	24,303
Randall	46,751	57,491	57,491	57,491	57,491	57,491	57,491
Roberts	7,057	5,755	5,755	5,755	5,755	5,755	5,755
Sherman	259,210	195,197	195,197	195,197	195,197	195,197	195,197
Wheeler	2,956	5,698	5,698	5,698	5,698	5,698	5,698
Total	**1,850,192**	**1,522,985**	**1,522,985**	**1,522,985**	**1,522,985**	**1,522,985**	**1,522,985**

Source: TWDB, 1998; PWPG, 1999

The study indicated that irrigation water use in 2000 would be 18 percent less than the amount TWDB indicated was used in 1996. The five counties of highest irrigation water use (Dallam, Hansford, Hartley, Moore, and Sherman) are projected to utilize approximately 73 percent of the total irrigation water use in the PWPA in 2000. The irrigation water use projections for future decades in the planning period may change and will need to be revised with each plan update to accurately reflect changes in the farming community due to new technologies, economic considerations, and crop acreages.

Livestock Watering. Water requirements of livestock are influenced by type and size of animal, feed intake and composition, rate of gain, condition of pregnancy, activity, ambient temperature, and water quality (Chirase et al., 1997). Increased levels of protein or salt in cattle diets increases water consumption. The TWDB estimate of total use for livestock watering is based on the total number of livestock in the region and application of a uniform water consumption rate for each type of animal. The different kinds of livestock considered include beef cattle (cows, feedlot cattle, dairy cattle, and stockers on pasture winter or summer) and calves, poultry, sheep and lambs, and hogs and pigs.

Total livestock water use for the PWPA in 1997 was estimated by the TWDB (1998) to be 50,818 acre-feet. Table 1-15 contains TWDB estimates of livestock water use by county supplied by surface and groundwater sources. Moore County and Hansford County accounted for the most livestock water use in the region with Moore using 8,002 acre-feet and Hansford using 6,768 acre-feet. Approximately 52 percent of the total livestock water use was supplied from groundwater sources.

Table 1-15. Estimates of Livestock Water Use in the PWPA during 1997 (acre-feet)

County	Surface Water	Groundwater	Total
Armstrong	128	513	641
Carson	289	1,156	1,445
Childress	438	49	487
Collingsworth	705	78	783
Dallam	717	2,869	3,586
Donley	663	74	737
Gray	2,567	285	2,852
Hall	313	35	348
Hansford	4,061	2,707	6,768
Hartley	2,938	2,938	5,876
Hemphill	1,234	822	2,056
Hutchinson	466	52	518
Lipscomb	867	96	963
Moore	1,600	6,402	8,002
Ochiltree	1,562	174	1,736
Oldham	1,582	176	1,758
Potter	68	610	678
Randall	982	3,928	4,910
Roberts	289	32	321
Sherman	825	3,299	4,124
Wheeler	2,006	223	2,229
TOTAL	**24,300**	**26,518**	**50,818**

Source: TWDB, 1998

The majority of livestock water used in the PWPA is accounted for by feedlot cattle and swine production. According to Southwestern Public Service Company (SPS) (Bilbrey et al., 1999), 16 of the PWPA counties within the SPS service area have cattle feedlots or starter (backgrounding) lots. These cattle feeding operations had a combined capacity of 1,284,100 head and marketed 2.63-2.83 million head in 1998. The largest cattle feeding operations are in Hansford and Hartley counties. Other counties with more than 100,000 head feedlot capacity are: Dallam, Moore, Ochiltree, Randall and Sherman.

Swine production is concentrated generally in counties along the northern portion of the PWPA. It is estimated that production in this area will experience an annual growth rate of approximately 8 percent for 11 years and then 1.5 percent thereafter, with a corresponding increase in water demand (PWPG, 1999).

Methods used to develop TWDB livestock water use projections were also evaluated in the PWPG agricultural water use study and new projections were developed (Table 1-16). Seven counties, Dallam, Hansford, Hartley, Moore, Ochiltree, Randall, and Sherman, are projected to use over 71 percent of the total livestock water use in the PWPA in 2000, and approximately 77 percent by 2050.

Table 1-16. Projections for Livestock Water Use in the PWPA (acre-feet)

County	2000	2010	2020	2030	2040	2050
Armstrong	590	647	701	755	814	880
Carson	1,084	1,154	1,226	1,293	1,366	1,446
Childress	295	313	373	385	397	411
Collingsworth	608	637	710	735	764	795
Dallam	6,973	10,737	12,234	13,799	15,590	17,644
Donley	1,171	1,251	1,331	1,392	1,459	1,531
Gray	1,973	2,585	2,933	3,194	3,484	3,808
Hall	289	301	310	320	330	343
Hansford	5,192	8,993	10,165	11,320	12,629	14,115
Hartley	4,066	4,471	4,912	5,223	5,555	5,912
Hemphill	1,452	1,579	1,721	1,883	2,004	2,135
Hutchinson	590	657	722	781	845	915
Lipscomb	1,127	2,281	2,645	3,007	3,424	3,906
Moore	3,510	7,158	8,105	9,059	10,146	11,386
Ochiltree	6,747	7,253	8,255	9,308	10,514	11,897
Oldham	1,717	1,888	2,068	2,222	2,390	2,574
Potter	475	519	564	612	665	724
Randall	3,067	3,387	3,752	4,019	4,308	4,621
Roberts	525	574	618	668	722	782
Sherman	3,813	5,576	6,279	6,945	7,695	8,543
Wheeler	1,529	1,632	1,788	1,868	1,954	2,046
TOTAL	**46,793**	**63,593**	**71,412**	**78,788**	**87,055**	**96,414**

Source: PWPG, 1999

1.5 NATURAL RESOURCES

1.5.1 Natural Region

A natural region is classified primarily on the common characteristics of climate, soil, landforms, microclimates, plant communities, watersheds, and native plants and animals (TPWD, 1999a). As shown in Figure 1-5, the PWPA includes portions of the Rolling Plains and the High Plains natural regions.

The High Plains, also known as the Llano Estacado, are the southernmost extension of the Great Plains, a physiographic province that extends along the eastern slope of the Rocky Mountains from Canada to southwestern Texas. The High Plains comprise almost 8,000,000 acres of the PWPA and are characterized by relatively flat terrain with a general but very gradual slope toward the southeast. The large expanse of nearly level grassland is interrupted at various locations by small ephemeral lakes (playas), dune fields, draws, and drainages which are tributaries of the Canadian and Red rivers.

The Rolling Plains encompass over 4,000,000 acres within the PWPA, including three subregions – Mesquite Plains, Escarpment Breaks, and the Canadian Breaks (TAMU, 1999a). The Mesquite Plains subregion is located in the region of Dallam, Sherman, Hansford, and Hartley counties. This area has gently rolling topography with mesquite brush and short grasses. The vicinity of Wheeler, Gray, Donley, and Armstrong counties is included in the Escarpment Breaks, a natural boundary between the upper shortgrass plains and the mixed grass rolling plains. The Canadian Breaks subregion is similar to the Escarpment Breaks, but includes the floodplain and sandhills of the Canadian River in the northern Panhandle (vicinity of Moore, Hutchinson, Roberts, Oldham, Hartley, and Hemphill counties).

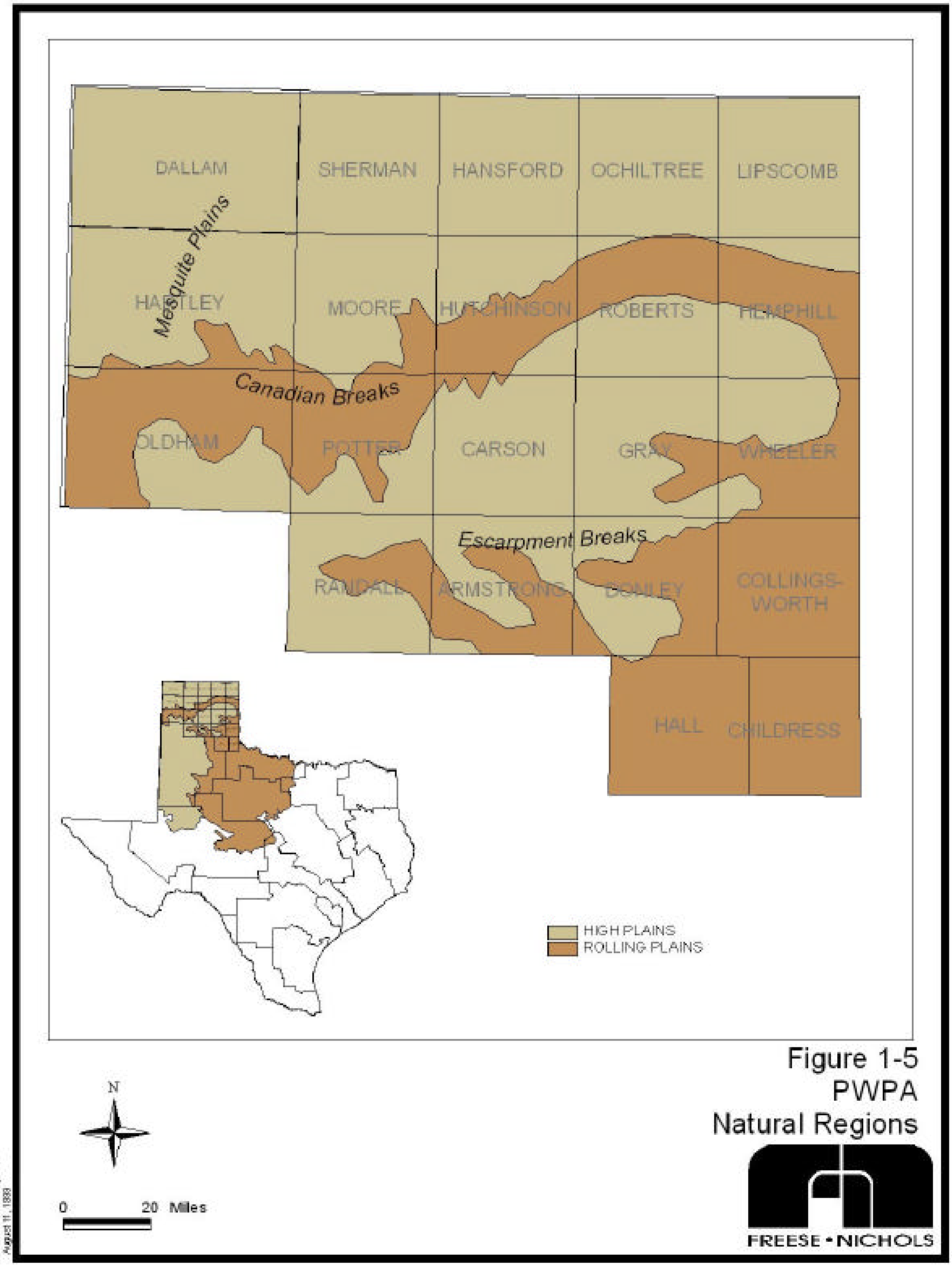


Figure 1-5
PWPA
Natural Regions

1.5.2 Regional Vegetation

The PWPA is located in two vegetation regions which generally correspond to the natural regions described in the previous section – the High Plains and Rolling Plains. Figure 1-6 illustrates the types of vegetation characteristic of the PWPA.

The vegetation of the High Plains is variously classified as mixed prairie, shortgrass prairie, and in some locations on deep, sandy soils as tallgrass prairie. Blue grama, buffalograss, and galleta are the principal vegetation on the clay and clay loam sites. Characteristic grasses on sandy loam soils are little bluestem, western wheatgrass, sideoats grama, and sand dropseed, while shinnery oak and sand sagebrush are restricted to sandy sites. The High Plains are characteristically free from brush, but sand sagebrush and western honey mesquite, along with pricklypear and yucca, have invaded the sandy and sandy loam areas. Several species of dropseeds are abundant on coarse sands. Various aquatic species such as curltop smartweed are associated with the playa lakes (TAMU, 1999b).

The Rolling Plains vegetation includes tall- and mid-grasses such as little, big, and sand bluestems; sideoats grama; indiangrass; switchgrass; hairy and blue grama, Canada wildrye, and western wheatgrass on the moister sites. Buffalograss, common curlymesquite, tobosa, threeawns, sand dropseed, and hooded windmillgrass are more common on the more xeric or overgrazed sites. The area is approximately half mesquite woodland and half prairie grassland.

Generally as a result of overgrazing and abandonment of cropland, woody invaders such as mesquite, lotebush, pricklypear, algerita, tasajillo, and others are common on all soils. Shinnery oak and sand sagebrush invade the sandy lands while redberry juniper has spread from rocky slopes to grassland areas. Western ragweed and annual broomweed are also common invaders (TAMU, 1999b).

Brush Encroachment. Brush encroachment is a concern in the Canadian River Breaks and the North Rolling Plains (the eastern panhandle counties of Collingsworth, Hall, Donley, and Wheeler). Brush canopies range from light to heavy in these counties and in the Canadian River Breaks (Potter, Moore, and Oldham Counties especially). The major species of concern is mesquite, which has been shown to be increasing in plant population virtually everywhere it is found. Other species that are encroaching are sand sagebrush, sand shinoak, and yucca. Salt cedar, a phreatophyte, now infests much of the Canadian River stream banks and has moved out onto the adjacent river terraces. Plants such as salt cedar are likely to use much more water than the upland species brush. According to the NRCS Resource Data and Concerns files in the local field offices, there are approximately 1,200,000 acres of brushy species that would be classified as medium to high priority for treatment within the PWPA.

A program recently initiated through the Texas State Soil and Water Conservation Board (TSSWCB) includes a study of the feasibility of brush management in eight Texas watersheds, including portions of the Canadian River Basin. The studies focused on economic aspects and potential changes in water availability related to brush management.

For the Canadian River Basin, the study examined the water availability benefits of controlling moderate to heavy concentrations of mesquite and mixed brush. Approximately 0.067 acre-feet water per acre per year additional water is estimated to be available with a continuing brush control program (Bretz, etal, 2000)

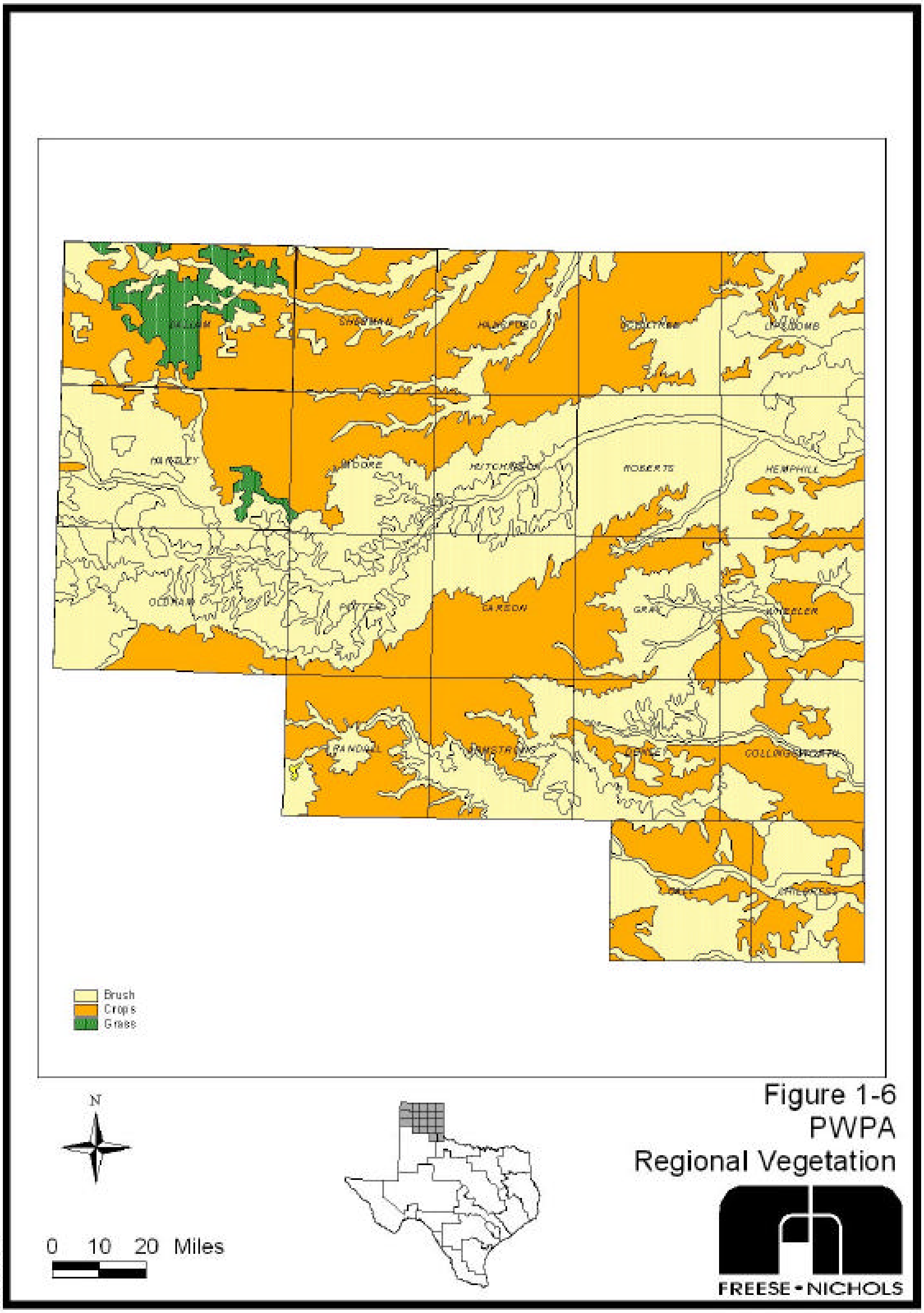


Figure 1-6
PWPA
Regional Vegetation

1.5.3 Regional Geology

Within the High Plains are sandstone and shale beds of the Cenozoic, Mesozoic and Paleozoic Ages. Major geologic systems which are found in the PWPA include the Tertiary, Triassic, Cretaceous, and Permian. Throughout the PWPA, the outcropping geology consists of westward-dipping Permian, Triassic and Tertiary age sandstone, shale, limestone, dolomite and gypsum. The Tertiary Ogallala Group can be found along the western section of the PWPA and includes the Birdwell/Couch Formation.

The eastern portion of the PWPA includes the Ogallala, Dockum, Quartermaster, Whitehorse, and Pease River groups (Figure 1-7). The Dockum Group formation includes the Santa Rosa, Trujillo, and Chinle Formations. The Whitehorse Group formations are undifferentiated in the west due to widespread solution, collapse, and erosional features. The Blaine Gypsum is the primary formation within the Pease River Group (AAPG, 1979).

1.5.4 Mineral Resources

Mineral resources produced in the PWPA (Table 1-17) are primarily oil and natural gas. Non-petroleum minerals produced include sand, gravel, caliche, stone and helium. Three counties, Dallam, Hall, and Randall, reportedly do not have any significant mineral production (Ramos, 1997).

Table 1-17. Mineral Resource Production for Counties in the PWPA

County	Sand	Gravel	Caliche	Stone	Oil	Gas	Helium
Armstrong	√	√					
Carson					√	√	
Childress					√		
Collingsworth					√	√	
Dallam							
Donley						√	
Gray					√	√	
Hall							
Hansford				√	√	√	√
Hartley						√	
Hemphill					√	√	
Hutchinson	√	√			√	√	
Lipscomb					√	√	
Moore					√	√	√
Ochiltree		√	√		√	√	
Oldham	√	√		√	√	√	
Potter					√	√	
Randall							
Roberts					√	√	
Sherman					√	√	
Wheeler					√	√	

Source: Ramos, 1997.

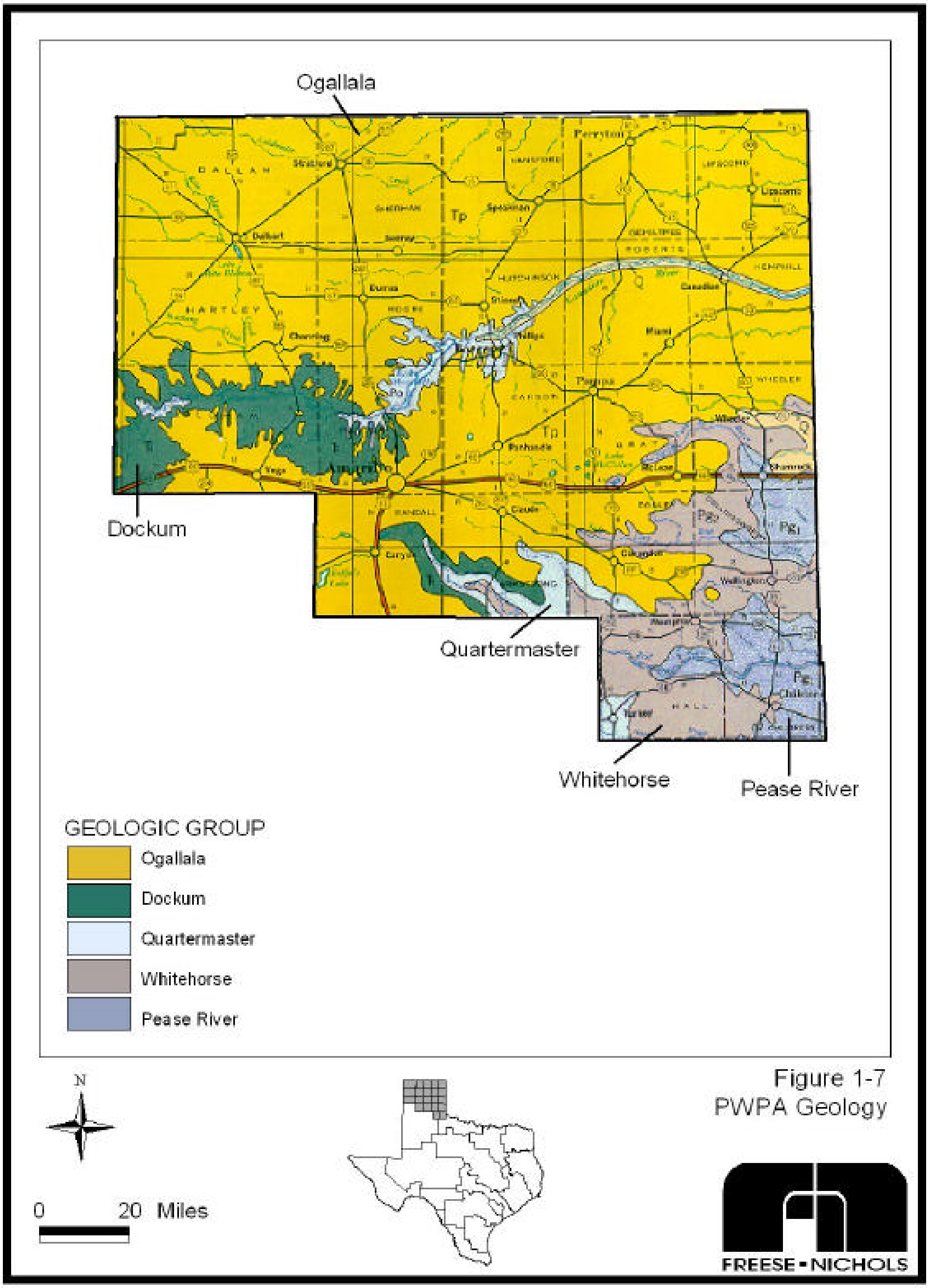


Figure 1-7
PWPA Geology

1.5.5 Soils

Soils of the High Plains formed under grass cover in Rocky Mountain outwash and sediment of variable sand, silt, clay, and lime content (Runkles, 1968). Calcium carbonate and to some extent gypsum are present in most soil profiles, and rainfall has been insufficient to leach these carbonates from the soil profiles. Many of the surface soils are moderately alkaline to calcareous and low in organic matter. The major soil associations found in the PWPA may be characterized as nearly level or outwash soils (Figure 1-8). Most of the nearly level soils in the PWPA have loamy surfaces and clayey subsoils. The major associations involving these nearly level soils are:

- Pullman-Olton-Mansker;
- Sherm-Gruver-Sunray;
- Dallam-Sunray-Dumas; and
- Sunray-Conlen-Gruver.

Much of the irrigation is on these soils because they are highly productive if sufficient water is available. Much of the eastern portion of the PWPA is characterized by red to brown soils formed from outwash of the clayey to silty red beds. Many of these soils have loamy surface layers and loamy subsoils. Some are shallow over indurated caliche. The major associations included in these outwash soils are:

- Mansker-Berda-Potter;
- Woodward-Quinlan-Vernon; and
- Miles-Springer-Woodward.

Infiltration rate of soils used as cropland is primarily affected by soil properties such as texture, structure, aggregate stability, and salinity status. Surface crusting tendencies and organic matter content, which are influenced by tillage management, play an important role in influencing infiltration rates. High soil density in the lower tillage zone (plow pan) restricts hydraulic conductivity and consequent irrigation application rates in many soils, thus enhancing runoff. Irrigation water quality also influences infiltration rate over time, especially with regard to total salinity, sodium concentration, and organic matter content when wastewater is used. Infiltration rates can vary significantly within a field and over time due to soil differences and cultural practices.

The nearly level soils are finer textured and have a restrictive horizon below the plowed layer that greatly reduces water intake after initial wetting to below 0.06 inches per hour (1.5 mm/hr). This profoundly affects soil management and irrigation practices. Root zone permeabilities for most other soils are usually well above 0.2 inches per hour (5 mm/hr). Plant available water holding capacities (i.e., difference in water content between field capacity at –0.33 bars matric potential and wilting point at –15 bars) varies from 0.7 to 2.4 inches per foot within the root zone. Soils with loam, silt loam, and clay load textures generally have higher water holding capacities than sandier soils. Each additional inch of plant available water in the soil at planting time can boost crop yields significantly. Therefore, soil water storage during a fallow season is an important consideration.

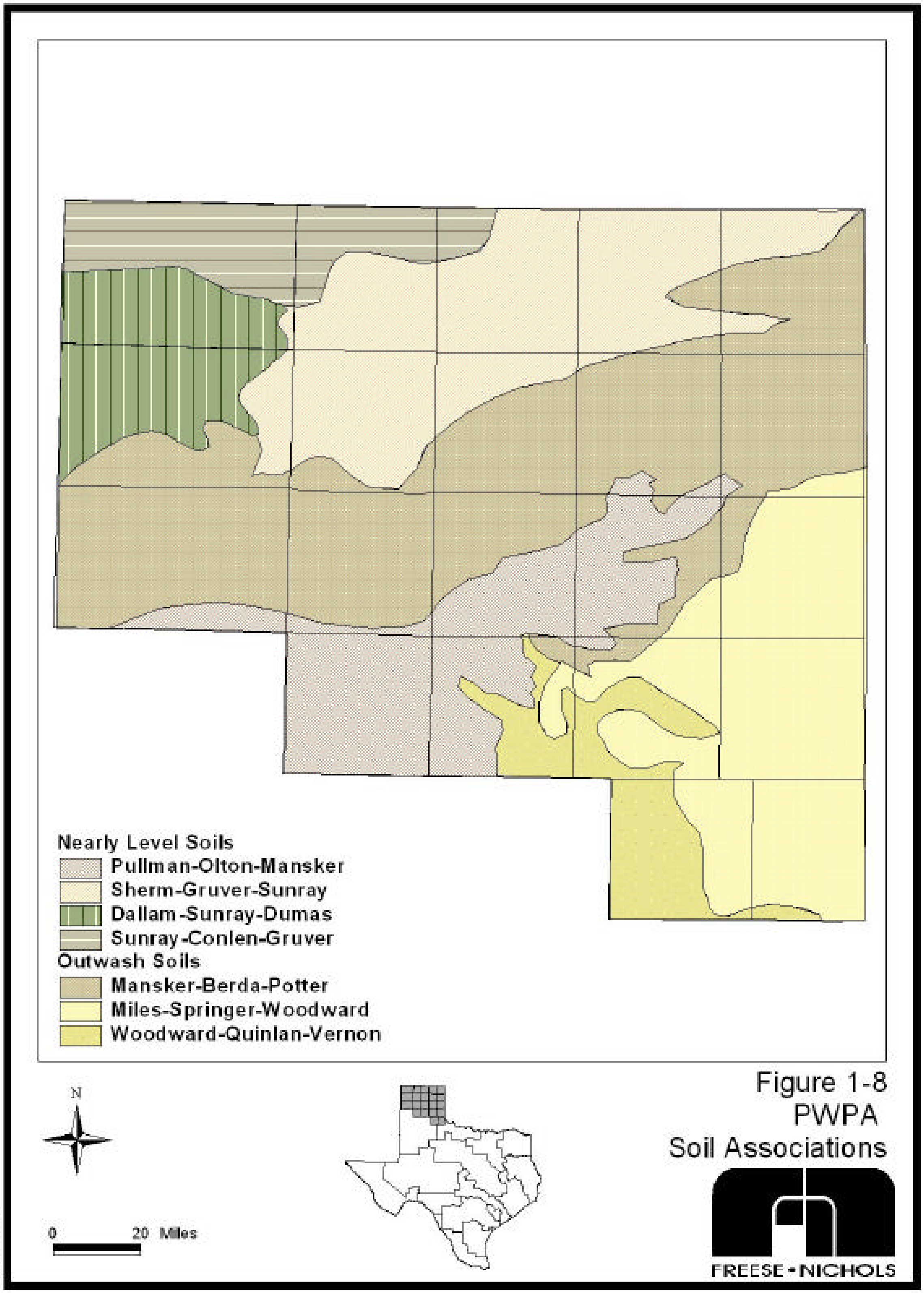


Figure 1-8
PWPA
Soil Associations

1.5.6 Wetlands

Wetlands are especially valued because of the wide variety of functions they perform, and the uniqueness of their plant and animal communities. Ecologically, wetlands can provide high quality habitat in the form of foraging and nesting areas for wildlife, and spawning and nursery habitat for fish. Approximately 4,884 playa lakes are located in the PWPA (Table 1-18), covering approximately one percent of the surface area (NRCS, 1999).

The most visible and abundant wetland features within the PWPA are playa lakes. These are ephemeral wetlands which are an important element of surface hydrology and ecological diversity. Most playas are seasonally flooded basins, receiving their water only from rainfall or snowmelt. Moisture loss occurs by evaporation and infiltration through the soil to underlying aquifers.

Playa basins have a variety of shapes and sizes which influence the rapidity of runoff and rates of water collection. Playas have relatively flat bottoms, resulting in a relatively uniform water depth, and are generally circular to oval in shape. Typically, the soil in the playas is the Randall Clay.

Playa basins also supply important habitat for resident wildlife. The basins provide mesic sites in a semi-arid region and therefore are likely to support a richer, denser vegetative cover than surrounding areas. Moreover, the perpetual flooding and drying of the basins promotes the growth of plants such as smartweeds, barnyard grass, and cattails that provide both food and cover. The concentric zonation of plant species and communities in response to varying moisture levels in basin soils enhances interspersion of habitat types (TPWD, 1999b). Playas offer the most significant wetland habitats in the southern quarter of the Central Flyway for migrating and wintering birds. Up to two million ducks and hundreds of thousands of geese take winter refuge here. Shorebirds, wading birds, game birds, hawks and owls, and a variety of mammals also find shelter and sustenance in playas (TPWD, 1999b).

Saline lakes are another type of wetland found primarily in the southern high plains. These lakes, mainly south of Amarillo, tend to be much larger than playa basins and irregular in shape.

Table 1-18. Physical Characteristics of Playas Within the PWPA

County	Number of Playa Lakes	Total Playa Area (acres)	Percent of County Area	Largest Playa (acres)	Smallest Playa (acres)	Average Perimeter (miles)
Armstrong	675	15,177	2.6%	356	1	0.6
Carson	544	18,270	3.1%	404	<1	0.7
Childress	8	116	<0.1%	24	7	0.6
Collingsworth	0	0	0.0%	0	0	0.0
Dallam	219	4,125	0.4%	201	2	0.6
Donley	107	1,903	0.3%	181	1	0.5
Gray	748	12,907	2.2%	388	1	0.5
Hall	0	0	0.0%	0	0	0.0
Hansford	342	6,981	1.2%	399	1	0.6
Hartley	125	3,791	0.4%	126	4	0.8
Hemphill	8	100	<0.1%	34	5	0.5
Hutchinson	167	3,297	0.6%	141	2	0.6
Lipscomb	18	234	<0.1%	36	3	0.5
Moore	190	4,635	0.8%	165	1	0.6
Ochiltree	593	15,836	2.7%	843	1	0.7
Oldham	160	4,336	0.5%	438	1	0.6
Potter	96	3,203	0.6%	292	2	0.7
Randall	561	16,792	2.9%	243	1	0.7
Roberts	109	1,368	0.2%	278	1	0.4
Sherman	214	4,498	0.8%	212	2	0.6
Wheeler	0	0	0.0%	0	0	0.0
REGION TOTAL	**4,884**	**117,569**	**0.9%**	**843.35**	**<1**	**0.6**

Source: NRCS, 1999

1.5.7 Aquatic Resources

Rivers and reservoirs within the planning area are recognized as important ecological resources. These are sources of diverse aquatic flora and fauna. Important river systems in the planning area are the Canadian River and the Red River. Reservoirs in the PWPA include Lake Meredith, Palo Duro Reservoir, Rita Blanca Lake, Marvin Lake, and Fryer Lake in the Canadian River Basin, and Greenbelt Reservoir, Bivens Reservoir, McClellan Lake, Lake Tanglewood, Baylor Lake, Lake Childress, and Buffalo Lake in the Red River Basin.

The high salinity of much of the area's surface and groundwater resources, largely due to natural salt deposits, presents a challenge to natural resource planners and managers. Municipal, agricultural, and industrial water users strive to lower the salinity of certain surface-water supplies for higher uses. One method for this is by intercepting and disposing of the naturally saline flows of certain streams, usually originating from natural salt springs and seeps, in order to improve the quality of downstream surface-water supplies. There are several such chloride control projects, both existing and proposed, in the study area.

Ecologically Unique Resources. Senate Bill 1 requires that the State Water Plan identify river and stream segments of unique ecological value. The identification of such resources may be done regionally by each Regional Water Planning Group or by the state. Several criteria are used to identify streams with unique ecological values. These include biological and hydrologic functions, riparian conservation areas, high water quality, exceptional aquatic life, or high aesthetic quality. Also, stream or river segments where water development projects would have significant detrimental effects on state or federally listed threatened or endangered species may be considered ecologically unique.

The Texas Parks and Wildlife Department (TPWD) has developed a draft list of Texas streams and rivers satisfying at least one of the criteria defined in SB-1 for ecologically unique river and stream segments. The PWPG is not currently recommending any segments in the PWPA for designation, the list developed by the TPWD for the PWPA is included in Appendix B for informational purposes.

1.5.8 Wildlife Resources

The abundance and diversity of wildlife in the PWPA is influenced by vegetation and topography, with areas of greater habitat diversity having the potential for more wildlife species. The Rolling Plains have a greater diversity of wildlife habitat, such as the Canadian Breaks and escarpment canyons. Mule deer, white-tailed deer, wild turkey are found along canyons and wooded streams. Antelope occur on the undulating prairies of the Canadian Breaks area and on the level margins of the High Plains. A number of wildlife species occur throughout the PWPA, including various lizards and snakes, rodents, owls and hawks, coyote, skunks, raccoons, and feral hogs.

Land in the High Plains is generally used for rangeland and cropland and support pronghorn (antelope), prairie dogs, jackrabbits, coyotes, and small mammals. Playas and grain fields attract large numbers of migratory ducks, geese and sandhill cranes. Pheasants and scaled (blue) quail can be locally abundant near corn and other grain fields.

The presence or potential occurrence of threatened or endangered species is an important consideration in planning and implementing any water resource project or water management strategy. Both the state and federal governments have identified species that need protection. Species listed by the U.S. Fish and Wildlife Service (USFWS) are afforded the most legal protection, but the Texas Parks and Wildlife Department (TPWD) also has regulations governing state-listed species. Appendix B contains the state or federally protected species which have the potential to occur within the PWPA. This list does not include species without official protection such as those proposed for listing or species that are considered rare or otherwise of special concern.

1.6 THREATS AND CONSTRAINTS TO WATER SUPPLY

Threats and constraints to water supply in the PWPA are related to surface water and groundwater sources. The actual and potential threats may be similar or unrelated for surface or groundwater. Because water use in the PWPA is primarily for agriculture, some of the constraints to use are not as severe as those for water used for human consumption. However, in most cases the same water sources are used for both agricultural and potable water supply.

Issues that are of concern for water supply in the PWPA include aquifer depletions due to pumping exceeding recharge; contamination of surface water and groundwater; and drought related shortages for both surface water and groundwater. Potential groundwater contamination may supersede water quantity as a consideration in evaluating the amount of water available for a use (see Section 5.4.15, Wheeler).

Most water used in the PWPA is supplied from aquifers such as the Ogallala, making aquifer depletion a potentially major constraint on water sources in the region. Depletions lower the water levels, making pumping more expensive and reducing the potential available supply. Another potential constraint to both groundwater pumping and maintenance of stream flows relates to restrictions that could be implemented due to the presence of endangered or threatened species. The recent Federal listing of the Arkansas River shiner as threatened species has the potential to affect water resource projects as well as other activities in Hemphill, Hutchinson, Oldham, Potter, and Roberts Counties.

Potential contamination of groundwater may be associated with oil-field practices, including seepage of brines from pits into the groundwater; brine contamination from abandoned wells; and broken or poorly constructed well casings. Agricultural and other practices may have contributed to elevated nitrates in groundwater and surface water. Surface waters in the PWPA may also experience elevated salinity due to brines from oil-field operations, nutrients from municipal discharges, and other contaminants from industrial discharges. Other potential sources of contaminants include industrial facilities such as the Pantex plant near Amarillo; the Celanese plant at Pampa; an abandoned smelter site at Dumas; and concentrated animal feeding operations in various locations throughout the PWPA. However, most of these potential sources of contamination are regulated and monitored by TNRCC or other state agencies. Naturally occurring brine seeps also restrict the suitability of surface waters, such as Lake Meredith, for certain uses.

Drought Contingency. Drought contingency plans are required by the TNRCC for wholesale water suppliers, irrigation districts and retail water suppliers. To aid in the preparation of the water plans, workshops sponsored by the Texas Rural Water Association (TRWA), Texas Water Utilities Association (TWUA), TNRCC and TWDB have been provided for those required to submit plans.

SB-1 requires that surface water right holders that supply 1,000 acre-feet or more per year for non-irrigation use and 10,000 acre-feet per year for irrigation use prepare a water conservation plan and submit it to TNRCC by September 1, 1999. According to TNRCC (1999c), entities required to submit a plan in accordance with SB-1 are the Canadian River MWA, Greenbelt M & IWA, and Palo Duro River Authority.

Drought contingency plans have been prepared by different stakeholders in the planning area. Canadian River Municipal Water Authority, Greenbelt Municipal and Industrial Water Authority, city of Gruver, city of Canyon, city of Borger, Pantex Water System, TCW Supply Inc., and Moortex Water Supply Corporation are the major water suppliers with available drought contingency plans within PWPA.

As discussed in Chapter 3, all of the major reservoirs in the PWPA are currently still in their critical period, the time frame typically used to identify the drought of record. Using that definition, the PWPA is in a drought of record.

Drought trigger conditions for the reservoirs will be those detailed in each of the respective reservoir operators' drought contingency plans. Drought triggers for all groundwater sources will be based on local atmospheric conditions using the currently available PET stations.

Precipitation at less than 50 percent of the 30-year average for the month and 55 percent of the 30 year average of the preceding twelve months triggers the Alert Stage of drought response.

Precipitation at less than 25 percent of the 30-year average for the month and 45 pecent of the 30-year average of the preceding twelve months triggers the Warning Stage of drought response.

The PWPA will be divided into geographical areas based on location of existing PET stations for drought trigger and response purposes. The current locations of PET stations are Dalhart, Etter, Morse, Perryton, Bushland, White Deer, and Wellington.

Below is the breakdown of drought trigger and response zones in the PWPA:

Dalhart	Dallam & Hartley
Etter	Sherman and Moore
Morse	Hutchinson and Hansford
Perryton	Ochiltree, Lipscome, Roberts and Hemphill
Bushland	Oldham, Potter, and Randall
White Deer	Carson, Armstrong, and Gray
Wellington	Wheeler, Collingsworth, Childress, Donley and Hall

Drought Response

As the PWPG is a planning body only, with no implementation authority, it should be carefully considered as to what appropriate drought response should be included in the Plan. Currently, local public water suppliers, water districts, etc. are all required to have adopted a Drought Contingency Plan. These drought contingency plans contain drought responses unique to each specific entity. As these entities are the only ones who have the authority to manage their particular water supply or area of authority, it could be suggested that these are the only entities who can describe or implement a drought response.

Example:

When the Alert Stage Drought Conditions have been triggered as described above, the respective reservoir operators and groundwater districts will notify all affected entities in the relevant geographical area. Those entities exercise their authority to implement their own drought contingency plans as they deem necessary.

When the Warning Stage Drought Conditions have been triggered as described above, the respective reservoir operators and groundwater districts will notify all affected entities in the relevant geographical area. These entities exercise their authority to implement their own drought contingency plans as they deem necessary.

In addition to the individual entities DCPs, the PWPG has prepare this regional water plan to be in general accordance with groundwater districts and net depletion rules/management goals. The PQPG has defined available groundwater as being 50 percent of the total water in storage to allow for water to remain for future planning cycles beyond the current 50-year period.

1.7 EXISTING PROGRAMS AND GOALS

1.7.1 Federal Programs

Clean Water Act. - The 1972 Federal Water Pollution Control Act, which, as amended, is known as the Clean Water Act (CWA), is the federal law with the most impact on water quality protection in the PWPA. The CWA (1) establishes the framework for monitoring and controlling industrial and municipal point source discharges through the National Pollutant Discharge Elimination System (NPDES); (2) authorizes federal assistance for the construction of municipal wastewater treatment facilities; and (3) requires cities and certain industrial activities to obtain permits for stormwater or non-point source pollution (NPS) discharges. The CWA also includes provisions to protect specific aquatic resources. Section 303 of the CWA establishes a non-degradation policy for high quality waters and provides for establishment of state standards for receiving water quality. Section 401 of the CWA allows states to enforce water quality requirements for federal projects such as dams. Section 404 of the CWA provides safeguards for wetlands and other waters from the discharge of dredged or fill material. In accordance with Section 305 of the CWA, TNRCC prepares and submits to the U.S. Environmental Protection Agency a Water Quality Inventory. Other provisions protect particular types of ecosystems such as lakes (Section 314), estuaries (Section 320) and oceans (Section 403). Several of these provisions are relevant to specific water quality concerns in the PWPA.

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

North American Waterfowl Management Playa Joint Ventures - The Playa Lakes Joint Venture -- a partnership of state and federal agencies, landowner's conservation groups and businesses was established in 1990 to coordinate habitat protection and enhancement efforts on the southern High Plains. Because the playa lakes region provides crucial wintering, migrating and breeding habitat for waterfowl in the Central Flyway, this is one of 10 priority efforts under the North American Waterfowl Management Plan, an agreement between the United States, Canada and Mexico to restore declining waterfowl populations across the continent.

Almost all of the 25,000 playas in Texas, Kansas, New Mexico, Oklahoma, Colorado are privately owned, and much of the surrounding landscape is in agriculture. Programs are being developed that will provide incentives to private landowners to manage playas for waterfowl and other wildlife.

Joint Venture efforts focus on providing:

- sufficient wetland acres to avoid undesirable concentrations of waterfowl that lead to disease outbreaks;
- enough feeding areas for both breeding and wintering birds; and
- healthy upland and wetland habitats to maximize waterfowl production and winter survival.

The Federal Agriculture Improvement and Reform Act of 1996 (The National Farm Bill) - The 1996 farm legislation, signed into law in April, expanded on the market-oriented provisions of previous legislation and redesigned farm income support and supply management programs for major program crops. The Federal Agriculture Improvement and Reform Act of 1996--in effect through 2002--greatly increased planting flexibility for individual program participants.

In addition, the conservation provisions of the 1996 farm bill simplified existing conservation programs and improved their flexibility and efficiency. The bill also created new programs to address high priority environmental protection goals.

The farm bill authorized more than $2.2 billion in additional funding for conservation programs, extended the Conservation Reserve Program and Wetland Reserve Program, and created new initiatives to improve natural resources on America's private lands.

To qualify for market transition payments under basic commodity programs which replaced traditional farm subsidies, farm operators must agree to abide by Conservation Compliance and Wetlands Conservation (Swampbuster) provisions in the 1996 farm bill.

1.7.2 Interstate Programs

Canadian River Compact. - Entered into by New Mexico, Oklahoma and Texas, the compact guarantees that Oklahoma shall have free and unrestricted use of all waters of the Canadian River in Oklahoma, and that Texas shall have free and unrestricted use of all water of the Canadian River in Texas subject to limitations upon storage of water (500,000 acre-feet of storage in Texas until such time as Oklahoma has acquired 300,000 acre-feet of conservation storage, at which time Texas' limitation shall be 200,000 acre-feet plus the amount stored in Oklahoma reservoirs). New Mexico shall have free and unrestricted use of all waters originating in the drainage basin of the Canadian River above Conchas Dam, and free and unrestricted use of all waters originating in the drainage basin of the Canadian River below Conchas Dam, provided that the amount of conservation storage in New Mexico available for impounding waters originating below Conchas Dam shall be limited to 200,000 acre-feet. Water originating from the North Canadian River in Texas is limited to domestic and municipal use.

Red River Compact. - The Red River Compact was entered into by the states of Arkansas, Oklahoma, Louisiana and Texas for the purpose of apportioning the water of the Red River and its tributaries. The Red River is defined as the stream below the crossing of the Texas-Oklahoma state boundary at longitude 100 degrees west. The two reaches pertinent to the states of Oklahoma and Texas are Reach I and Reach II. Reach I is defined as the Red River and its tributaries from the New Mexico-Texas state boundary to Denison Dam. Reach II is defined as the Red River from Denison Dam to the point where it crosses the Arkansas-Louisiana state boundary and all tributaries which contribute to the flow of the River with in this Reach.

In Reach I, four subbasins are defined and the annual flow within these subbasins is apportioned as follows: 60 percent to Texas and 40 percent to Oklahoma in subbasin 1; Oklahoma has free and unrestricted use of water in subbasin 2; Texas has free and unrestricted use of water in subbasin 3; and equal quantities to both states of the annual flows and storage capacity of Lake Texoma in subbasin 4. In Reach II, annual flow in subbasin 1 is apportioned wholly to Oklahoma, while annual flow in subbasin 2 is apportioned wholly to Texas.

1.7.3 State Programs

The TNRCC is the state lead agency for water resource protection, administering both state and federally mandated programs, such as the Resource Conservation and Recovery Act; the Clean Water Act; the Comprehensive Environmental Response, Compensation Liability and Recovery Act; the Safe Drinking Water Act; and state management plan development for prevention of pesticide contamination of groundwater under the Federal Insecticide, Fungicide, and Rodenticide Act. The TNRCC conducts regulatory groundwater protection programs that focus on: (1) prevention of contamination; and (2) identification, assessment, and remediation of existing problems (TNRCC, 1997).

<u>Surface Water Rights.</u> – Surface water rights are administered by the TNRCC under Section 11 of the Texas Water Code. The TNRCC has the authority to revise existing water rights and grant new water rights if unappropriated water is available in the source of supply. The issuance of new water rights permits by the TNRCC is based on the following criteria to determine the availability of supply:

- At least 75 percent of the water can be expected to be available at least 75 percent of the time.
- For municipalities with no backup supply, if 100 percent of the water can be expected to be available 100 percent of the time.
- For municipalities with a backup supply, a permit may be issued to use water that can be expected to be available less than 100 percent of the time.

<u>Texas Pollutant Discharge Elimination System (TPDES) Program.</u> – The TPDES is the state program to carry out the National Pollutant Discharge Elimination System (NPDES) promulgated under the Clean Water Act. The Railroad Commission of Texas maintains authority in Texas over discharges associated with oil, gas, and geothermal exploration and development activities. The TPDES program covers all permitting, inspection, public assistance, and enforcement associated with:

- discharges of industrial or municipal waste;
- discharges and land application of waste from concentrated animal feeding operations;
- discharges of industrial and construction site storm water;
- discharges of storm water associated with city storm sewers;
- oversight of municipal pretreatment programs; and

- disposal and use of sewage sludge.

Texas Clean Rivers Program (TCRP). - The TCRP was established with the promulgation of the Texas Clean Rivers Act of 1991. TCRP provides for biennial assessments of water quality to identify and prioritize water quality problems within each watershed and subwatershed. In addition, TCRP seeks to develop solutions to water quality problems identified during each assessment.

Water for Texas (1997). - The Water for Texas Plan was adopted by the TWDB in August 1997. This comprehensive State water plan identifies current and prospective water uses, water supplies and water users, and it identifies needed water-related management measures, facility needs and costs. The plan also offers recommendations to better manage the State's water resources through the year 2050. Key management areas include:

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

The Water for Texas Plan will be updated in accordance with the findings of the PWPA Water Plan, as prescribed by Senate Bill 1.

State Authority and Programs for Groundwater Protection. - Following are major sections of TNRCC that may have relevance to municipal, industrial, agricultural, and utility users of groundwater (TNRCC, 1997):

- Office of Water Resource Management--Water Planning and Assessment Division, Agriculture and Watershed Management Division, and Water Utilities Division.
- Office of Waste Management--includes Hazardous Waste Division, Petroleum Storage Tank Division, Municipal Solid Waste Division, Pollution Cleanup Division, and Voluntary Cleanup Division.
- Office of Compliance and Enforcement--Field Operations Division, Compliance Support Division, and Enforcement Division.
- Texas Department of Licensing and Regulations – licenses well drilling operators.
- Groundwater Districts - regulate aspects of groundwater use and conservation such as well spacing, size, construction, closure, and the monitoring and protection of groundwater quality

Notable state programs for groundwater protection includes: (a) well-head protection areas; and (b) sole source aquifer designations.

(1) Wellhead protection areas - The Texas Water Code provides for a wellhead source water protection zone around public water supply wells extending to activities within a 0.25 mile radius. Specific types of sources of potential contamination within this wellhead/source water protection zone may be further restricted by TNRCC rule or

regulation. For example, wellhead/source water protection zones have been designated for many public water supply wells within or near Pantex (May and Block, 1997). More specific information on well head protection zones is available from TNRCC.

The Texas Water Code further provides for all wells to be designed and constructed according to TNRCC well construction standards (30 TAC 290). These standards require new wells to be encased with concrete extending down to a depth of 20 ft., or to the water table or a restrictive layer, whichever is the lesser. An impervious concrete seal must extend at least 2 ft.. laterally around the well head and a riser installed at least 1 ft. high above the impervious seal.

(2) Sole source aquifers - There are no sole source aquifers in the 21-county PWPA study area. The only sole source aquifer in the state of Texas is the Edwards aquifer in the San Antonio-Uvalde area, some 500 miles southeast of Amarillo (Ambrose, 1999).

(3) Texas Wetlands Conservation Plan – The State Wetlands Conservation Plan is an outgrowth of the National Wetlands Policy Forum, which was convened in 1987 at the request of the Environmental Protection Agency. In September 1994, a Statewide Scoping Meeting was held that led to the development of the Texas Wetlands Conservation Plan. The primary principals identified during the Plan's development were: 1) improve the transfer of information between agencies, groups and citizens; 2) develop incentives that encourage landowners to conserve wetlands on their property; and 3) increase the assessment of wetlands projects and research on conservation options. Additionally, the five general categories of wetlands issues identified during the development process were: 1) education; 2) economic incentives; 3) conservation; 4) private ownership; and 5) governmental relations. The Plan was finalized in the spring of 1997**.**

1.7.4 Local Programs

Canadian River Municipal Water Authority. – In 1993 the CRMWA completed a regional water supply study under a Regional Water Supply Planning Grant, TWDB Contract No. 92-483-314. This study determined that there were several sources of supplemental groundwater which could be used for conjunctive use with Lake Meredith water. The study also determined that the current yield of Lake Meredith is on the order of 76,000 acre-feet per year, and that additional supplies of 30,000 acre-feet. to 65,000 acre-feet. per year were needed to meet the current demands, bringing delivered water up to State or Federal standards, and provide for some future expansion of demand. The CRMWA is now in the process of implementing the recommendations of the study, with the development of a well field in eastern Hutchinson and western Roberts counties from which up to 50,000 acre-feet per year can be produced. A 36-mile long aqueduct of 54-inch pipe will bring the well water to intersect the Authority's existing aqueduct. Water from the two sources (groundwater and Lake Meredith water) will be mixed to produce a blend meeting the State drinking water quality standards. The new source of supply is expected to be online by spring 2001.

City of Amarillo. - In 1996 the City of Amarillo conducted a study to evaluate the adequacy of the Amarillo water supply and distribution system facilities and to determine the improvements needed to meet the City's water requirements through 2040 (Black & Veatch, 1996). Recommendations of the study included a 30 mgd expansion to the Osage WTP and associated improvements, participation in the CRMWA's Roberts County project, additional wells, and additional water rights. The Roberts County project would provide pre-blended surface and groundwater to Amarillo and increase the City's average day CRMWA allocation from about 27 mgd to about 40 mgd. The project will provide an additional supply source to meet projected increases in water demands. It was suggested in the study that additional water rights in Carson and Potter Counties be evaluated before new wells are constructed.

1.7.5 Other Information

In the process of developing information for this report, many sources of related data were identified which may or may not be discussed in the body of this report. A summary of these sources is located in Appendix C.

2.0 CURRENT AND PROJECTED POPULATION AND WATER DEMAND FOR THE REGION

Under Senate Bill 1, 75th Texas Legislative Session (SB1), the Panhandle Water Planning Group (PWPG) is charged with consideration of both State and Regional issues in the development of a regional water plan for the 21-county Panhandle Water Planning Area (PWPA) shown in Figure 2-1. The regional plan, developed using consensus-based population and water demand projections, will be used by the Texas Water Development Board (TWDB) to aid in the development of a state-wide water resource management plan.

Consensus-based population projections are those projections which were developed by the TWDB in coordination with the Texas Natural Resource Conservation Commission (TNRCC) and the Texas Parks Wildlife Department (TPWD). In lieu of TWDB projections, the planning group has developed revised population and water demand projections that are based on changed conditions and the availability of new information. Revised water demand projections used by the regional planning group are also developed for drought of record conditions.

Recognizing the importance of a water plan that would meet the unique needs of the Panhandle Water Planning Area, the PWPG compiled a database containing municipal, industrial, and agricultural water demands for the region. Municipal and industrial demands were identified using a survey questionnaire that was distributed to 155 entities identified as stakeholders in the region. The tremendous response that was received from the questionnaire indicates the willingness of regional entities to participate in the planning process and an interest in providing accurate information for the Panhandle Regional Water Plan. The demands identified by stakeholders were compared to the consensus-based projections previously adopted by the TWDB and were used to develop several revisions to TWDB population and water use projections.

Experts from the Texas Agricultural Experiment Station and the Texas Agricultural Extension Service developed agricultural water demand projections for the region. These experts examined methodologies used by the TWDB to develop projections for livestock and irrigation water use. New methodologies were developed and proposed by the experts, leading to the adoption of revised agricultural water demand projections for the PWPA.

This chapter documents historical and projected estimates of population and water demands of cities and counties in the PWPA, as well as the demands on designated major water providers. Discussions of population and water demands are contained in the following sections, with detailed data located in the appendices. Appendix D contains population information by city and rural areas. Appendix E contains water demand data for municipal, industrial, and agricultural uses. Appendix F contains information about demands on major water providers. Appendices D, E, and G correspond to TWDB Tables 1, 2, and 3 as required in the TWDB Exhibit B document. Revisions to population and water demand projections discussed in this chapter have been approved by the TWDB.

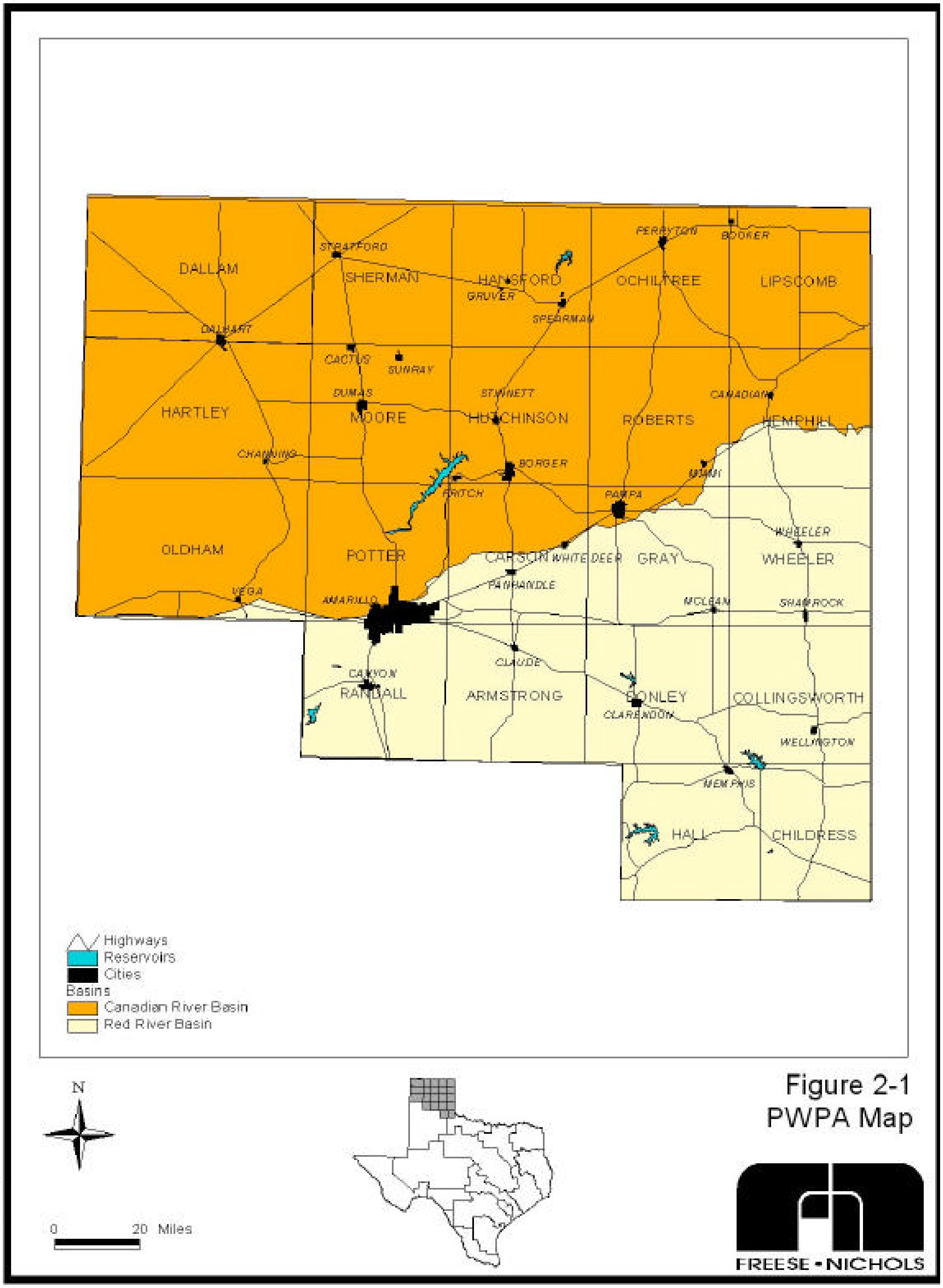
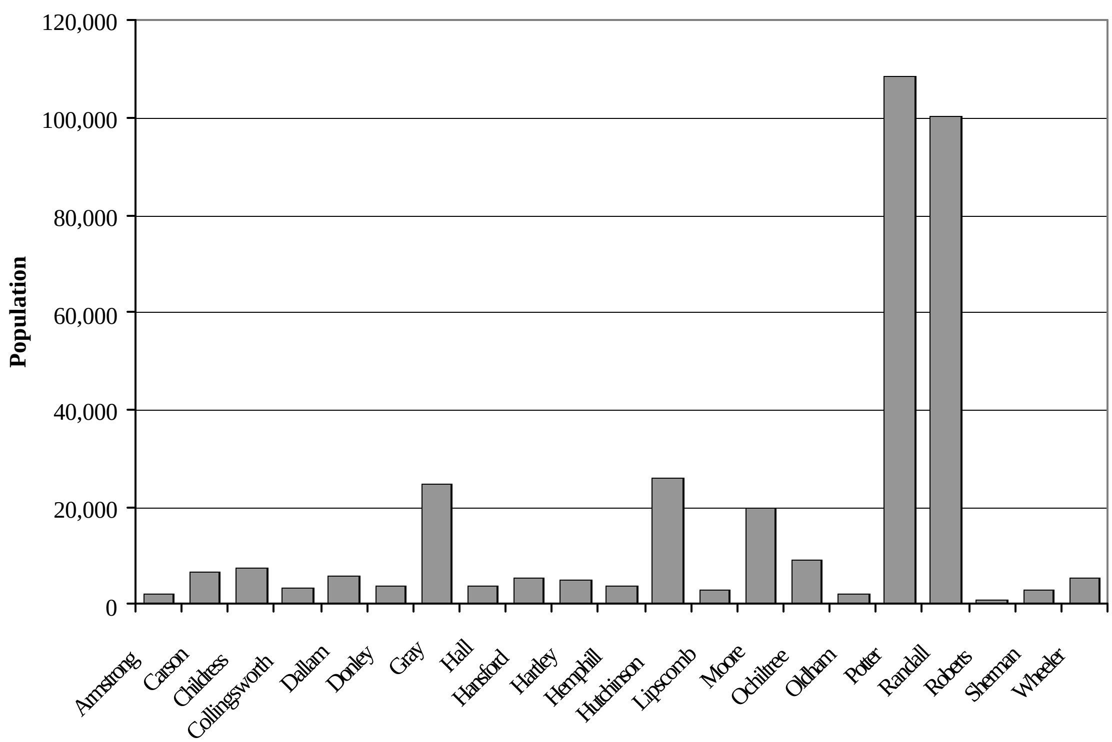


Figure 2-1
PWPA Map

2.1 Population

The population of Texas was approximately 17,000,000 in 1990 and by 1996 was over 18,000,000. The PWPA represented approximately 1.9 percent of the state's population during those years (TWDB, 1998). Figure 2-2 illustrates the 1996 populations of counties in the PWPA. In 1996 the population of the PWPA was estimated to be 351,780, with 45 percent of the total region's population located in Potter and Randall Counties. Amarillo, the major population center in the PWPA, is located in Potter and Randall Counties. Approximately 55 percent of the population in the PWPA is distributed among the remaining 19 counties, ranging from 875 in Roberts County to 25,907 in Hutchinson County.

Figure 2-2. 1996 Populations for Counties in the PWPA



Population growth patterns described in the 1997 Water Plan (TWDB, 1998) indicate that by 2050 the population of Texas will double, reaching over 36,000,000. Population for the PWPA is projected by the TWDB to be 515,359 in 2050, or approximately 1.4 percent of the projected state population for that decade.

As part of the regional planning process, revisions were proposed to TWDB population projections for several cities and counties. Based on stakeholder survey results, some cities and counties have 1997 Texas State Data Center (TSDC) populations that exceed the 2000 TWDB projected populations. Others have experienced much more rapid growth since the 1990 census than anticipated by the TWDB. In addition, there are several cities that have TSDC estimated 1997 populations that exceed the 2000 projections, but the growth rate is currently in a downward trend and the cities either concurred with the TWDB projections or did not return a survey which disagreed with the projections.

Cities that requested changes to the TWDB population projections due to current or anticipated development include Cactus, Canyon, Childress, Dalhart, Village of Lake Tanglewood, and Panhandle. Cities for which revisions were made based on 1997 TSDC populations that exceed the 2000 TWDB projections include Cactus, Dalhart, and Lipscomb. There are also several revisions to county populations due to the 1997 estimated population exceeding the 2000 TWDB projected population or because of changes in the city populations mentioned above. These include Carson, Childress, Dallam, Hartley, Lipscomb Moore, Potter, Randall and Sherman counties. Detailed information supporting these revisions is documented in *Analysis of Demands*, (PWPG, 1999).

The revisions represent an increase in the overall population from the TWDB projections by an average 6.7 percent over the planning period, ranging from a 6.1 percent increase in 2000 to a 7.1 percent increase in 2050. Total PWPA population is projected to increase from 379,019 in 2000 to 552,072 in 2050. This represents an increase of 46 percent over the course of the planning period. The data indicate that a major portion of the projected increase occurs in larger communities, such as Amarillo, with less increase in rural populations. Increases in population are projected for Carson, Childress, Hartley, Moore, and Wheeler counties, while decreases are projected for Armstrong, Donley, Hall, Roberts, and Sherman counties. The counties of Collingsworth, Dallam, Gray, Hansford, Hemphill, Hutchinson, Lipscomb, Ochiltree, and Oldham are projected to have an initial increase followed by a decrease, or are expected to have no significant change in population during the planning period.

Appendix A contains the current TWDB-approved revised populations for each city and smaller populated areas for each county in the PWPA. Rural and unincorporated areas within each county are included in the table as "County-Other." Figures 2-3a and 2-3b illustrate the current projected populations by county for the planning period.

Figure 2-3a. Projected Populations for Counties in the PWPA, excluding Potter and Randall Counties

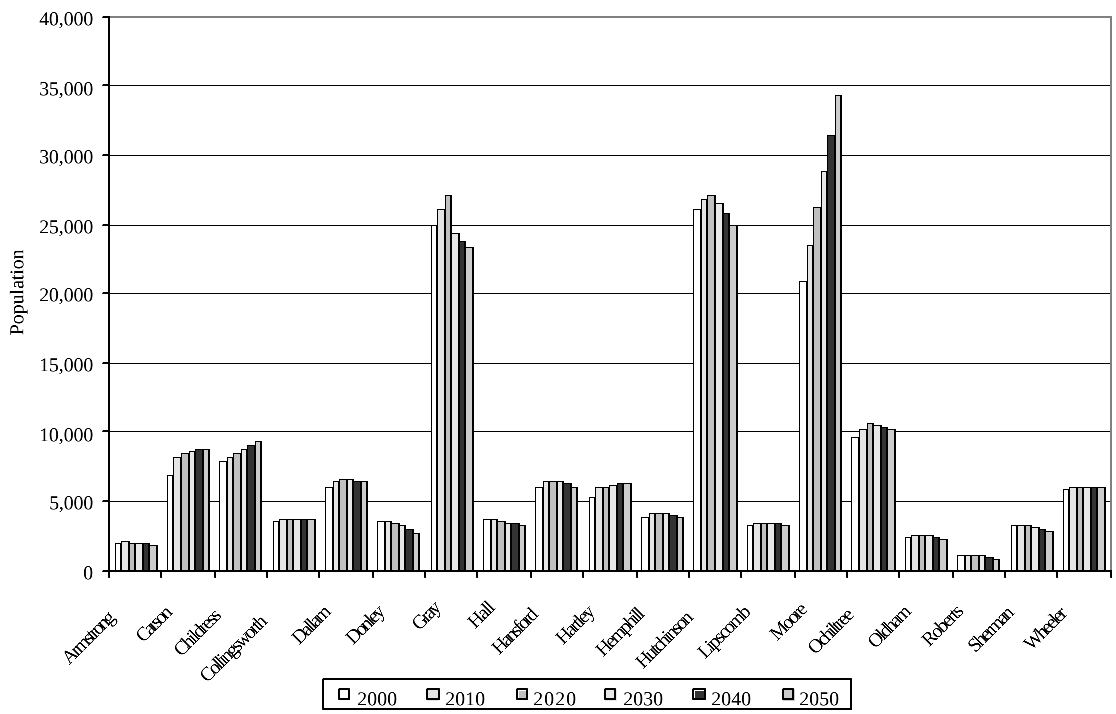
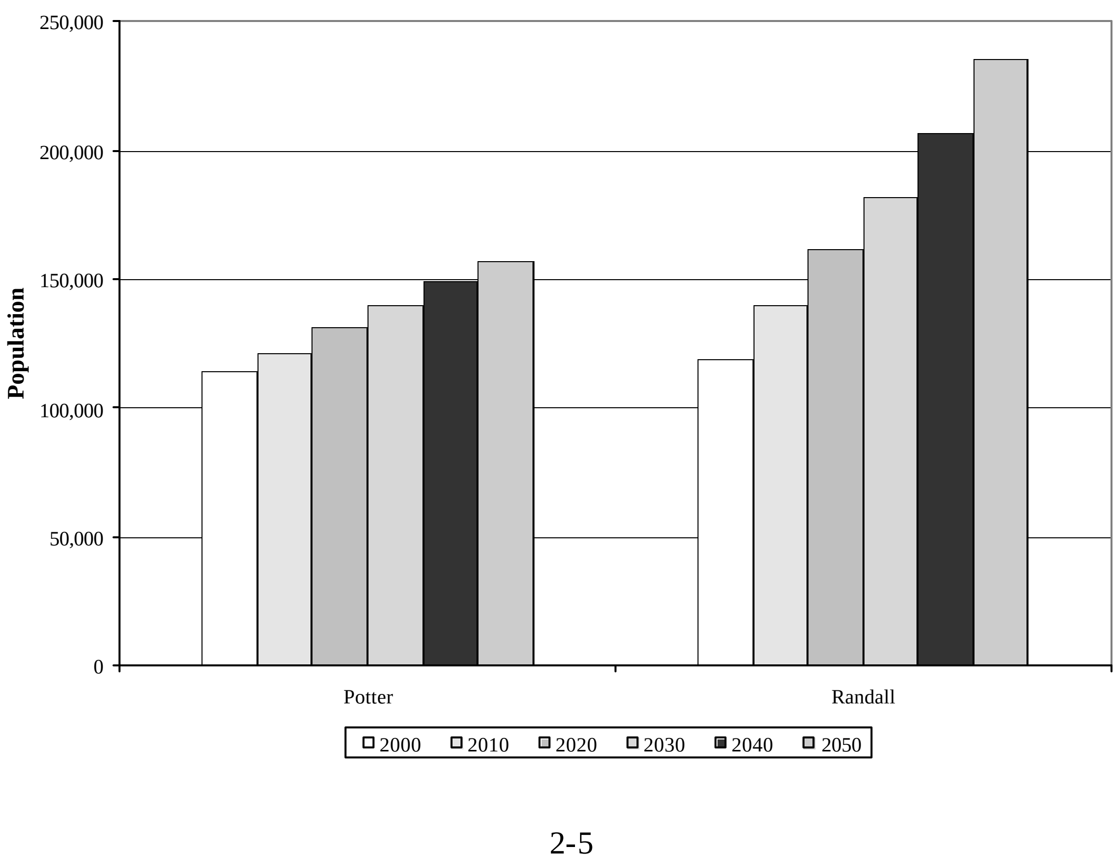


Figure 2-3b. Projected Populations for Potter and Randall Counties

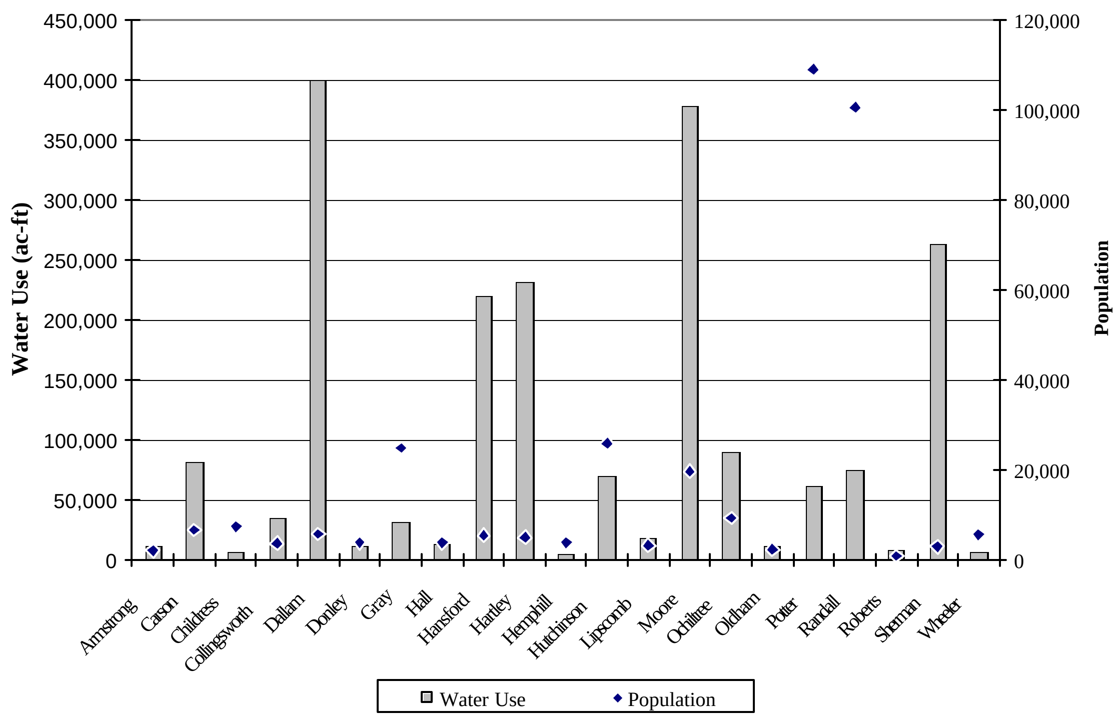


2.2 HISTORICAL WATER USE AND PROJECTED WATER DEMAND

Water use in the PWPA during 1996 totaled over 2 million acre-feet, or approximately 17 percent of the state total. Five counties in the PWPA, Dallam, Hansford, Hartley, Moore, and Sherman, reported a combined water use of almost 1.5 million acre-feet in 1996, ranging from 219,611 acre-feet in Hansford County to 399,575 acre-feet in Dallam County. Water use by these five counties represents approximately 74 percent of the total water use in the PWPA during that year. Water use of the remaining 16 counties totaled over 500,000 acre-feet and ranged from 4,890 acre-feet in Hemphill County to 89,877 acre-feet in Ochiltree County.

Figure 2-4 illustrates the 1996 reported water use for counties in the PWPA and compares these values with county populations. There is little correspondence between total water use and population centers such as Potter and Randall counties, indicating that municipal water usage is not as significant as other factors in determining total water usage.

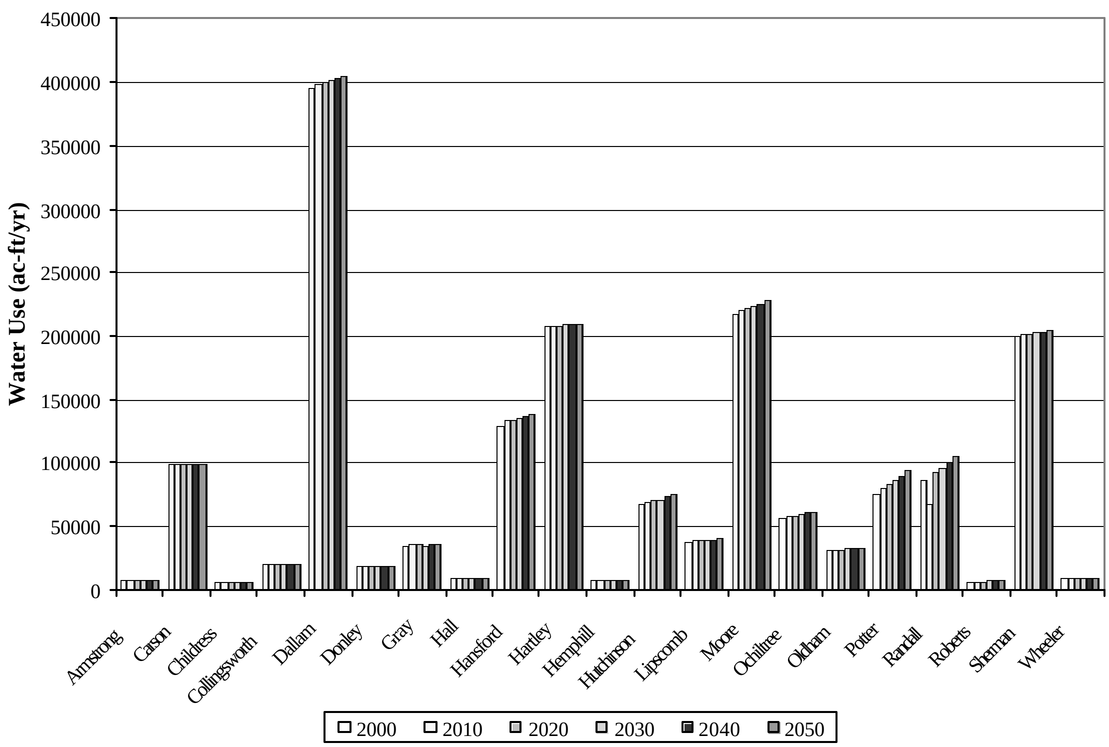
Figure 2-4 1996 Water Use and Population for Counties in the PWPA



Water demand projections provided by the TWDB (1998) indicate that total water usage in the PWPA would decrease from 1,965,190 acre-feet in 2000 to 1,784,585 acre-feet in 2050. Revisions to projected water demands for municipal, agricultural, and industrial uses were developed based on available data provided by the TWDB and input by regional water users. Appendix E contains detailed information on previous and current TWDB projected water use by municipal, agricultural, and industrial water users and the impact on projected demands. Due to these revised water use projections, the total revised water use projected for the 21 county region is 12.6 percent less than the TWDB projection for 2000 (1,718,402 acre-feet) and steadily increases to approximately 1.6 percent higher than the TWDB projection by 2050 (1,812,949 acre-feet).

Figure 2-5 shows the current TWDB-approved revised projected water demands for counties in the PWPA. The county with the highest projected water demand is Dallam County, with a projected use of 394,935 acre-feet in 2000 increasing to 405,458 acre-feet by 2050. This is almost twice the projected use of Moore County, the county with the next highest projected demands. Counties with projected increases in demand during the planning period include Dallam, Gray, Hansford, Hartley, Hutchinson, Lipscomb, Moore, Potter, Randall, and Sherman County. The remaining 10 counties are projected to have slight decreases or no significant change in projected water demand during the planning period.

Figure 2-5. Projected Total Water Demand by County



Municipal Water Demands

The distribution of municipal water use in the PWPA corresponds closely to the distribution of population centers in the PWPA. Projections of municipal water demands are calculated based on estimated changes in populations for cities and rural areas and on estimates of per capita water use. Per capita water use is estimated to decrease for each decade of the planning period under the assumption that conservation measures will be implemented and result in lower water use.

Revisions to previous TWDB projections for municipal water use were made for those cities and counties for which population projections were revised. Additionally, projections for the Village of Lake Tanglewood were revised based on changes to their estimates of per capita water use. As illustrated in Figure 2-6a and Figure 2-6b, the major portion of municipal water use occurs in Potter and Randall counties which, along with Carson and Moore counties, are the only counties in the PWPA projected to have an increase in total municipal water use.

Municipal water use in the PWPA was reported to be 80,309 acre-feet in 1996, or approximately four percent of total water use in the PWPA for that year. Although most counties are estimated to observe decreases, total municipal water use for the PWPA is projected to increase from 84,814 acre-feet in 2000 to 105,268 acre-feet by 2050. The combined municipal water usage by Potter and Randall counties accounted for 62 percent of the PWPA municipal water use in 1996 and is projected to increase to 71 percent by 2050.

Figure 2-6a. Historical and Projected Municipal Water Use for Counties in the PWPA, excluding Potter and Randall Counties

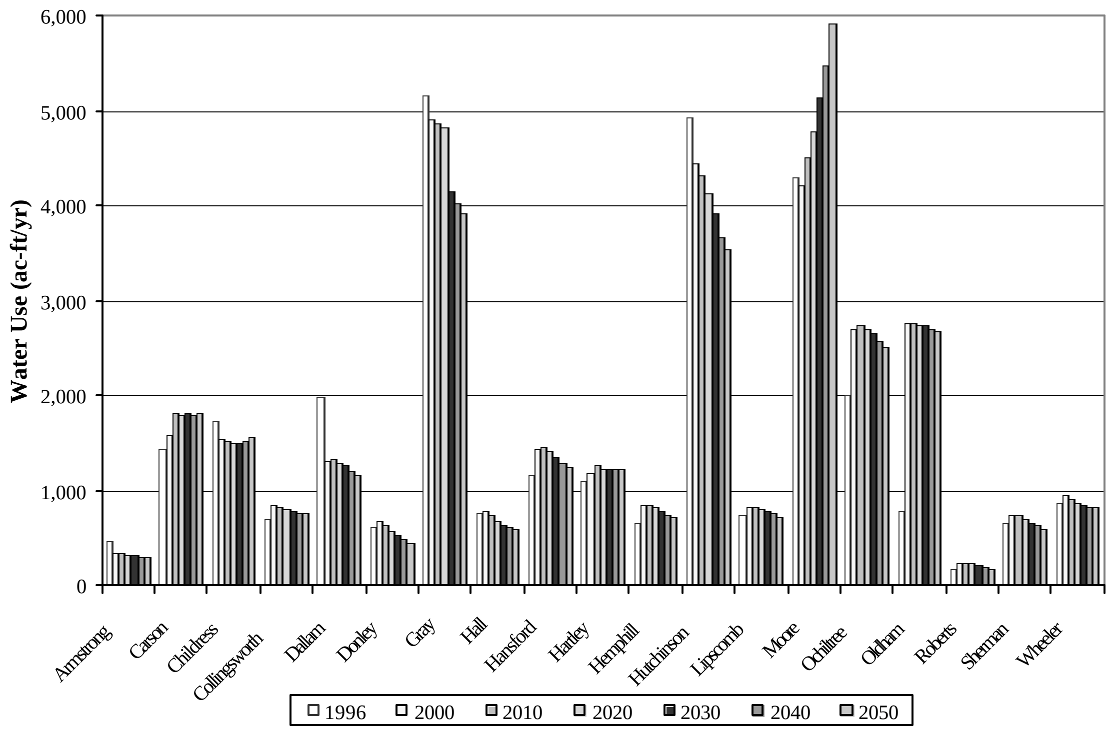
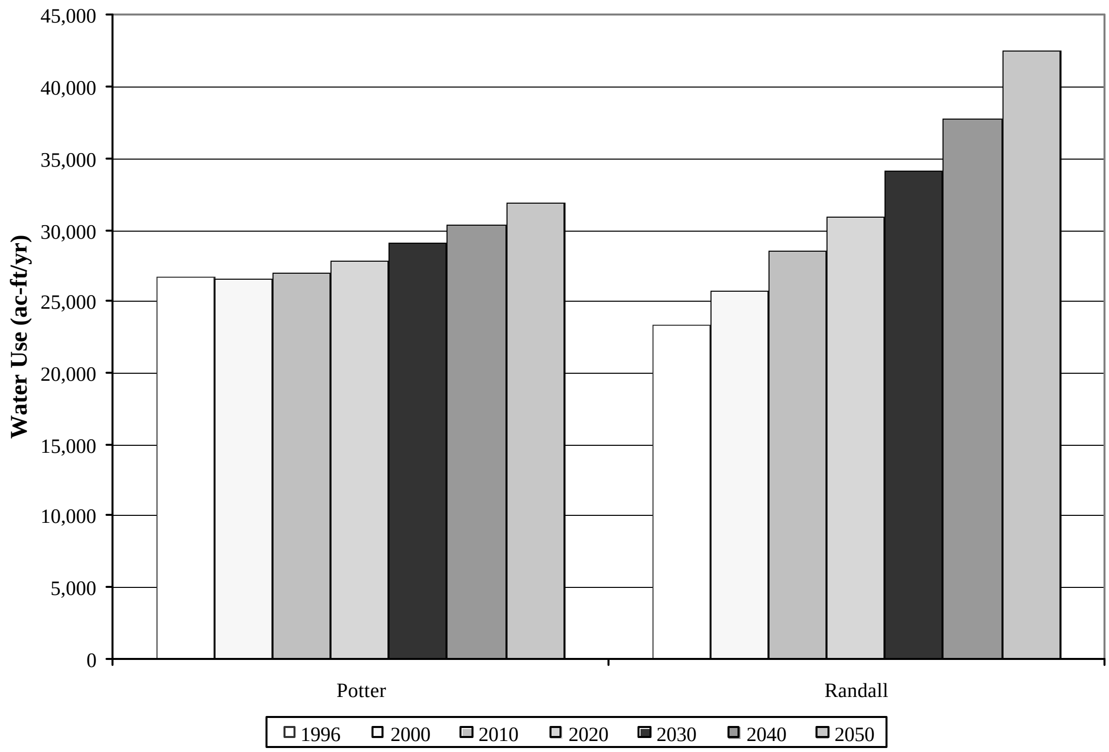


Figure 2-6b. Historical and Projected Municipal Water Demand for Potter and Randall Counties



Industrial Water Demands

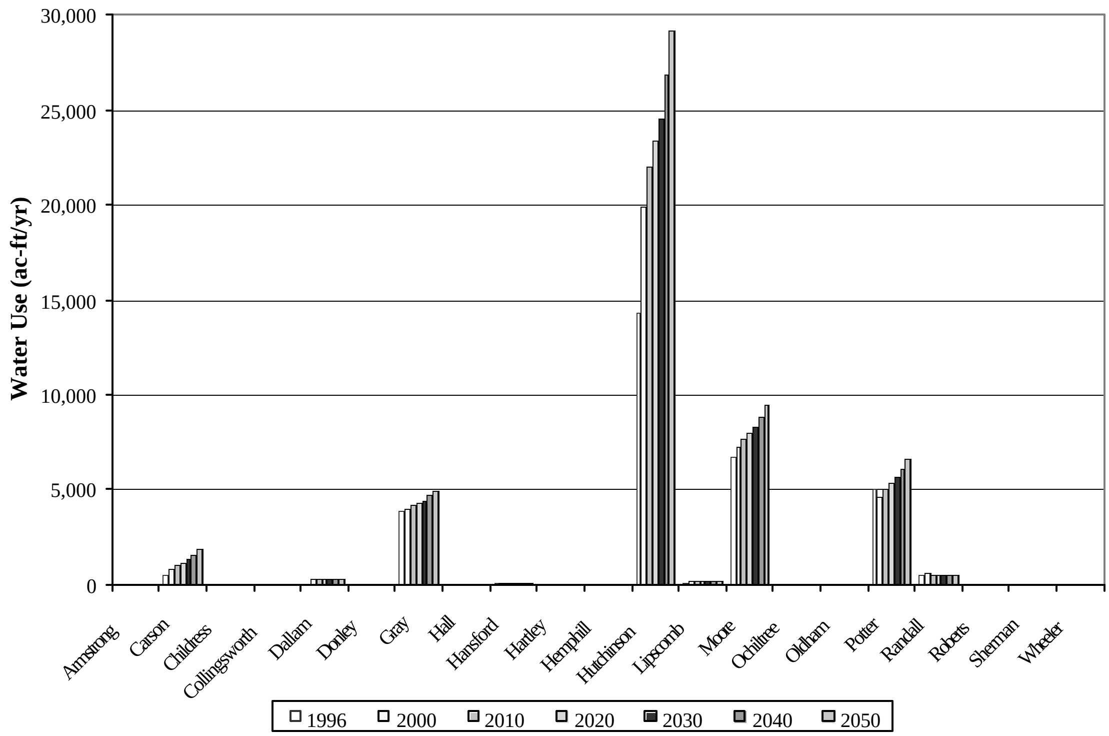
The TWDB defines industrial water use as water used in the production process of manufactured products, including water used by employees for drinking and sanitation purposes. The activity areas include manufacturing, steam power generation, and mining.

Manufacturing

Manufacturing water use in 1996 was 31,162 acre-feet for the nine counties with documented manufacturing water usage. Manufacturing water use in these counties ranged from one acre-foot in Ochiltree County to 14,371 acre-feet in Hutchinson County. Hutchinson County accounted for 46 percent of the manufacturing water use in the PWPA reported for 1996.

A previously unaccounted for industrial user in the city of Texline necessitated a revision to the TWDB projected manufacturing water demands for Dallam County. Based on estimates of the water used by a fertilizer plant in Texline, 235 acre-feet were added to the projected manufacturing water demands for Dallam County. Figure 2-7 shows the 1996 water use and the projected water demand of manufacturing users. Total manufacturing water demand for the PWPA is projected to increase from 37,493 acre-feet in 2000 to 53,009 acre-feet by 2050. This represents 2.2 percent of the total water use in the PWPA in 2000, increasing to 2.9 percent by 2050.

Figure 2-7. Historical and Projected Manufacturing Water Use for Counties in the PWPA

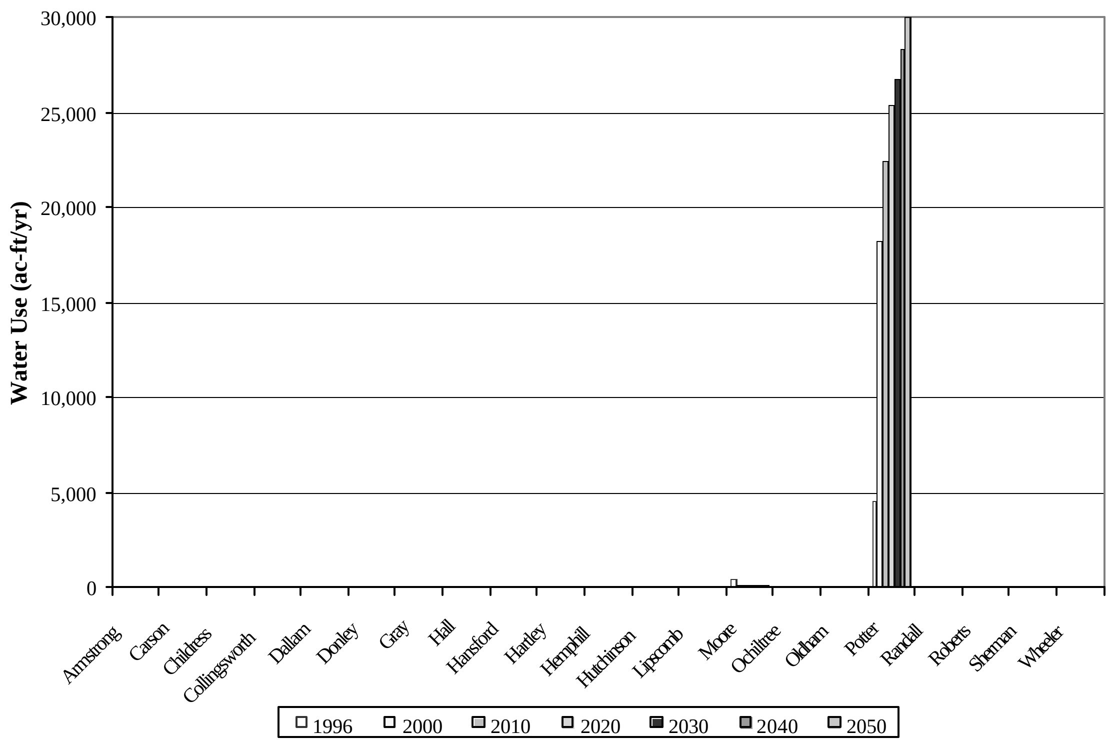


Steam Power Generation

Southwest Public Service (SPS) power generation plants located in Moore and Potter counties account for all of the water use by power generators in the PWPA. In 1996, power generation comprised 0.2 percent of the total water use in the PWPA, with a reported 5,023 acre-feet. In conjunction with regional water planning efforts, SPS performed a detailed analysis of steam electric generation and water use for their facilities in the PWPA. It was found that TWDB projections did not include any provisions for water use by steam electric in Moore County (estimated 200 acre-feet per year) and that historical water use reported for the Potter County facility did not agree with SPS reports of water used. Also, the SPS projected demands for future years at the Potter County facility were greater than the TWDB projections. This information supported the revision of TWDB water demand projections for power generation in the PWPA.

Based on the analyses by SPS, water demand for power generation is projected to increase from 18,500 acre-feet in 2000 to 30,211 acre-feet by 2050. This represents approximately 1.1 percent of the total water use in the PWPA in 2000 and 1.7 percent by 2050. Figure 2-8 illustrates the historical water needs and projected water demands of steam power generators in the PWPA.

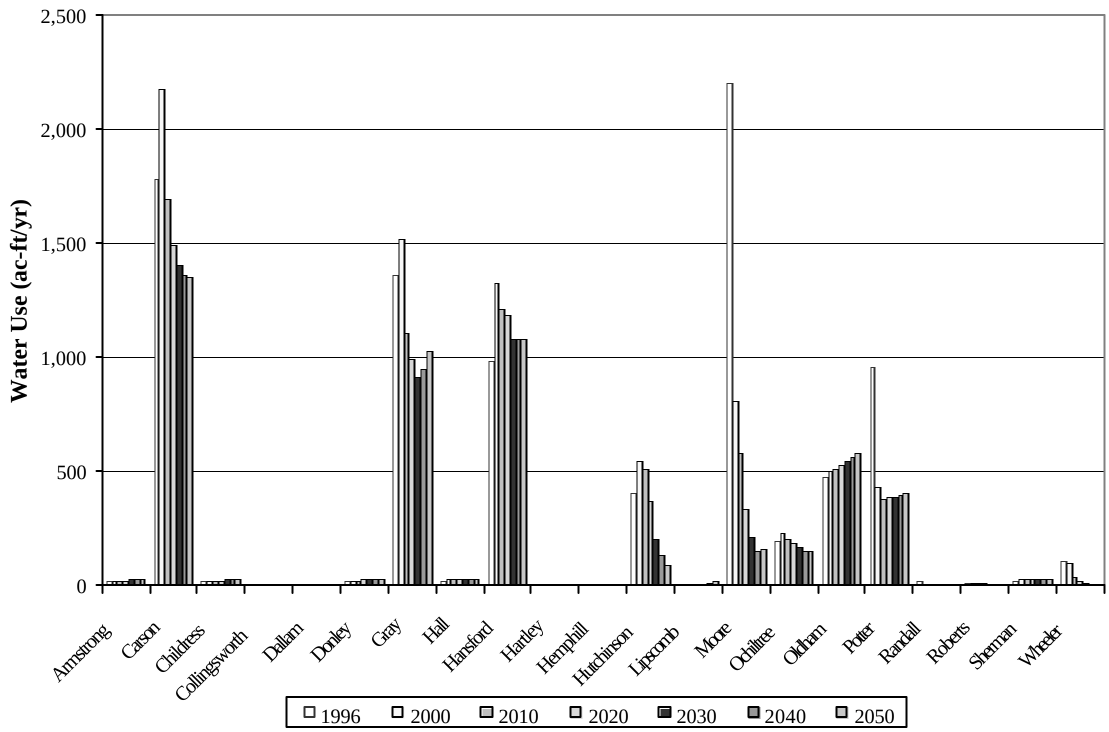
Figure 2-8. Historical and Projected Steam Power Water Use for Counties in the PWPA



Mining

Mining operations in the PWPA consist primarily of oil and gas extraction and removal of industrial minerals such as sand, gravel, and gypsum. Water use for mining operations was reported in 1996 for 17 counties in the PWPA, totaling 8,644 acre-feet, or 0.4 percent of the total water use in the PWPA. No revisions were proposed to TWDB projections of water demands by mining operations for the planning period. It is estimated that mining water demand will decrease from 7,817 acre-feet in 2000 to 5,062 acre-feet by 2050. This decrease is driven primarily by projected decreases in mining activities for Carson, Gray, Hansford, and Moore Counties. Figure 2-9 illustrates historical water use and projected water demands by mining operations in the PWPA.

Figure 2-9. Historical and Projected Mining Water Use for Counties in the PWPA



Agricultural Water Demand

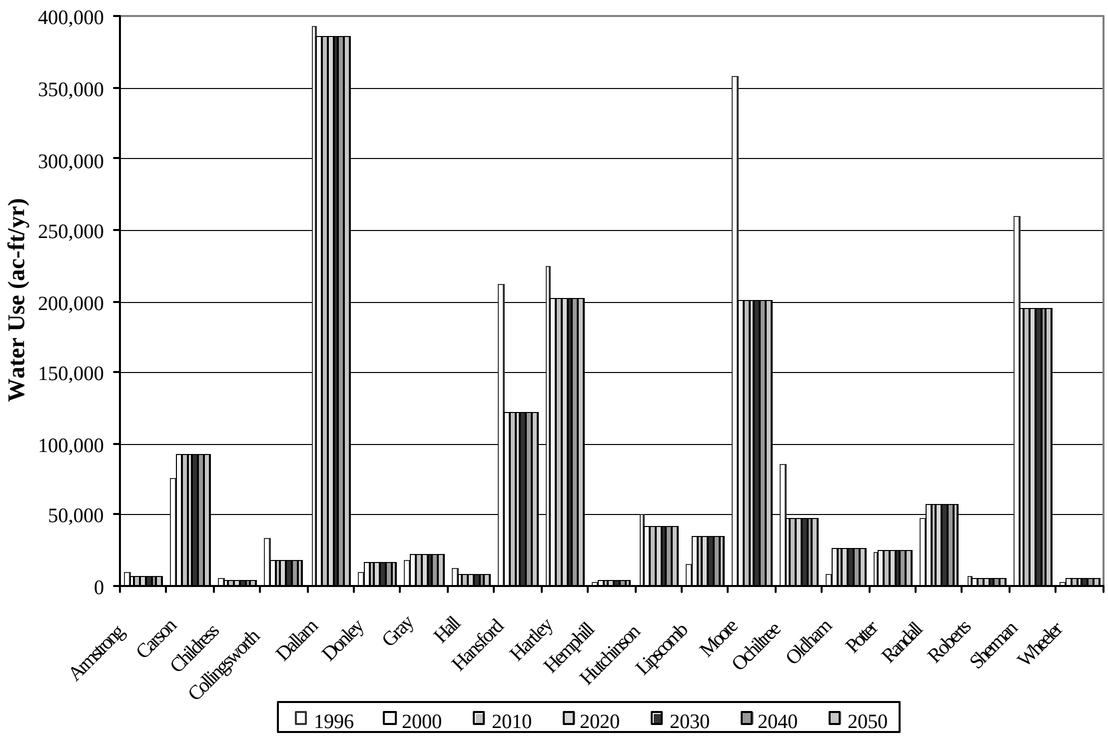
Irrigation

According to the TWDB (1998), water used for irrigation totaled 1,850,192 acre-feet in 1996, or 91 percent of the total water used in the PWPA. As part of the regional water planning process, representatives of commodity groups, producers, and underground water districts expressed concerns that TWDB projections for irrigation demand tended to over estimate irrigation water use. The Texas Agricultural Experiment Station (TAES) and the Texas Agricultural Extension Service (TAEX) evaluated the methodologies used by the TWDB for estimating irrigation water use.

The TAES/TAEX team began by developing and documenting a methodology for estimating the amount of irrigation water pumped in a county during a given year. The model was developed using data from 1997 and was expanded to include data from 1987 and 1992 to correspond to the years in which Agricultural Census data were published. Agricultural census data is collected every five years and was not collected during 1996. This precludes the use of 1996 data as a standard year of comparison. Methodology included estimates of water usage by irrigated crops based on optimal water use (based on potential evapotranspiration), sub optimal water application by producers (determined by agri-partner demonstration data), effective rainfall received during the growing season, and seasonal usable soil moisture from the soil profile. Projections of annual future water use were made using planted irrigated acreage (pia) and the long-term averages for rainfall and potential evapotranspiration (PET) by county. The crop mix and acreage was assumed to remain unchanged from what was reported in 1997. Where available, demonstration data and well depletion data were used to verify the model estimates.

The results of the evaluation and modeling efforts represent a comparison based on best available current data and have been included in the planning process as projections through 2050. The irrigation water use projections should be re-evaluated as more data becomes available to accurately reflect changes in the farming community due to new technologies, economic considerations, or crop acreages. The current annual projections are 15 percent less than previous TWDB values in 2000, but only 2 percent different by 2050. Methodologies used in the development of the irrigation water use projections are discussed in greater detail in *Analysis of Demands* (PWPG, 1999). Figure 2-10 illustrates the TWDB reported 1996 reported water use and TWDB-approved projections of irrigation water demand for counties in the PWPA.

Figure 2-10. Historical Water Use and Projected Demands for Irrigation Water Use for Counties in the PWPA



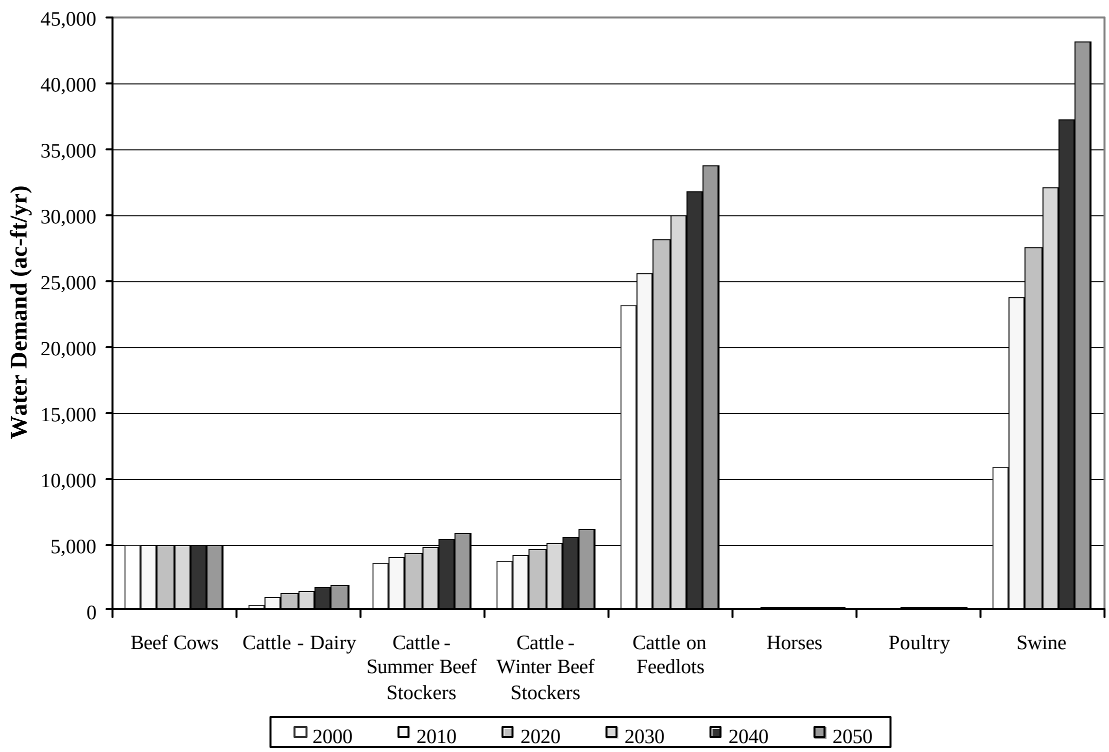
<u>Livestock</u>

According to the TWDB (1998), water used for livestock totaled 50,368 acre-feet in 1996 and ranged from 348 acre-feet in Hall County to 6,020 acre-feet in Hartley County. This represents approximately 2.5 percent of the total water used in the PWPA for that year. As in the case of irrigation water demands, the methodologies used by the TWDB were evaluated and revised as part of the regional water planning process. Concerns expressed by commodity groups and producers include the under estimation of future livestock water demands.

New projections were developed by TAES/TAEX which include the most recent inventories of various livestock species for each county, estimates of annual industry growth rates, and regional species-level water use estimates. TAES/TAEX staff developed estimates of livestock inventories and water use for beef cattle feedlots, summer and winter stockers, beef cows, swine, horses, dairy cattle, and poultry for each county in the PWPA. Water use values were obtained from regional and national studies and were used to determine the relative water demand for each livestock category.

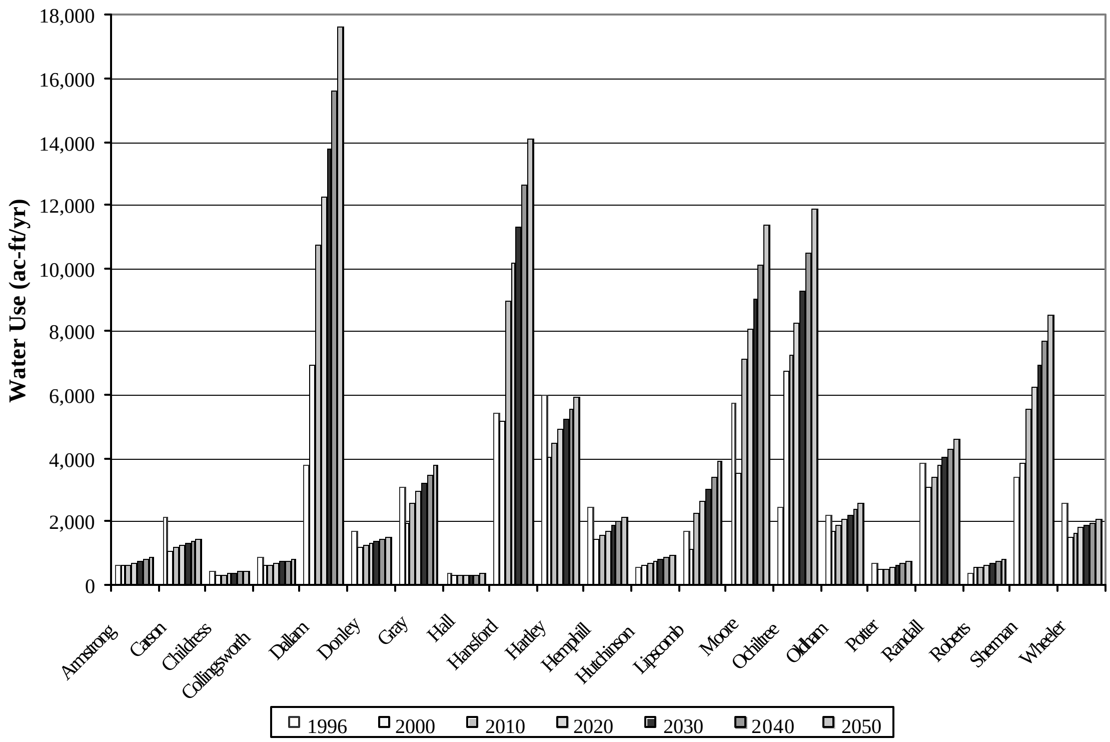
Figure 2-11 illustrates the projected livestock water demand by livestock category for the planning period. Detailed data is contained in Appendix F. Annual growth rates were determined by TAES/TAEX staff based on published studies, knowledge of the local agricultural economy and environment, and in consultation with industry sources. This methodology incorporates a larger body of information for the determination of projected water uses than the more traditional methodology utilized by the TWDB. Methodologies used in the development and evaluation of current livestock water use projections are discussed in detail in *Analysis of Demands* (PWPG, 1999).

Figure 2-11. Projected Livestock Water Demands by Animal Category



Livestock water demands are projected to increase from 46,793 acre-feet in 2000 to 96,414 acre-feet by 2050. This represents approximately 2.7 percent of the total water use in the PWPA in 2000, increasing steadily to approximately 5.3 percent of the total projected water use by 2050. Figure 2-12 illustrates the historical water use and projected water demands for livestock use in the PWPA. Increases in livestock water demands are projected for every county in the PWPA, with the largest increase projected for Dallam County.

Figure 2-12 Historical and Projected Livestock Water Use for Counties in the PWPA



2.3 Major Water Providers

As discussed in Chapter 1, the term Major Water Provider (MWP) was established by SB-1 for the purpose of including major providers of water for municipal and manufacturing use into the regional planning process. A MWP is an entity which delivers and sells a significant amount of water on a wholesale and/or retail basis. MWPs designated for the PWPG include the city of Amarillo, Greenbelt Municipal and Industrial Water Authority (GM&IWA) and the Canadian River Municipal Water Authority (CRMWA).

For purposes of the regional planning process, new projections of demands on these MWPs were developed and submitted to the TWDB for approval. Coordination with adjoining planning Region B and the Llano Estacado Water Planning Region (Region O) was necessary to develop projections for CRMWA and GM&IWA because several recipient cities are located in those regions. Appendix G contains detailed information on historical and projected demands by recipient on MWPs.

According to TWDB (1998) the combined water sales of the designated MWPs for municipal and manufacturing use was 137,961 acre-feet. In 1996 the city of Amarillo accounted for approximately 42 percent, GM&IWA for three percent, and CRMWA for 56 percent of the combined demand on MWPs in the PWPA. Demands on these MWPs are projected to increase from 121,251 acre-feet in 2000 to 156,462 acre-feet by 2050. Total demands on Amarillo and CRMWA as MWPs are projected to increase from 50,963 acre-feet in 2000 to 72,755 acre-feet in 2050 and 66,496 acre-feet in 2000 to 80,108 acre-feet in 2050, respectively. GM&IWA is expected to see a slight decrease in demands as a MWP from 3,792 acre-feet to 3,599 acre-feet during the planning period. Figure 2-13 illustrates the historical and projected water demands for each of the three designated MWPs during the planning period.

In 1996, the city of Amarillo supplied a total of 50,040 acre-feet of water for municipal use by the city of Amarillo, the city of Canyon, and Texas Parks and Wildlife Department (Palo Duro State Park), and industrial use by ASARCO and IBP, Inc (TWDB, 1998). Projected demands on the city of Amarillo were developed based on each recipient's projected water demand and what percentage of their historical water demands the city of Amarillo had supplied. Water demand for municipal and manufacturing use within Amarillo is anticipated to increase from 44,374 acre-feet in 2000 to 62,621 acre-feet in 2050. Figure 2-14 illustrates the historical and projected demands on the city of Amarillo for municipal and manufacturing use.

Figure 2-13. Historical and Projected Water Demands on Major Water Providers in the PWPA

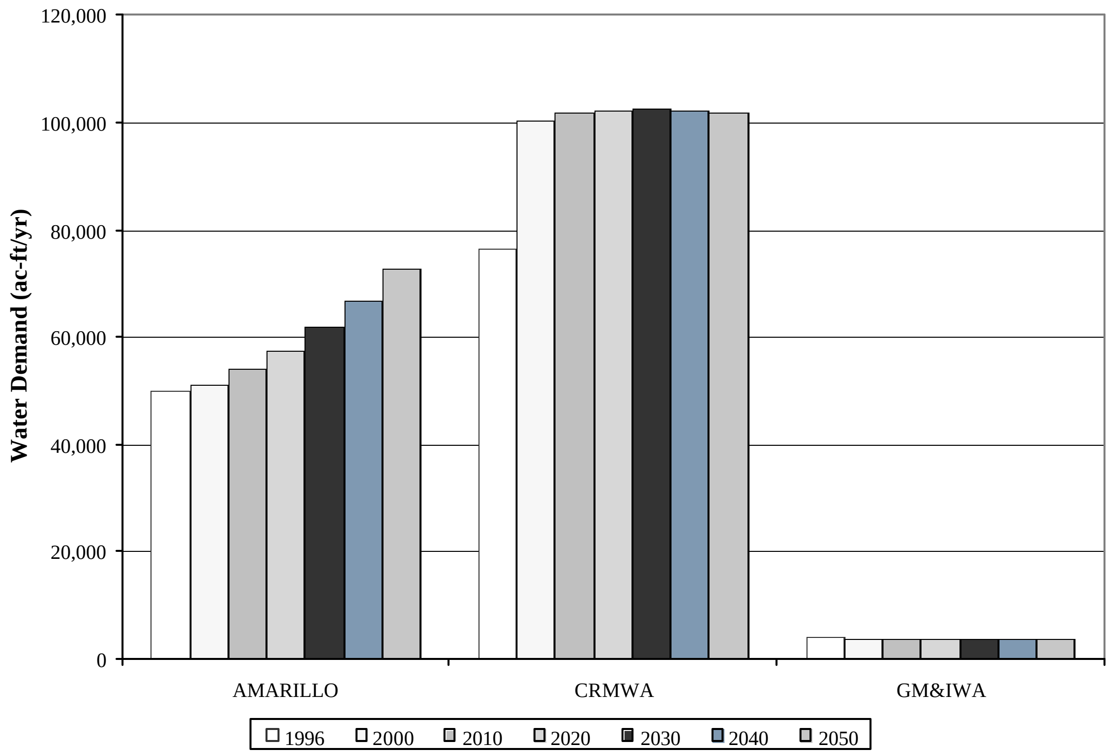
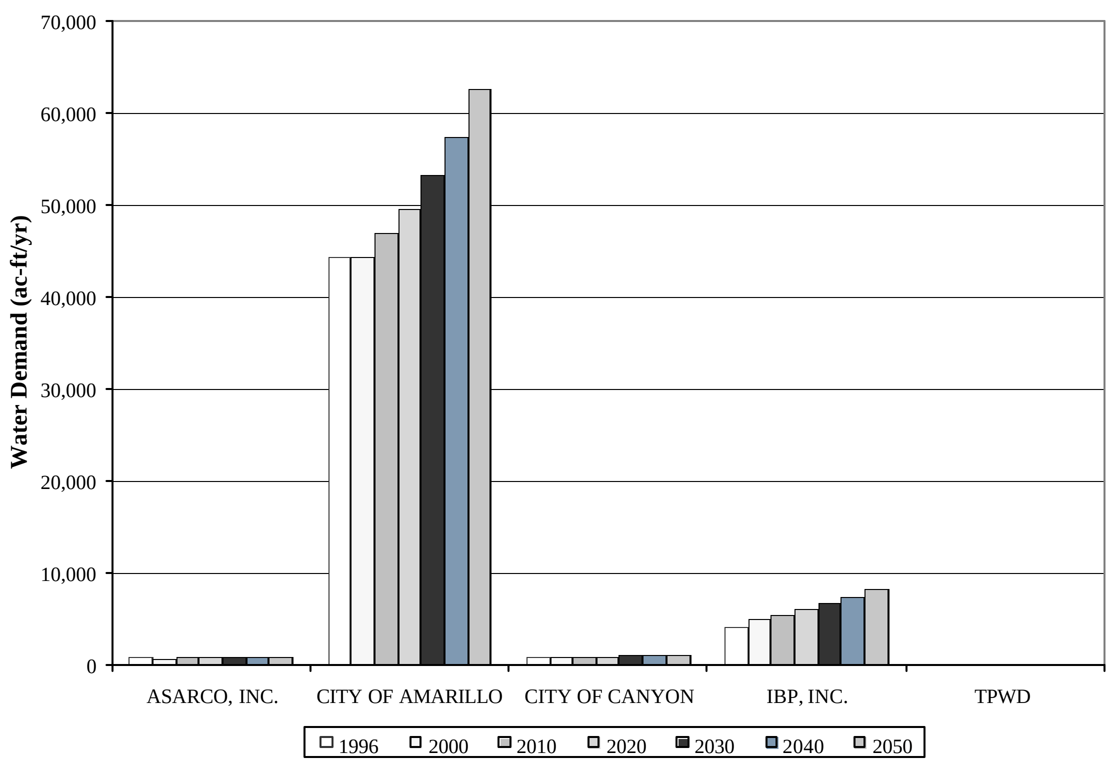
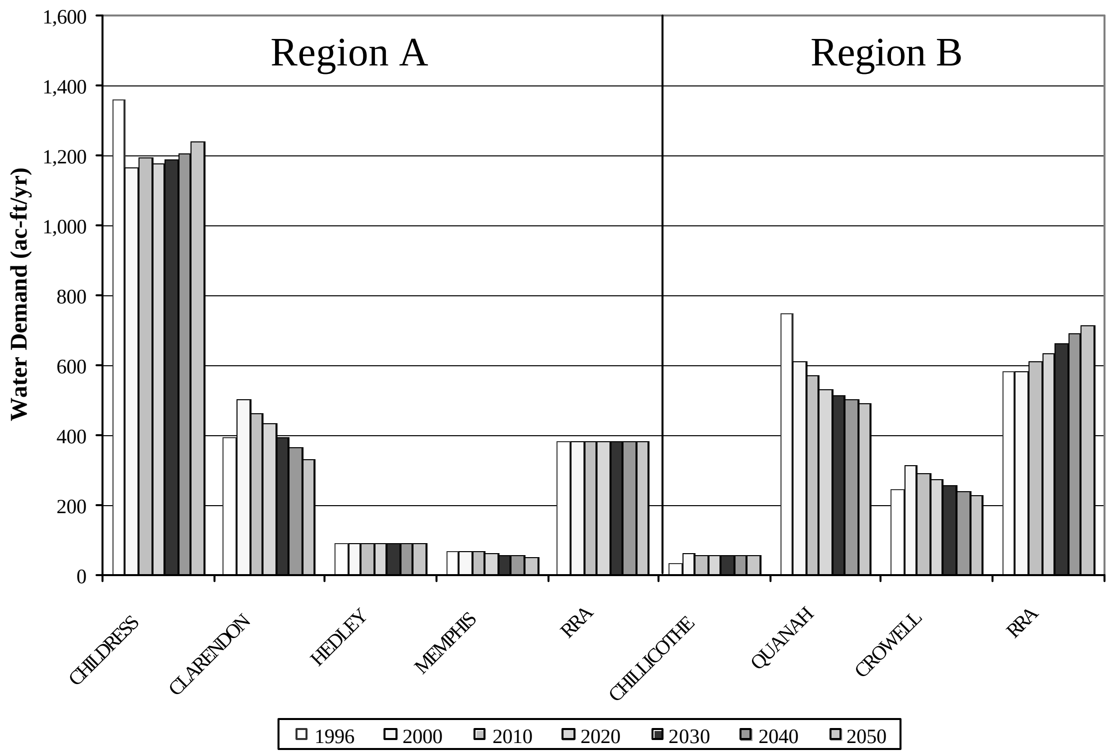


Figure 2-14. Historical and Projected Water Demand on City of Amarillo for Municipal and Manufacturing Water Use



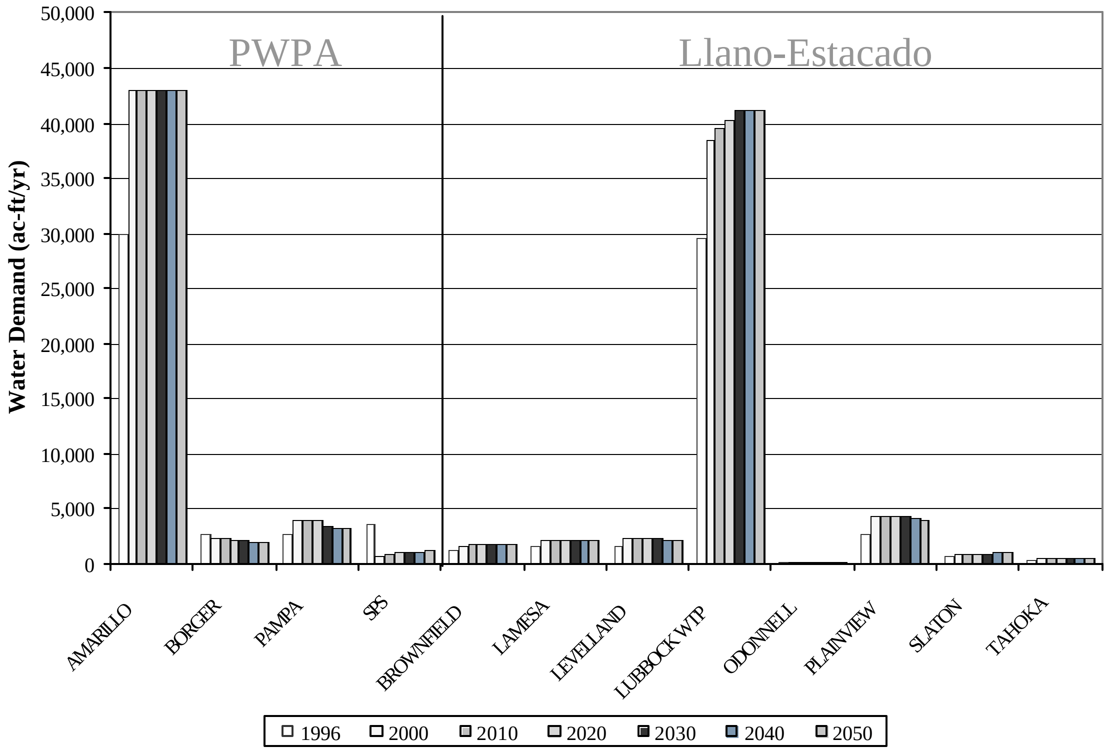
In 1996, GM&IWA supplied 3,905 acre-feet to four cities in the PWPA, three cities in Region B, and to the Red River Authority for subsequent sales in both regions (TWDB, 1998). Approximately 59 percent of the sales by GM&IWA were to the cities of Childress, Clarendon, Hedley, and Memphis, and to the RRA for sales in the PWPA. The remaining sales were to the cities of Chillicothe, Crowell, and Quanah, and to the RRA in Region B. Demand projections for GM&IWA as a MWP were developed based on each recipient's projected water demand and what percentage of their historical water demands the GM&IWA had supplied. The percentage of the projected demand that is anticipated to remain in the PWPA is expected to remain at approximately 58 percent throughout the planning period. Figure 2-15 illustrates the historical and projected demands on the GM&IWA for municipal and manufacturing water use.

Figure 2-15. Historical and Projected Water Demand on Greenbelt Municipal and Industrial Water Authority for Municipal and Manufacturing Water Use



In 1996, CRMWA supplied 76,631 acre-feet of water, of which approximately 51 percent was sold to three cities in the PWPA, Amarillo, Borger, and Pampa, and one industry, SPS. The remaining 49 percent was sold to eight cities in the Llano Estacado Water Planning Region. These include Brownfield, Lamesa, Levelland, Lubbock, O'Donnell, Plainview, Slaton, and Tahoka. Projected demands for recipients of CRMWA water were developed based on historical demands by recipients, projected demands of recipients, and increased availability of new ground water sources to supplement CRMWA's surface water supply. Approximately 42 percent of water supplied by CRMWA is projected to remain in the PWPA in 2000, increasing to 47 percent by 2050. Figure 2-16 illustrates the historical and projected demands on CRMWA for municipal and manufacturing water use.

Figure 2-16. Historical and Projected Water Demand on Canadian River Municipal Water Authority for Municipal and Manufacturing Water Use



3.0 EVALUATION OF ADEQUACY OF CURRENT WATER SUPPLIES

An integral part of the water resource planning process is an evaluation of the supplies available to meet demands in the Panhandle Water Planning Area (PWPA). This chapter of the regional water plan presents an evaluation of current groundwater and surface water supplies available to the Region for use during the drought of record.

Sources of water discussed in the following sections are presented in detail in Appendix H - Table 4, Current Water Supply Sources. Estimates of the volumes available from these sources for municipalities and other water users are presented in Appendix I – Table 5, Current Water Supplies Available to the PWPA by City and Category. Estimates of availability by Major Water Provider are included in Appendix J – Table 6, Current Water Supplies Available to the PWPA by Major Water Provider of Municipal and Manufacturing Water.

Groundwater sources which were identified in this chapter include two major and four minor aquifers. These include the Ogallala, Seymour, Blaine, Dockum, Rita Blanca, and Whitehorse aquifers. The volume of water available from the Ogallala aquifer was determined using a numerical model developed by the Bureau of Economic Geology (BEG). Available supplies of water from the remaining aquifers was determined using estimates of saturated thickness, specific yield, and recharge rates from historical studies and published reports.

Surface water supplies identified in the regional water plan include three reservoirs designated for drinking water supply. The three major reservoirs that were identified as significant sources of surface water in the PWPA are Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir. Available supplies from these sources were determined using historical yield studies and an assessment of existing infrastructure. An evaluation of the adequacy of hydrologic data from U.S. Geological Survey (USGS) gaging stations and the need for more current hydrologic data is also presented. The quality of hydrologic data and its potential effect on the reservoir yield analyses is also discussed.

Ten smaller reservoirs are discussed with respect to their use as potential future surface water supplies. These reservoirs are currently used for recreation, flood control, soil erosion control, and wildlife habitat. These include Lake McClellan, Buffalo Lake, Lake Tanglewood, Rita Blanca Lake, Lake Marvin, Baylor Lake, Lake Childress, Lake Fryer, Club Lake, and Bivens Lake. Because yield studies are not routinely performed on smaller reservoirs designated for uses other than drinking water supply, no firm yield information is available for these reservoirs.

As required by TWDB rules [§357.5(k)(1)F, county judges in each of the 21 counties were contacted to determine if any of the county commissioner's courts had water availability requirements. None were identified.

3.1 Groundwater Supplies

Two major aquifers, the Ogallala and Seymour (Figure 3-1), and four minor aquifers, the Blaine, Dockum, Rita Blanca, and Whitehorse (Figure 3-2) supply the majority of all water uses in the PWPA. The Ogallala aquifer supplies the predominant share of groundwater, with additional supplies obtained from the remaining aquifers.

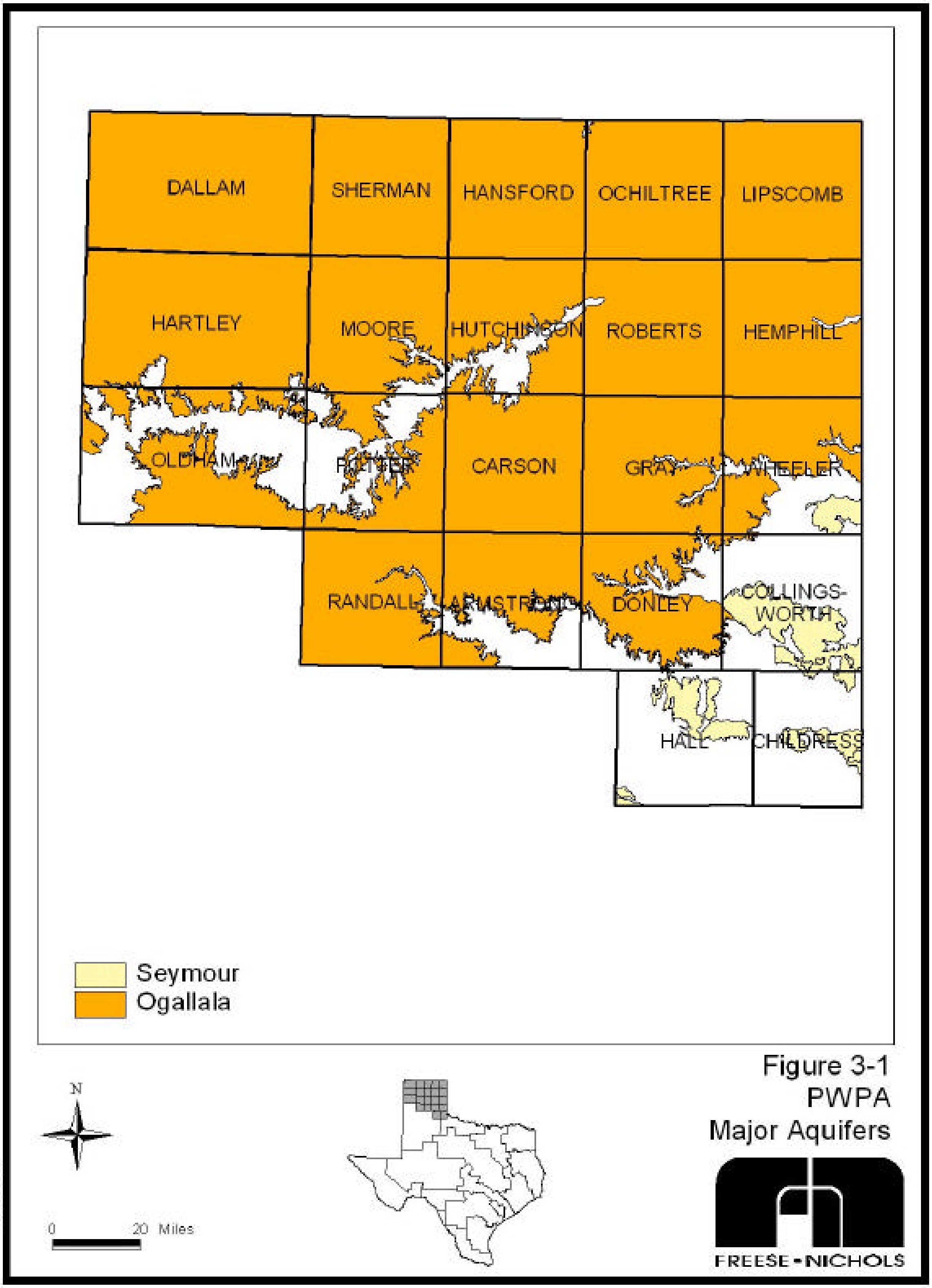


Figure 3-1
PWPA
Major Aquifers

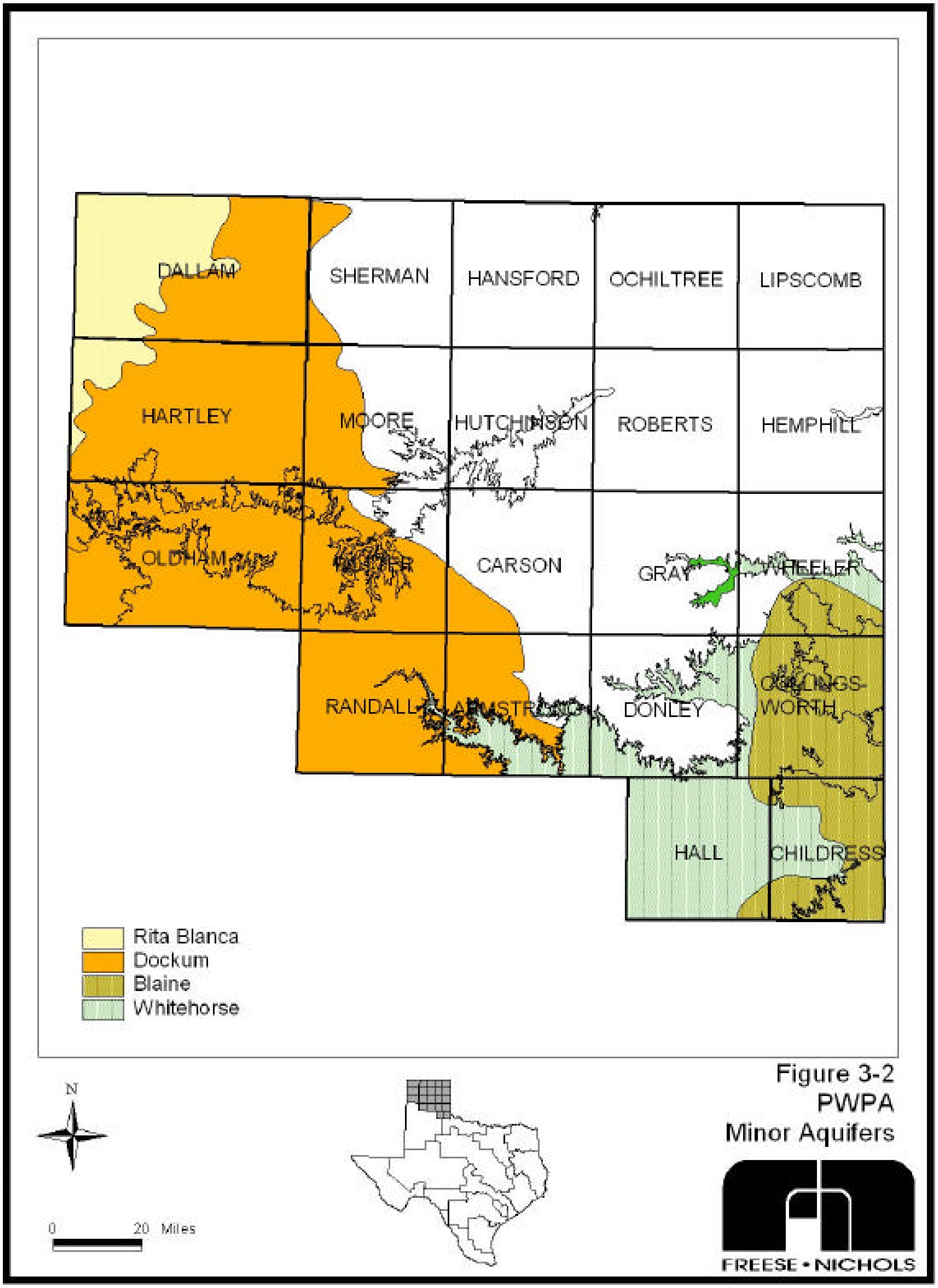


Figure 3-2
PWPA
Minor Aquifers

The Texas Water Development Board (TWDB) estimated the volume of water available from each aquifer for each county in the PWPA for the 1997 State Water Plan; however, adequate documentation of the TWDB methodology for estimating availability of water from the aquifers of the PWPA is not available for this report. For purposes of this study groundwater availability is considered to be fifty percent of the volume in storage or the total effective recharge plus the volume of available storage up to fifty percent of the current total storage, allocated over the 50-year planning period. This methodology was chosen in order to be consistent with groundwater districts' management plans and goals.

Groundwater availability for the Ogallala aquifer was determined by a numerical model developed by the Bureau of Economic Geology (BEG). The report for the BEG model development is presented in Appendix K. The availability of water from the remaining aquifers was determined using estimates of saturated thickness, specific yield, and recharge rates. In cases where this data was not available, historical reports of pumpage and local well level data were used. Details of the calculation for the availability from each of the remaining aquifers are located in Appendix L. The details of annual availability are included in Appendix H, Table 4 of the TWDB Exhibit B. Table 5 of the TWDB Exhibit B is in Appendix I and shows the annual availability for each category, in each county, with limitations to the supply based on developed groundwater rights. If no information was available regarding the ownership of groundwater rights, the supply was limited based on assumed infrastructure limitations using historical usage as the limiting factor.

A description of the aquifers with regard to their location, geologic and hydrogeologic characteristics, historical yields, chemical quality, and available supply is provided in the following paragraphs.

3.1.1 Major Aquifers

Ogallala Aquifer

The Ogallala aquifer in the study area consists of Tertiary-age alluvial fan, fluvial, lacustrine, and eolian deposits derived from erosion of the Rocky Mountains. The Ogallala unconformably overlies Permian, Triassic, and other Mesozoic formations and in turn may be covered by Quaternary fluvial, lacustrine, and eolian deposits (Dutton et. al. 2000a).

The Bureau of Economic Geology (BEG) prepared a numerical model of the Ogallala aquifer for that portion of the aquifer that underlies 18 of the 21 counties of the Panhandle Water Planning Area (PWPA). The model improved on previously prepared models of the aquifer by (1) covering the Ogallala aquifer within most of each county in the PWPA with detailed resolution, (2) using as much as possible spatially controlled geologic and hydrologic data, and (3) placing of the model edges to minimize their effects on the area of interest in Texas (Dutton, et. al., 2000a).

Using the model, BEG estimated volumes of water in storage in the aquifer which have, in turn, been used to determine the available groundwater supply in the Ogallala. For two of the counties (Oldham and Randall) which were not completely covered by the model, BEG developed water-in-storage values using a water budget approach (Dutton, et. al., 2000b). Table 3-1 shows the total value of water available for each of the counties.

Table 3-1. Available Water Supply from the Ogallala Aquifer

County	Water Supply Available (acre-feet)
Armstrong	2,095,000
Carson	8,700,000
Dallam	13,165,000
Donley	1,990,000
Gray	11,015,000
Hansford	12,085,000
Hartley	19,010,000
Hemphill	10,190,000
Hutchinson	3,950,000
Lipscomb	8,635,000
Moore	6,325,000
Ochiltree	9,370,000
Oldham*	1,420,000
Potter	1,430,000
Randall*	2,440,000
Roberts	12,590,000
Sherman	10,415,000
Wheeler	4,900,000
Total	**139,725,000**

*from BEG water budge since the entire counties were not included in the mode.

Seymour Aquifer

The Seymour is a major aquifer located in north central Texas and some Panhandle counties. For the PWPA, the Seymour is located entirely within the Red River basin in Childress, Collingsworth, Hall, Wheeler, and a very small portion of Donley counties. Groundwater in the Seymour formation is found in unconsolidated sediments representing erosional remnants from the High Plains. The saturated thickness of the Seymour Formation is less than 100 feet throughout its extent and is typically less than 50 feet thick in the PWPA. Nearly all recharge to the aquifer is as a result of direct infiltration of precipitation on the land surface. Surface streams are at a lower elevation than water levels in the Seymour aquifer and do not contribute to the recharge. Leakage from underlying aquifers also appears to be insignificant (Duffin, 1992).

Annual effective recharge to the Seymour aquifer in the PWPA is approximately 33,087 acre-feet, or five percent of the average annual rainfall that falls on the outcrop area. No significant groundwater level declines have occurred in wells that pump from the Seymour (TWDB, 1997). As a result, the greater volume of either historical pumpage or effective recharge is used to estimate groundwater availability for the aquifer by county, as shown in Table 3-2.

Table 3-2. Recharge Rate, Pumpage Rate, and Estimated Annual Availability of the Seymour Aquifer

County	Effective Recharge* (acre-feet/yr)	Average Pumpage 1994-1997** (acre-feet/yr)	Estimated Annual Availability (acre-feet/yr)
Childress	4,625	215	4,625
Collingsworth	16,293	20,595	20,595
Donley	12	0	12
Hall	8,182	11,612	11,612
Wheeler	3,975	73	3,975
Total	33,087	32,495	40,189

Source: *WorldClimate, 1999
**TWDB, 1997

3.1.2 Minor Aquifers

Blaine Aquifer

The Blaine Formation is composed of anhydrite and gypsum with interbedded dolomite and clay. Water occurs primarily under water-table conditions in numerous solution channels. Natural salinity in the aquifer from halite dissolution and upward migration of deeper, more saline waters limits the quality of this aquifer. The aquifer is located in four counties in the PWPA, including, Childress, Collingsworth, a small portion of Hall, and Wheeler. It lies completely within the Red River basin.

Effective recharge to the Blaine is estimated to be 94,782 acre-feet per year throughout its extent in the PWPA (TWDB, 1997). Precipitation in the outcrop area is the primary source of recharge. Annual effective recharge is estimated to be five percent of the mean annual precipitation, with higher recharge rates occurring in areas with sandy soil surface layers. No significant water level declines have occurred in the Blaine aquifer. Declines that have occurred are due to heavy irrigation use and are quickly recharged after seasonal rainfall (TWDB, 1997). As shown in Table 3-3, the annual availability of water from the Blaine aquifer is considered to be the greater of either effective recharge or pumpage rates.

Table 3-3. Recharge Rate, Pumpage Rate, and Estimated Annual Availability of the Blaine Aquifer

County	Effective Recharge* (acre-feet/yr)	Average Pumpage 1994-1997** (acre-feet/yr)	Estimated Annual Availability (acre-feet/yr)
Childress	29,075	5,416	29,075
Collingsworth	48,403	6,874	48,403
Hall	3,063	0	3,063
Wheeler	14,241	40	14,241
TOTAL	94,782	12,330	94,782

Source * WorldClimate, 1999; TWDB 1997
** TWDB, 1999

Dockum Aquifer

The Dockum is a minor aquifer that underlies the Ogallala aquifer and extends laterally into parts of West Texas and New Mexico. The primary water-bearing zone in the Dockum Group, commonly called the "Santa Rosa", consists of up to 700 feet of sand and conglomerate interbedded with layers of silt and shale. Domestic use of the Dockum occurs in Oldham, Potter, and Randall counties. The effective recharge rate to the Dockum aquifer is estimated to be 23,500 acre-feet per year and is primarily limited to outcrop areas. Oldham and Potter counties are the main sources of recharge in the PWPA. Differences in chemical quality makeup of Ogallala and Dockum groundwater indicate that very little leakage (<0.188 in/year) occurs into the Dockum from the overlying Ogallala formation (BEG, 1986).

Groundwater storage and recharge of the Dockum aquifer is presented in Table 3-4 (Bradley, 1997). The availability of water from the Dockum aquifer is estimated to be fifty percent of the total storage estimate plus effective annual recharge, using the same availability definition as for the Ogallala. Table 3-4 shows the estimated groundwater availability from the Dockum for each county.

Table 3-4. Estimated Storage, Recharge Rate, Pumpage Rate, and Estimated Annual Availability of the Dockum Aquifer

County	Estimated Storage* (acre-feet)	Estimated Annual Recharge* (acre-feet)	Average Pumpage 1994-1997** (acre-feet/yr)	Estimated Annual Availability (acre-feet)
Armstrong	1,700	0	0	17
Carson	1,200	0	0	12
Dallam	20,000	0	4,967	200
Hartley	39,000	0	819	390
Moore	300	0	13,600	3
Oldham	491,000	2,800	922	7,710
Potter	180,000	300	443	2100
Randall	23,000	0	215	230
Total	756,200	3,100	20,966	10,662

Source: * Bradley, 1997 Estimated storage is for volume < 5,000 mg/L TDS
** TWDB, 1999
NOTE: Although the data in the storage, recharge and pumpage columns may appear inconsistent, it is shown as reported in the cited references.

Rita Blanca Aquifer

The Rita Blanca is a minor aquifer that underlies the Ogallala Formation and extends into New Mexico, Oklahoma, and Colorado. The portion of the aquifer which underlies the PWPA is located in western Dallam and Hartley counties. Groundwater in the Rita Blanca occurs in sand and gravel formations of the Cretaceous and Jurassic Age. The Romeroville Sandstone of the Dakota Group yields small quantities of water, whereas the Cretaceous Mesa Rica and Lytle Sandstones yield small to large quantities of water. Small quantities of groundwater are also located in the Jurassic Exeter Sandstone and sandy sections of the Morrison Formation (Ashworth & Hopkins, 1995).

Recharge to the aquifer occurs by lateral flow from portions of the aquifer system in New Mexico and Colorado and by leakage from the Ogallala. No estimates of recoverable storage, saturated thickness, or other water availability parameters for the aquifer were located for the Rita Blanca aquifer. As a result, historical pumpage data from the aquifer was used to estimate water availability for the Rita Blanca.

According to TWDB data, pumpage from the Rita Blanca averaged about 5,250 acre-feet per year from 1994 to 1997 (Table 3-5). Less than 500 acre-feet per year was pumped by the city of Texline for municipal/industrial supply over this time period. An average of 4,970 acre-feet/yr was pumped for irrigation supply and 70 acre-feet/yr for livestock uses. All pumpage occurs in Dallam County, and no pumping of the Rita Blanca is reported for Hartley County. Municipal water well levels in the Rita Blanca aquifer have historically remained stable, whereas irrigation well water levels have declined steadily. This indicates that irrigation usage rates are currently mining the Rita Blanca supply. Insufficient data exist to quantify the rate.

Table 3-5. Average Pumpage and Projected Groundwater Availability in the Rita Blanca Aquifer for Counties in the PWPA

County	Average Pumpage 1994-1997* (acre-feet/yr)
Dallam	5,250
Hartley	n/a
Total	5,250

Source:*TWDB, 1999

Whitehorse Aquifer

The Whitehorse is a minor Permian aquifer occurring in beds of shale, sand, gypsum, anhydrite, and dolomite. The Whitehorse Formation has an approximate maximum thickness of 500 feet. It is an important source of water in and near the outcrop area around Wheeler County. Wells in the Whitehorse aquifer often pump large quantities of sand and require screens for larger yields. Water from this aquifer is generally used for irrigation, but other uses include livestock and domestic. Water from areas of the Whitehorse that receive recharge from the Ogallala is generally suitable in quality for human consumption (Maderak, 1973).

For the purposes of this water plan, the Whitehorse is assumed to extend into Wheeler, Collingsworth, Donley, Armstrong, Hall, and Childress counties. Wells drawing water from aquifers other than those specifically identified are assumed to be pumping from the Whitehorse, although some wells may be in alluvial formations. Table 3-6 shows the historical pumpage for wells in the Whitehorse aquifer, which is the best data available for available groundwater for usage.

Table 3-6. Projected Groundwater Availability in the Whitehorse Aquifer for Counties in the PWPA

County	Average Pumpage 1994-1997* (acre-feet/year)	Historical Maximum Pumpage (1994-1997)* (acre-feet/year)
Armstrong	120	144
Childress	62	82
Collingsworth	30	32
Donley	43	71
Hall	40	46
Wheeler	271	335
Total	566	664

Source: * TWDB 1999

3.2 Surface Water Supplies

Surface water supplies in the PWPA include Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir. The supply available from these reservoirs is determined through yield studies and sedimentation surveys which include evaluations of critical drought, and sedimentation rates. The firm yield for a reservoir is defined as the safe water supply available during a critical drought. Ideally, the period of analysis for a yield study includes the entire critical drought period. This "critical period" of a reservoir is that time period between the date of minimum content and the date of the last spill. If a reservoir has reached its minimum content but has not yet filled enough to spill, then it is considered to still be in its critical period. A definition of the critical period for each reservoir is essential to determine the yield, or estimate of available water supply. The safe yield is defined as the amount of water that can be diverted annually, leaving a minimum of a one year supply in reserve during the critical period. Conservation storage is the amount of water held for later release for usual purposes such as municipal water supply, power, or irrigation in contrast with storage capacity used for flood control. The following sections contain an evaluation of these reservoirs based on reviews of the 1997 State Water Plan, historical reservoir studies, and water rights.

U.S. Geological Survey (USGS) streamflow gages in the Panhandle Water Planning Area (PWPA) are used to estimate runoff received by the region's main surface water supply reservoirs: Lake Meredith, Palo Duro Reservoir, and Greenbelt Lake. A discussion of the gage information available for evaluation of yield for each of these reservoirs is also presented.

Figure 3-3 shows the forty-four USGS gages throughout and surrounding the PWPA with available hydrologic data. Fourteen of those gages were in operation as of water year 1997. Only five of them have a period of record extending before 1960, and two provide lake elevation records (Lakes Meredith and Greenbelt). Figures 3-4a and 3-4b show the periods of hydrologic record for gaging stations in the Canadian River basin and the Red River basin, respectively. Some gages are not within the PWPA boundary, but are included since they provide useful data for PWPA watersheds.

Table 3-7 summarizes the existing yield studies for the three main water supply reservoirs in the PWPA: Lake Meredith, Palo Duro Reservoir, and Greenbelt Lake. According to the existing yield studies for these reservoirs, all of them appear to be currently experiencing their critical drought period.

The uncertainty in the firm yield of the three surface water supply reservoirs for the PWPA will very likely be reduced when the 1998 and 1999 hydrologic data are included in the analyses. However, the firm yield for Palo Duro Reservoir will remain difficult to define using the available hydrologic records in the area.

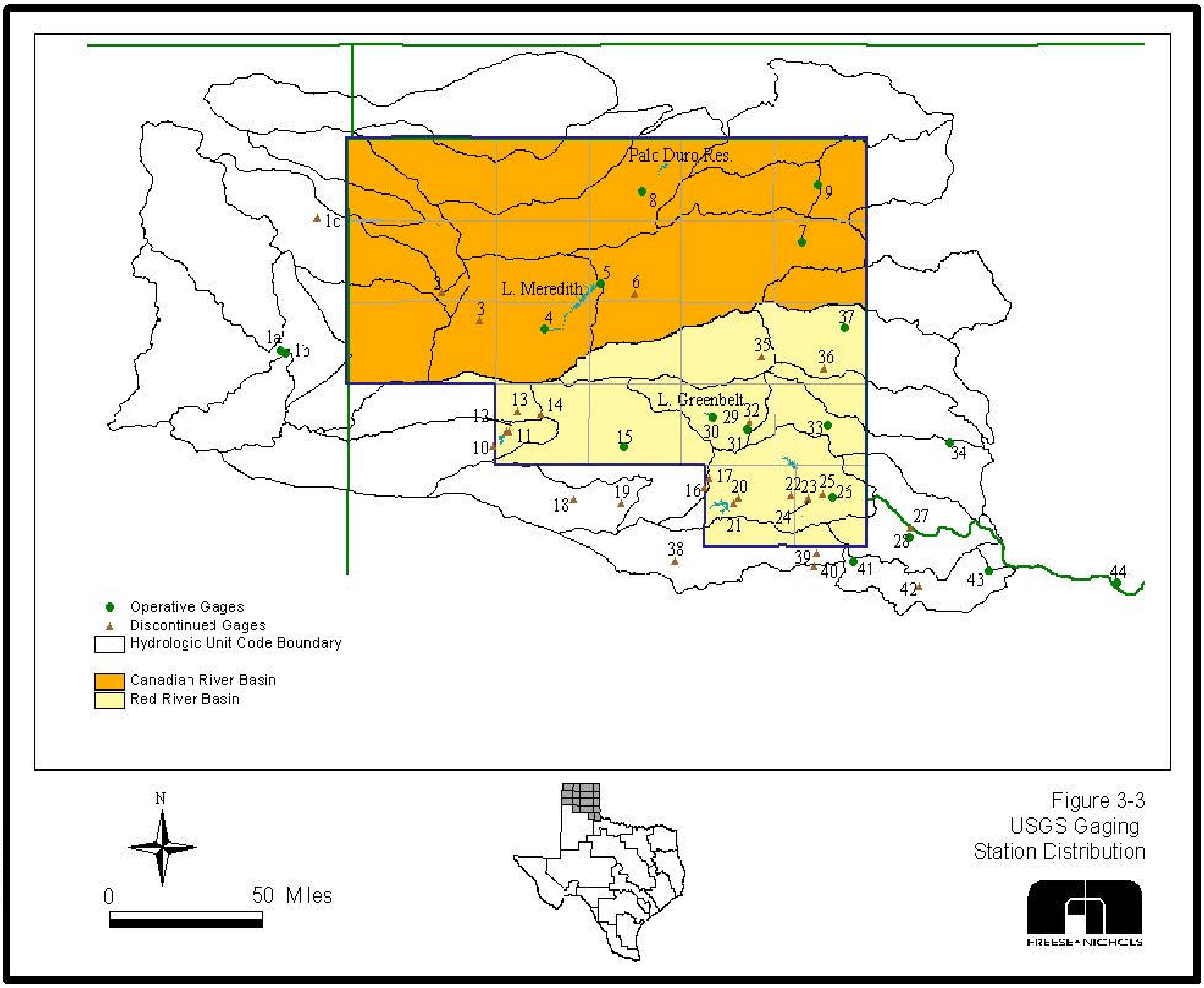


Figure 3-3
USGS Gaging
Station Distribution

Figure 3-4a. Periods of Hydrologic Record for Gaging Stations in the Canadian River Basin of the PWPA

ID	Station	HUC Name
1a	7227000	Upper Canadian-Ute Reservoir Basin
1b	7227100	Revuelto Basin
1c	7227200	Punta de Agua Basin
2	7227448	Punta de Agua Basin
3	7227470	Lake Meredith Basin
4	7227500	Lake Meredith Basin
5	7227900	Lake Meredith Basin
6	7227920	Middle Canadian-Spring Basin
7	7228000	Middle Canadian-Spring Basin
8	7233500	Palo Duro Basin
9	7235000	Lower Wolf Basin

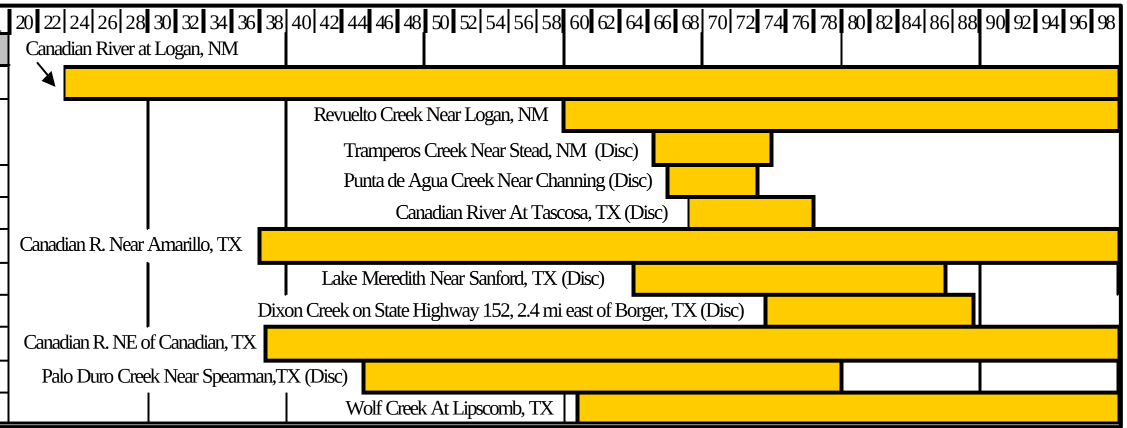


Figure 3-4b. Periods of Hydrologic Record for Gaging Stations in the Red River Basin of the PWPA

ID	Station	HUC Name	
10	7295500	Tierra Blanca Basin	Tierra Blanca Cr Ab Buf.Lk Nr Umbarger,TX (Disc)
11	7296000	Tierra Blanca Basin	Buffalo Lake Near Umbarger, TX (Disc)
12	7296100	Tierra Blanca Basin	Tierra Blanca C Bl Buf.Lk Near Umbarger,TX (Disc)
13	7297000	Lower Salt Fork Red Basin	Palo Duro Creek At Amarillo City Lake Nr Canyon, TX
14	7297500	Upper Prairie Dog Town Fork Red Basin	Prairie Dog Town F Red R Near Canyon, TX (Disc)
15	7297910	Upper Prairie Dog Town Fork Red Basin	Prairie Dog Town Fork Red River Near Wayside, TX
18	7298000	Tule Basin	North Tule Draw at Res. Nr Tulia, TX (Disc)
19	7298200	Tule Basin	Tule Creek Near Silverton, TX (Disc)
16	7298500	Upper Prairie Dog Town Fork Red Basin	Prairie Dog Town Fork Red R Near Brice TX (Disc)
17	7299000	Upper Prairie Dog Town Fork Red Basin	Mulberry Creek Near Brice, TX (Disc)
20	7299200	Lower Prairie Dog Town Fork Red Basin	Prairie Dog Town Fork Red River Near Lakeview,TX (Disc)
21	7299300	Lower Prairie Dog Town Fork Red Basin	Little Red River Near Turkey, TX (Disc)
22	7299500	Lower Prairie Dog Town Fork Red Basin	Prairie Dog Town Fork Red River Near Estelline,TX (Disc)
23	7299512	Lower Prairie Dog Town Fork Red Basin	Jonah Creek At Weir Near Estelline,TX (Disc)
24	7299514	Lower Prairie Dog Town Fork Red Basin	Jonah Creek Below Wier Near Estelline,TX (Disc)
25	7299530	Lower Prairie Dog Town Fork Red Basin	Salt Creek Near Estelline, TX (Disc)
26	7299540	Lower Prairie Dog Town Fork Red Basin	Prairie Dog Town Fork Red River Near Childress, TX
27	7299570	Groesbeck-Sandy Basin	Red River Near Quanah, TX (Disc)
28	7299670	Groesbeck-Sandy Basin	Groesbeck Creek At S.H. 6 Near Quanah, TX
29	7299840	Upper Salt Fork Red Basin	Greenbelt Lake Near Clarendon, TX
30	7299850	Upper Salt Fork Red Basin	Salt Fork Red River Near Clarendon TX (Disc)
31	7299890	Upper Salt Fork Red Basin	Lelia Lake Creek Below Bell Creek Near Hedley, TX
32	7299900	Upper Salt Fork Red Basin	Lelia Lake Creek Near Hedley,TX (Disc)
33	7300000	Lower Salt Fork Red Basin	Salt Fork Red River Near Wellington, TX
34	7300500	Lower Salt Fork Red Basin	Salt Frk Red R at Mangum, TX
35	7301200	Upper North Fork Red Basin	McClellan Cr Near Mclean,TX (Disc)
36	7301300	Middle North Fork Red Basin	North Fork Red River Near Shamrock, TX
37	7301410	Middle North Fork Red Basin	Sweetwater Creek Near Kelton, TX
38	7307500	North Pease Basin	Quitaque Creek Near Quitaque,TX (Disc)
39	7307600	North Pease Basin	N Pease River Near Childress,TX (Disc)
40	7307750	Middle Pease Basin	Middle Pease River Near Paducah, TX (Disc)
41	7307800	Pease Basin	Pease River Near Childress, TX
42	7308000	Pease Basin	Pease River Near Crowell TX (Disc)
43	7308200	Pease Basin	Pease River Near Vernon, TX
44	7308500	Blue-China Basin	Red River Near Burkburnett, TX

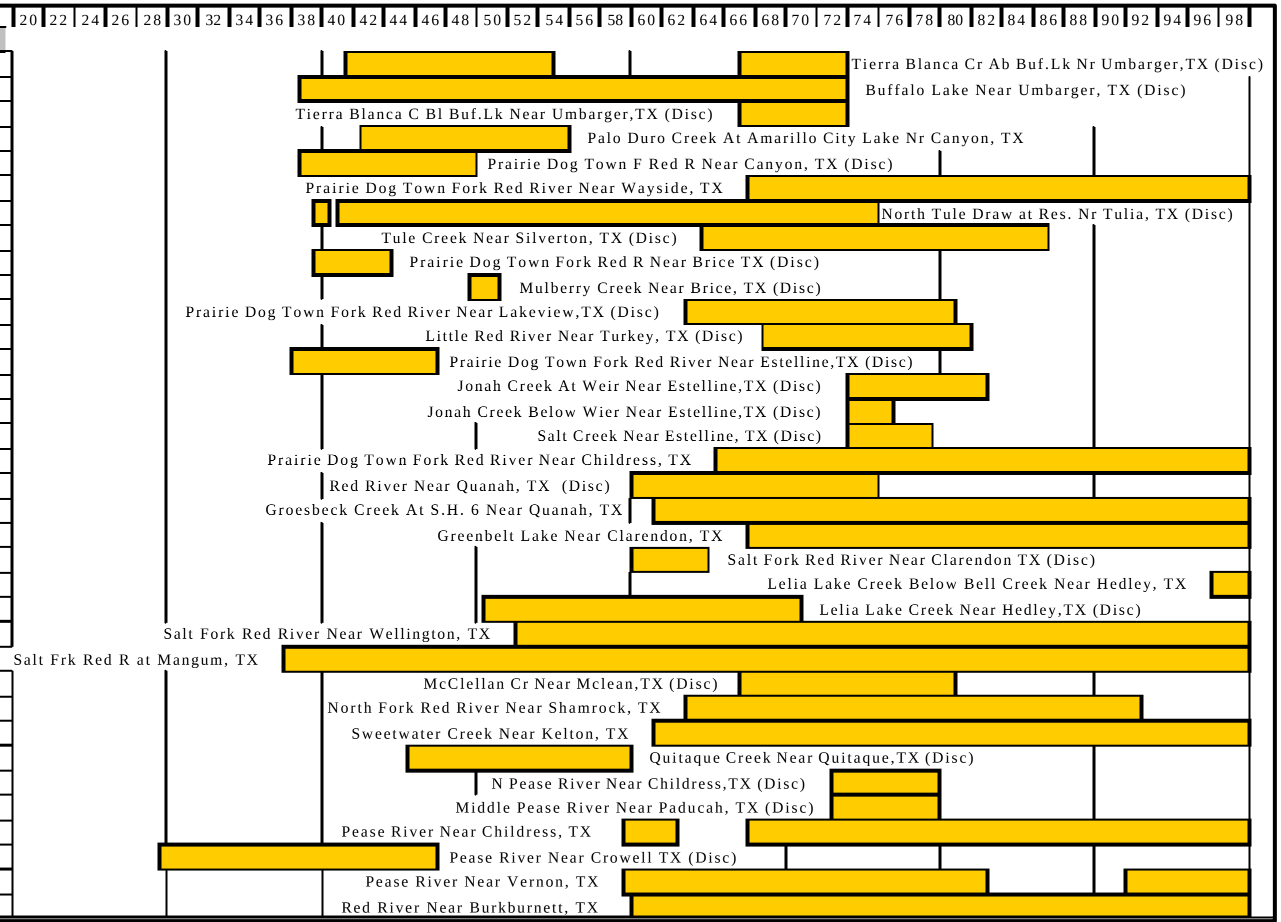


Table 3-7. Descriptive Information of Water Supply Reservoirs in the PWPA

	Palo Duro Reservoir	Lake Meredith	Greenbelt Reservoir
Owner/Operator	PDRA	National Park Service, BuRec and CRMWA	GM&IWA
Stream	Palo Duro Creek	Canadian River	Salt Fork Red River
Dam	Palo Duro	Sanford	Greenbelt
Use	Municipal	Municipal and Industrial; Flood Control; Sediment Storage	Municipal, Industrial, and Mining
Date of Impoundment	January 1991	January 1965	December 1966
Sources of Information	PDRA, TWDB, and USGS	CRMWA, TWDB, and USGS	GMIWA, TWDB, and USGS
Conservation Storage (most recent survey)	60,897 acre-feet (1974)	817,970 acre-feet (1995) (includes sediment storage)	59,110 acre-feet (1965)
Firm Yield	10,460 acre-feet/yr (permitted) 6,570 acre-feet/yr	151,200 acre-feet/yr (permitted) 76,000 acre-feet/yr	16,230 (permitted) 7,457 acre-feet/yr (1997)

Water Rights

According to the TNRCC water rights database (TNRCC, 1999) there are 80 water rights permit holders in the PWPA representing a total of 191,343 acre-feet/yr. As shown in Table 3-8, five water rights permits have been assigned to four permittees for rights greater than 1,000 acre-feet/yr. These represent a total of 181,590 acre-feet/yr, or approximately 95 percent of the total water rights allocated in the PWPA. Table 3-9 summarizes the remaining 76 water rights in the PWPA which are less than 1,000 acre-feet/yr, representing 9,753 acre-feet/yr.

Table 3-8. Water Rights in the PWPA Greater Than 1,000 acre-feet/yr

County	Basin Name	Stream/Reservoir	WR Owner	Authorized Use	Authorized Diversion (acre-feet)
Donley	Red	Greenbelt Reservoir	GM&IWA	Municipal/Domestic	14,530
Hansford	Canadian	Palo Duro Reservoir	PDRA	Municipal/Domestic	10,460
Hutchinson	Canadian	Lake Meredith	CRMWA	Industrial	51,200
Hutchinson	Canadian	Lake Meredith	CRMWA	Municipal/Domestic	100,000
Randall	Red	Palo Duro Creek	City of Amarillo	Other	5,400
Total					181,590

Table 3-9. Water Rights in the PWPA Less Than 1,000 acre-feet/yr

County	Basin Name	Stream/Reservoir	Authorized Use	Authorized Diversion (acre-feet/yr)
Carson	Red	McClellan	Irrigation	445
Childress	Red	Baylor	Municipal/Domestic	397
		Buck	Irrigation	39
Collingsworth	Red	Cody	Irrigation	34
		Crow	Irrigation	23
		Elm Creek	Irrigation	215
		Panther Branch	Irrigation	60
		Salt Fork Red River	Irrigation	281
		Sand	Irrigation	300
		Unnamed Tributary to Salt Fork Red River	Irrigation	75
		Unnamed Tributary to Wolf Creek	Irrigation	159
Dallam	Canadian	Coldwater Creek	Irrigation	190
Donley	Red	Carroll Creek	Irrigation	200
		Lelia Lake Creek	Irrigation	184
		Salt Fork Red River	Irrigation	200
		Salt Fork Red River	Industrial	500
		Salt Fork Red River	Irrigation	250
		Salt Fork Red River	Mining	750
		Whitefish Creek	Irrigation	80
Gray	Canadian	Unnamed Tributary to Red Deer Creek	Irrigation	4
	Red	Hackberry Creek	Irrigation	70
		Unnamed Tributary	Irrigation	129
		Unnamed Tributary to Sweetwater Creek	Irrigation	60
Hall	Red	Cottonwood Creek	Irrigation	101
Hansford	Canadian	Horse Creek	Irrigation	360
		Palo Duro Creek	Irrigation	90
		Unnamed Tributary to Coldwater Creek	Irrigation	40
		Unnamed Tributary Hackberry Creek	Irrigation	40
Hutchinson	Canadian	Bent Creek	Irrigation	250
		Unnamed Tributary to Canadian River	Industrial	230
		Unnamed Tributary Dixon Creek	Industrial	60
		Unnamed Tributary South Palo Duro Creek	Irrigation	106
Lipscomb	Canadian	Kiowa Creek	Irrigation	102
		Plum Creek	Irrigation	20
Moore	Canadian	North Palo Duro Creek	Irrigation	90
		Unnamed Tributary North Blue Creek	Irrigation	10
		Unnamed Tributary South Palo Duro Creek	Irrigation	245
Oldham	Canadian	Unnamed Tributary Ranch Creek	Mining	30
Potter	Canadian	Unnamed Tributary	Irrigation	180
		Unnamed Tributary West Amarillo Creek	Irrigation	169
Randall	Red	Palo Duro Creek	Irrigation	80
		Prairie Dog Town Fork Red River	Irrigation	38
		Prairie Dog Town Fork Red River	Municipal/Domestic	2
		South Cita	Irrigation	400
		Tierra Blanca	Irrigation	502

Table 3-9 Water Rights in the PWPA Less Than 1,000 acre-feet/yr – (cont.)

County	Basin Name	Stream/Reservoir	Authorized Use	Authorized Diversion (acre-feet/yr)
Roberts	Canadian	Red Deer Creek	Irrigation	640
Sherman	Canadian	North Palo Duro Creek	Irrigation	275
Wheeler	Red	Cogurn	Irrigation	20
		Gageby	Irrigation	70
		Lower Hackberry	Irrigation	100
		North Elm Creek	Irrigation	119
		Salt Creek	Irrigation	123
		Sweetwater Creek	Irrigation	257
		Unnamed Tributary to Bronco Creek	Irrigation	10
		Unnamed Tributary North Fork Red River	Irrigation	30
		Unnamed Tributary South Sweetwater Creek	Irrigation	319
Total				**9,753**

3.2.1 Lake Meredith

Lake Meredith is owned by the National Park Service and the Bureau of Reclamation (BuRec) and is operated by the Canadian River Municipal Water Authority (CRMWA). It was built by the Bureau of Reclamation with a conservation storage of 500,000 acre-feet, limited by the Canadian River Compact (CRC). Impoundment of Lake Meredith began in January 1965 (TWDB, 1974), but hydrological and climatic conditions have prevented the reservoir from ever spilling. Most of the inflow to Lake Meredith originates below the Ute Reservoir in New Mexico.

Two yield studies have been published for Lake Meredith since its construction in 1956 (HDR, 1987; Lee Wilson and Associates). The study by HDR (1987) estimated that the firm yield was about 76,000 acre-feet/yr. and that development of New Mexico projects might further reduce the yield to 66,000 acre-feet/yr. Another yield study in 1993 (Lee Wilson and Associates, 1993) estimated a firm yield of approximately 76,000 acre-feet based on 1991 area-capacity conditions and 1980 sedimentation rates. The yield study showed the reservoir reaching a minimum content of 59,700 acre-feet in May 1981. This content represents the lowest elevation from which the water intake structures can divert water. A TWDB survey of Lake Meredith in 1995 estimated conservation and sediment storage of 817,970 acre-feet (TWDB, 1995). The CRC limits the conservation storage to 500,000 acre-feet.

Projections of conservation storage, firm yield, and available supply for Lake Meredith during planning period of 2000 through 2050 are based on the provisions of the CRC. Sedimentation is not anticipated to adversely affect the yield of Lake Meredith during the 50-year planning period. Table 3-10 shows the projected storage, yield, and available supply of Lake Meredith by decade for the planning period.

Table 3-10. Projected Yield and Available Supply of Lake Meredith

	2000	2010	2020	2030	2040	2050
Storage Capacity (acre-feet)	810,932	796,857	782,782	768,707	754,632	740,557
Conservation Storage * (acre-feet)	500,000	500,000	500,000	500,000	500,000	500,000
Firm Yield (acre-feet/yr)	76,000	76,000	76,000	76,000	76,000	76,000
Available Supply (acre-feet)	76,000	76,000	76,000	76,000	76,000	76,000

* Limited by provisions of the Canadian River Compact

A large portion of Lake Meredith's inflow (about 90%) originates upstream of the Canadian River gage near Amarillo. The most recent yield study of Lake Meredith was performed in February 1993 (Parkhill, Smith, and Cooper, 1993). Total inflows for this study were estimated through a volumetric water balance, subtracting evaporation, diversions, releases and seepage from the observed change in storage. In this analysis, the runoff below the Amarillo gage amounted to about 10% of the total inflow.

Inflow data sources for Lake Meredith have been adequate for previous firm yield studies. The U.S. Geological Survey gage on the Canadian River near Amarillo has supplied important hydrologic records for these computations. The critical period for the reservoir extends beyond the most recent period of analysis. The Amarillo gaging station should continue to serve as the best estimate of the majority of Lake Meredith inflows in future yield studies.

3.2.2 Palo Duro Reservoir

The Palo Duro River Authority owns and operates the Palo Duro Reservoir as a water supply for its six member cities of Cactus, Dumas, Sunray, Spearman, Gruver, and Stinnett. The reservoir is located on Palo Duro Creek in Hansford County, 12 miles north of Spearman. The dam began impounding water in January 1991 and was over 80% full (by depth) in July 1999. Construction of transmission systems for delivering water to member cities is anticipated to be complete by 2030.

The original conservation storage capacity of the reservoir was estimated to be 60,897 acre-feet. A study by Freese & Nichols (1974) estimated the yield to be approximately 8,700 acre-feet per year. The most recent yield studies for the Palo Duro Reservoir show that it is currently in its critical period (Freese and Nichols, 1974, 1984, 1986) and that the yield is estimated to be 6,543 acre-feet/yr. In all these studies inflows from January 1946 through September 1979 are based on flow measurement at the gage on Palo Duro Creek near Spearman. This gage was discontinued in September 1979, but was reactivated in 1999.

USGS gages in nearby watersheds are not well correlated with the Spearman gage, although they provide the best means of predicting reservoir inflows. Figure 3-5 shows a scatter plot of the monthly Wolf Creek gage records vs. the Spearman gage records for the overlapping period (from October 1961 through September 1979). The large scatter in Figure 3-5 indicates a degree of uncertainty in estimated inflow to Palo Duro Reservoir during the critical period. Without a stronger correlation in inflows between the two gages, the yield for the reservoir is difficult to define.

Normally, a volumetric balance can be used to estimate inflows to existing reservoirs. However, the balance for Palo Duro shows large apparent losses from the reservoir. The apparent monthly net runoff (runoff - losses) is normally negative for the operation period from May 1991 to June 1999. The negative net runoff estimates mean that losses from the reservoir often exceed the inflows. Large losses are not impossible when a reservoir is filling. To quantify these losses, an independent estimate of inflows is required.

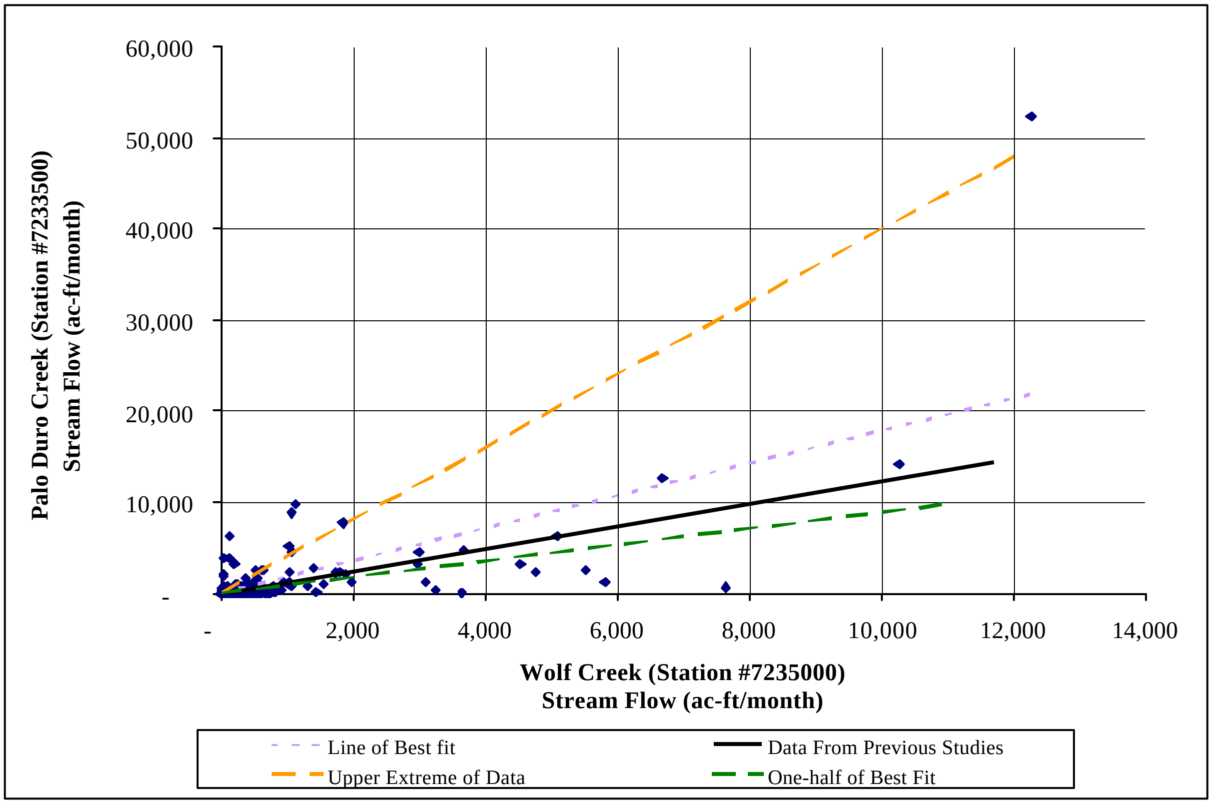
The Palo Duro Reservoir firm yield is currently not well defined. The best available data for the computation of inflows are the records from the Wolf Creek gage, located 50 miles east of the reservoir in a different watershed. The reactivation of the Spearman gage should improve estimates of the reservoir's inflow, losses, and firm yield.

Based on a linear interpolation of the most recent yield estimate, the projected firm yield of Palo Duro Reservoir is expected to decrease from 6,543 acre-feet in 2000 to 6,092 acre-feet by 2050. Table 3-11 shows the projected yield and available supply from Palo Duro Reservoir during the planning period. The available supply from Palo Duro Reservoir is limited during the beginning of the planning period by the lack of a delivery system.

Table 3-11 Projected Yield and Available Supply of Palo Duro Reservoir

	2000	2010	2020	2030	2040	2050
Conservation Capacity (acre-feet)	59,792	58,564	57,336	56,108	54,880	53,652
Firm Yield (acre-feet/yr)	6,543	6,453	6,363	6,273	6,182	6,092
Available Supply (acre-feet)	--	--	--	--	--	--

Figure 3-5. Monthly Stream Flows Recorded at Wolf Creek and Spearman Gaging Stations



3.2.3 Greenbelt Reservoir

Greenbelt Reservoir is owned and operated by the Greenbelt Municipal and Industrial Water Authority (GM&IWA), and is located on the Salt Fork of the Red River near the city of Clarendon. Construction of Greenbelt Reservoir was completed in March 1968 and impoundment of water began on December 1966 (Freese & Nichols, 1978). The original storage capacity of Greenbelt was 59,100 acre-feet at the spillway elevation of 2,663.65 feet (TWDB, 1974).

Two yield studies have been completed for Greenbelt Reservoir since its original permit application in 1965 (Freese & Nichols, 1978 & 1997). The most recent of the studies estimated the firm yield of Greenbelt Reservoir to be 7,699 acre-feet/yr. The reservoir's critical period occurred from August 1961 to December 1996, with a minimum content occurring in June 1996. The safe yield of the reservoir is estimated to be 6,350 acre-feet/yr (5.67 MGD).

Inflow estimates prior to September 1967 were based on USGS gages near Mangum, Wellington, and Clarendon. Inflows after September 1967 were based on a volumetric balance of the reservoir with USGS surface elevation measurements taken at the dam. Net reservoir evaporation rates were derived from 1-degree quadrangle data published by the TWDB (TWDB, 1967). Reservoir operation studies also included an estimate of historical low-flow releases.

Sedimentation rates characteristic of the area were used to estimate a reservoir capacity reduction of 5,770 acre-feet by 1996 (Freese & Nichols, 1997).

Based on analysis of existing studies and historical data, estimates of capacity, firm yield, and available supply of Greenbelt Reservoir were projected by decade for the planning period. As shown in Table 3-12, the yield is expected to decrease from 7,699 acre-feet in 2000 to 6,942 acre-feet by 2050.

Table 3-12. Projected Yield and Available Supply of Greenbelt Reservoir

	2000	2010	2020	2030	2040	2050
Conservation Capacity (acre-feet)	52,472	50,402	48,332	46,262	44,192	42,122
Firm Yield (acre-feet/yr)	7,699	7,548	7,396	7,245	7,093	6,942
Available Supply (acre-feet)	7,699	7,548	7,396	7,245	7,093	6,942

<u>Evaluation of Reservoir Yield Studies</u>
Information provided in the existing yield studies of Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir should be updated as new information and studies become available, specifically, the determination of critical periods, net evaporation rates, and sedimentation surveys. Changes in these parameters may significantly change the estimates of available surface water supply in the PWPA.

The critical period for each of the three reservoirs extends beyond the most recent periods of analyses. Firm yield analyses based on portions of a critical period rather than the entire critical period may overestimate yields.

In April 1998, the Texas Water Development Board (TWDB) revised (generally reduced) its estimates of lake evaporation by quadrangle, a key factor governing the yield of West Texas water supply reservoirs. This could result in changes to estimations of historical and naturalized flows as well reservoir simulation results. Most of the previous yield studies for Palo Duro Reservoir and Greenbelt Reservoir used the TWDB's previous net reservoir evaporation rates. However, Lake Meredith yield studies used CRMWA pan evaporation data.

Each of the existing yield studies has been completed without a recent sedimentation survey. As more recent surveys are conducted, the new area-capacity information should be used to revise the yield estimates. At the time of this report, the 1995 Lake Meredith sedimentation survey conducted by the TWDB has not been used to define the yield. Sedimentation surveys are not available for either Palo Duro or Greenbelt Lake.

3.2.4 <u>Other Potential Surface Water Sources</u>

Ten minor reservoirs in the PWPA have been identified as other potential sources of surface water. These include Lake McClellan, Buffalo Lake, Lake Tanglewood, Rita Blanca Lake, Lake

Marvin, Baylor Lake, Lake Childress, Lake Fryer, Club Lake, and Bivens Lake. The historical or current supply of these water bodies has not been quantified through yield studies. The following paragraphs discuss the available information about each of these water bodies. Table 3-13 summarizes descriptive information about each of the minor reservoirs.

Table 3-13. Descriptive Information of Minor Reservoirs in the PWPA

Reservoir	Stream	River Basin	Use	Water Rights *	Date of Impoundment	Capacity (acre-feet)
Lake McClellan	McClellan Creek	Red	soil conservation, flood control, recreation, promotion of wildlife	USFS (recreational)	1940s	5,005 *
Buffalo Lake	Tierra Blanca Creek	Red	flood control, promotion of wildlife,	n/a	1973-1975	18,150
Lake Tanglewood	Palo Duro Creek	Red	recreation	n/a	1960s	n/a
Rita Blanca Lake	Rita Blanca Creek	Canadian	recreation	Dallam & Hartley Counties (recreational)	1941	12,100
Lake Marvin	Boggy Creek	Canadian	soil conservation, flood control, recreation, promotion of wildlife	U.S. Forest Service (recreational)	1930s	553 *
Baylor Lake	Baylor Creek	Red	recreation	City of Childress 397 acre-feet/yr	1949	9,220
Lake Childress	unnamed tributary to Baylor Creek	Red	n/a	n/a	1923	4,600 (as built)
Lake Fryer	Wolf Creek	Canadian	soil conservation, flood control, recreation,	n/a	1938	n/a
Club Lake	n/a	Red	n/a	n/a	N/a	n/a
Bivens Lake	Palo Duro Creek	Red	ground water recharge	n/a	1926	5,120

Source: Breeding, 1999
*TNRCC, 1999
n/a – data not available

Lake McClellan

Lake McClellan in the Red River basin and also known as McClellan Creek Lake was constructed on McClellan Creek twenty-five miles south of Pampa in southern Gray County. It was built in the late 1940's by the Panhandle Water Conservation Authority, primarily for soil conservation, flood control, recreation, and promotion of wildlife. The U.S. Forest Service has a recreational water right associated with McClellan Creek National Grassland (TNRCC, 1999). Lake McClellan has a capacity of 5,005 acre-feet (Breeding, 1999).

Buffalo Lake

Buffalo Lake is a reservoir impounded by Umbarger Dam, three miles south of the city of Umbarger on upper Tierra Blanca Creek in western Randall County. The reservoir is in the Red River basin. The original dam was built in 1938 by the Federal Farm Securities Administration to store water for recreational purposes. The lake's drainage area is 2,075 square miles, of which 1,500 square miles are probably noncontributing.

In 1973-1975 a low water dam was built to increase habitat for ducks and geese. In 1978, the low water dam was washed out and the water was released. In 1982, the low water dam was rebuilt, and was reworked in 1992 to become a flood control structure (R.N. Clark, Personal Communication). Several species of waterfowl use the lake as a winter refuge (Breeding, 1999). There are no water rights associated with Buffalo Lake (TNRCC, 1999).

Lake Tanglewood

Lake Tanglewood is located in the Red River basin and is formed by an impoundment constructed in the early 1960's on Palo Duro Creek in northeastern Randall County. Lake Tanglewood, Inc., a small residential development is located along the lake shore (Breeding, 1999). There are no water rights associated with Lake Tanglewood (TNRCC, 1999)

Rita Blanca Lake

Rita Blanca Lake is on Rita Blanca Creek, a tributary of the Canadian River, in the Canadian River basin three miles south of Dalhart in Hartley County. The Rita Blanca Lake project was started in 1938 by the WPA in association with the Panhandle Water Conservation Authority. In June 1951, Dalhart obtained a ninety-nine-year lease for the operation of the project as a recreational facility without any right of diversion (Breeding, 1999). The lake is currently owned by the Texas Parks and Wildlife Department and is operated and managed jointly by Hartley and Dallam county commissioners for recreational purposes. The two counties have joint recreational water rights (TNRCC, 1999). The lake has a capacity of 12,100 acre-feet and a surface area of 524 acres at an elevation of 3,860 feet above mean sea level. The drainage area above the dam is 1,062 square miles. The city of Dalhart discharges treated domestic wastewater to Rita Blanca Lake.

Lake Marvin

Lake Marvin, also known as Boggy Creek Lake, was constructed in the 1930s on Boggy Creek, in east central Hemphill County by the Panhandle Water Conservation Authority. The lake is in the Canadian River basin and was constructed for soil conservation, flood control, recreation, and promotion of wildlife (Breeding, 1999). The reservoir has a capacity of 553 acre-feet and is surrounded by the Panhandle National Grassland. The USFS has a water right for recreational use of Marvin Lake (TWDB, 1999).

Baylor Lake

Baylor Lake is on Baylor Creek in the Red River basin, ten miles northwest of Childress in western Childress County. The reservoir is owned and operated by the city of Childress. Although the City has water rights to divert up to 397 acre-feet per year from the reservoir (TWDB, 1999), there is currently no infrastructure remaining to divert water for municipal use. Construction of the earthfill dam was started on April 1, 1949, and completed in February 1950. Deliberate impoundment of water was begun in December 1949. Baylor Lake has a capacity of 9,220 acre-feet and a surface area of 610 acres at the operating elevation of 2,010 feet above mean sea level. The drainage area above the dam is forty square miles. (Breeding, 1999).

Lake Childress

Lake Childress is eight miles northwest of Childress in Childress County. This reservoir, built in 1923 on a tributary of Baylor Creek, in the Red River basin, had an original capacity of 4,600 acre-feet; it is adjacent to Baylor Lake. In 1964 it was still part of the City's water supply system, as was the smaller Williams Reservoir to the southeast [Breeding, 1999]. There are no water rights shown for the lake in TNRCC's water rights database (TNRCC, 1999).

Lake Fryer

Lake Fryer, originally known as Wolf Creek Lake, was formed by the construction of an earthen dam on Wolf Creek, in the Canadian River basin, in eastern Ochiltree County. After the county purchased the site, construction on the dam was begun in 1938 by the Panhandle Water Conservation Authority. The dam was completed by the late summer of 1940. During the next few years Wolf Creek Lake was used primarily for soil conservation, flood control, and recreation. In 1947, a flash flood washed away the dam, but it was rebuilt in 1957. During the 1980s the lake and the surrounding park were owned and operated by Ochiltree County and included a Girl Scout camp and other recreational facilities (Breeding, 1999).

Club Lake

Brookhollow Country Club Lake, a private fishing lake with cabin sites, is six miles northeast of the city of Memphis in Hall County. The reservoir is in the Red River basin. No estimates of lake capacity are available.

Bivens Lake

Bivens Lake, also known as Amarillo City Lake, is an artificial reservoir formed by a dam on Palo Duro Creek, in the Red River basin, ten miles southwest of Amarillo in western Randall County. It is owned and operated by the city of Amarillo to recharge the groundwater reservoir that supplies the City's well field. The project was started in 1926 and completed a year later. It has a capacity of 5,120 acre-feet and a surface area of 379 acres at the spillway crest elevation of 3,634.7 feet above mean sea level. Water is not diverted directly from the lake, but the water in storage recharges, by infiltration, a series of ten wells that are pumped for the City supply. Because runoff is insufficient to keep the lake full, on several occasions there has been no storage. The drainage area above the dam measures 982 square miles, of which 920 square miles are probably noncontributing (Breeding, 1999).

Playa Lakes

The most visible and abundant wetlands features within the PWPA are playa basins. These are ephemeral wetlands which are an important element of surface hydrology and ecological diversity. Most playas are seasonally flooded basins, receiving their water only from rainfall or snowmelt. Moisture loss occurs by evaporation and filtration through the soil to underlying aquifers.

Wetlands are especially valued because of the wide variety of functions they perform, and the uniqueness of their plant and animal communities. Ecologically, wetlands can provide high quality habitat in the form of foraging and nesting areas for wildlife, and spawning and nursery habitat for fish. Approximately 4,884 playa lakes are located in the PWPA, covering approximately one percent of the surface area (NRCS, 1999).

Playa basins have a variety of shapes and sizes which influence the rapidity of runoff and rates of water collection. Playas have relatively flat bottoms, resulting in a relatively uniform water depth, and are generally circular to oval in shape. Typically, the soil in the playas is the Randall Clay.

Playa basins also supply important habitat for resident wildlife. The basins provide mesic sites in a semi-arid region and therefore are likely to support a richer, denser vegetative cover than surrounding areas. Moreover, the perpetual flooding and drying of the basins promotes the growth of plants such as smartweeds, barnyard grass, and cattails that provide both food and cover. The concentric zonation of plant species and communities in response to varying moisture levels in basin soils enhances interspersion of habitat types. Playas offer the most significant wetland habitats in the southern quarter of the Central Flyway for migrating and wintering birds. Up to two million ducks and hundreds of thousands of geese take winter refuge here. Shorebirds, wading birds, game birds, hawks and owls, and a variety of mammals also find shelter and sustenance in playas. Table 3-14 shows the estimated acreage and water storage for playa lakes in the PWPA.

Table 3-14. Acreage and Estimated Maximum Storage of Playa Lakes in the PWPA

County	Estimated Area (acres)	Estimated Maximum Storage* (acre-feet)
Armstrong	15,177	45,532
Carson	18,270	54,810
Childress	116	347
Collingsworth	0	0
Dallam	4,125	12,374
Donley	1,903	5,710
Gray	12,907	38,722
Hall	0	0
Hansford	6,981	20,942
Hartley	3,791	11,373
Hemphill	100	299
Hutchinson	3,297	9,890
Lipscomb	234	703
Moore	4,635	13,906
Ochiltree	15,836	47,509
Oldham	4,336	13,009
Potter	3,203	9,609
Randall	16,793	50,378
Roberts	1,368	4,103
Sherman	4,499	13,496
Wheeler	0	0
TOTAL	**117,571**	**352,712**

Source: Fish, et. al., 1997
*Based on average depth of 3 feet

A number of other small reservoirs are currently used for private storage and diversion purposes. In order to use any of the minor reservoirs for water supply purposes, water rights for diverting the water for a specific use may be needed. Other issues may be associated with diverting water from playa lakes. Therefore, these surface water sources have not been included as sources of available water supplies.

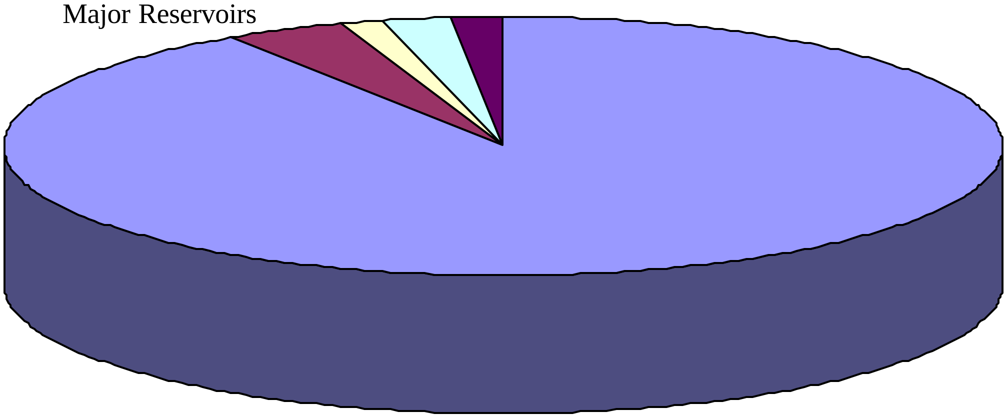
4.0 COMPARISON OF CURRENT WATER SUPPLIES TO DEMAND

This chapter discusses the comparison of the currently developed supply in the Panhandle Water Planning Area (PWPA) to the projected demands developed in Chapter 2. This comparison is made for the region, county, and each water user group. If the projected demands for an entity exceed the available supplies, then a need is identified (represented by a negative number). For some users, the available supplies may exceed the demands (positive number). For groundwater users, this water is not considered surplus, but a supply that will be available for use after 2050.

Current Supply

The current supply in the PWPA consists mainly of groundwater with small amounts of surface water from in-region reservoirs, local supplies and wastewater reuse. The Ogallala is the largest source of water in the PWPA, accounting for 90 percent of the total supply in year 2000. For users with sufficient infrastructure to meet their projected demands, it was assumed that the demands would be met until the available developed groundwater was used. For counties with heavy use from the Ogallala, the supply was severely limited in the latter portion of the planning period. For cities, the supplies were limited to the developed water rights reported to the PWPA. For other users, the groundwater supplies were limited to historical use to account for infrastructure limitations. With these restrictions for allocating the currently available supplies, the total developed water supply for the PWPA in year 2000 is estimated at approximately 1,971,000 acre-feet per year, decreasing to 1,395,032 acre-feet per year in 2050. The distribution of the developed supply by source is shown on Figure 4-1. (Note: The developed supply differs from the total available supply reported in Chapter 3 due to the limitations identified during the allocation process.)

Figure 4-1 Distribution of Current Supply
Year 2000



Regional Demands

Regional demands were developed by city, county and category, and are discussed in Chapter 2. In summary, the total demands for the PWPA are projected to increase from 1,718,402 to 1,812,949 acre-feet per year. The largest water demand category is irrigation, which accounts for nearly 90 percent of the total demand in the region. Municipal is the next largest water user in the PWPA, and livestock is the third largest demand. Manufacturing, mining, and steam electric power demands together account for only three percent of the total water demands. Over the planning period, irrigation and mining demands are expected to remain about the same, while municipal, manufacturing, livestock and steam electric demands are projected to increase. The projected increases in municipal and manufacturing demands are expected to occur near the larger municipalities, and to a lesser extent in the rural areas. Livestock increases are due to growth in the concentrated animal feedlot operations industry.

4.1 Comparison of Demand to Currently Available Supplies

A comparison of supply to demand was performed using the projected demands developed in Chapter 2 and the currently available supplies developed in Chapter 3. As discussed in Chapter

3, currently available supplies were based on the most restrictive of current water rights, contracts and available yields for surface water and historical use and/or groundwater availability for groundwater. There may be supplies available that can meet a need with changes to existing infrastructure or contractual agreements. This will be addressed in Chapter 5 with the water management strategies.

Figure 4-2 compares the supply allocation to demands for the entire region. In the PWPA, the available supply exceeds the demands by nearly 376,344 acre-feet per year in the year 2000, with a regional need beginning in 2030. The reductions in supply beginning in 2020 are mainly due to the process of allocating the available groundwater in counties with high demands. For these counties, groundwater supplies were used to meet demands until the available groundwater in storage was exhausted. Once the available storage was used, no additional supply was considered to be available from the respective source. As a result, there are significant shortages for some users beginning in 2020. The largest needs are associated with irrigation use, followed by municipal and livestock uses. By 2050, the total regional need is 777,406 acre-feet per year. Of this amount, irrigation represents 89 percent with a need of 668,579 acre-feet per year. The needs attributed to the other water use categories total 108,559 acre-feet per year.

Figure 4-2 PWPA Supplies and Demands (ac-ft/yr)

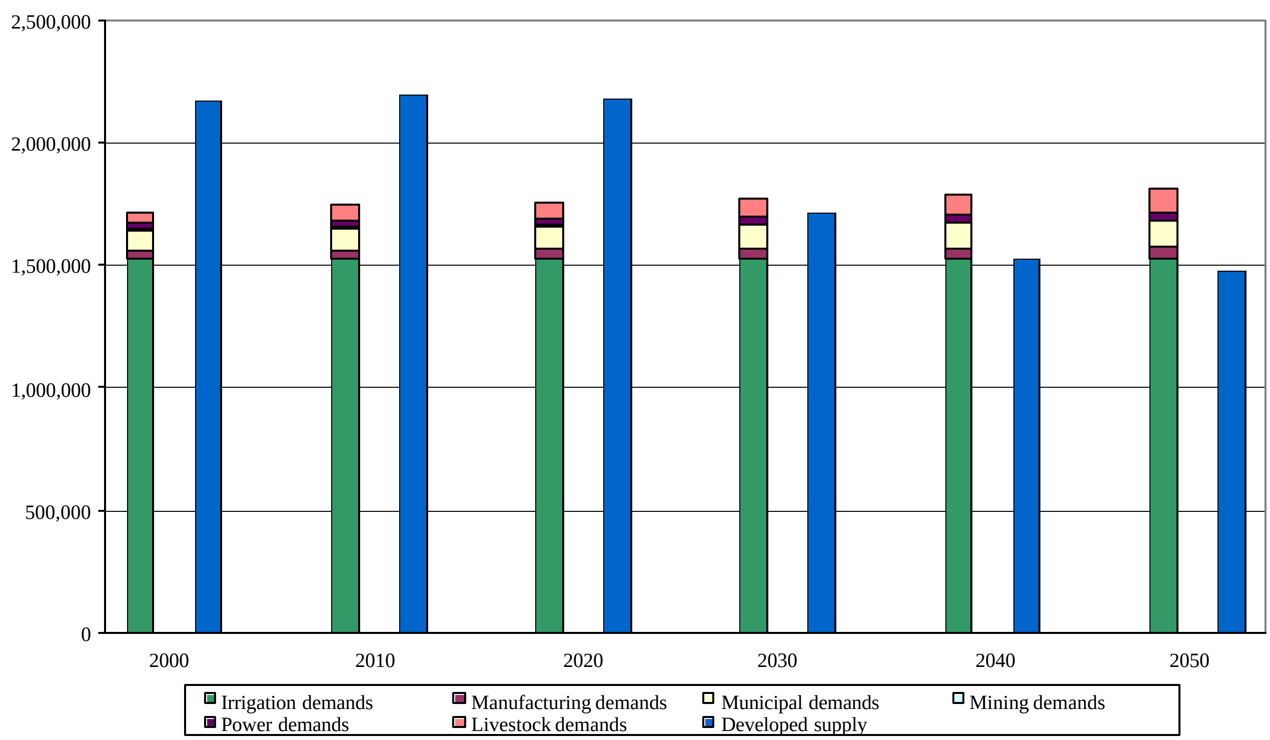


Table 4-1 presents current available supply versus demand by county. Figures 4-6 and 4-7 show the spatial distribution of needs in the region for years 2020 and 2050. Typically the counties with the largest needs are those with large irrigation demands. The needs by category and county for years 2000, 2020 and 2050 are summarized in Tables 4-2, 4-3 and 4-4, respectively. Based on this analysis, there are significant irrigation needs over the 50-year planning period. The municipal needs shown are typically attributed to growth or limitations in developed water rights. Specific needs by user group are included in Table 7 of the TWDB Exhibit B. A brief discussion of these needs is presented in the following section.

Table 4-1

Comparison of Supply and Demand by County

	Year 2000		Year 2020		Year 2050	
County	Currently Available Supply	Demand	Currently Available Supply	Demand	Currently Available Supply	Demand
Armstrong	18,558	7,725	18,559	7,807	18,292	7,959
Carson	116,231	98,699	116,543	98,713	116,031	99,462
Childress	7,786	5,691	7,714	5,722	7,745	5,819
Collingsworth	28,128	19,260	28,094	19,324	28,069	19,370
Dallam	394,935	394,935	400,168	400,168	7,467	405,458
Donley	19,992	18,916	19,922	18,973	19,827	19,041
Gray	48,327	34,631	48,363	35,358	48,311	36,004
Hall	12,241	9,185	12,211	9,107	12,155	9,051
Hansford	246,181	129,504	246,174	134,309	246,145	138,012
Hartley	383,857	207,479	383,867	208,375	382,692	209,380
Hemphill	7,891	6,678	7,673	6,926	7,187	7,252
Hutchinson	69,283	67,212	72,606	70,358	78,458	75,520
Lipscomb	37,952	37,251	38,872	38,751	40,127	39,979
Moore	217,411	216,560	203,052	222,034	3,261	227,676
Ochiltree	68,282	56,979	65,878	58,451	68,845	61,866
Oldham	31,933	31,477	31,942	31,845	3,554	32,337
Potter	76,637	74,730	85,068	83,822	48,046	93,975
Randall	86,876	86,875	92,261	92,605	32,455	105,116
Roberts	12,796	6,539	12,857	6,615	13,000	6,727
Sherman	199,781	199,781	202,218	202,218	204,372	204,372
Wheeler	9,667	8,295	9,332	8,383	8,993	8,573
TOTAL	**2,094,745**	**1,718,402**	**2,103,374**	**1,759,864**	**1,395,032**	**1,812,949**

Table 4-2

Year 2000 Needs by County and Category

(values in acre-feet per year)

County	Irrigation			Manufacturing			Mining			Municipal			S.E. Power			Livestock			Total		
	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need
ARMSTRONG	16,967	6,753	0	0	0	0	26	25	0	406	357	0	0	0	0	1,159	590	0	18,558	7,725	0
CARSON	110,090	93,020	0	825	825	0	2,183	2,183	0	1,587	1,587	0	0	0	0	1,546	1,084	0	116,231	98,699	0
CHILDRESS	5,416	3,819	0	0	0	0	41	25	0	1,720	1,552	0	0	0	0	609	295	0	7,786	5,691	0
COLLINGSWORTH	26,336	17,811	0	0	0	0	0	0	0	908	841	0	0	0	0	884	608	0	28,128	19,260	0
DALLAM	386,403	386,403	0	235	235	0	0	0	0	1,324	1,324	0	0	0	0	6,973	6,973	0	394,935	394,935	0
DONLEY	17,516	17,031	0	0	0	0	28	24	0	737	690	0	0	0	0	1,711	1,171	0	19,992	18,916	0
GRAY	33,623	22,270	0	3,947	3,947	0	1,790	1,524	0	5,773	4,917	0	0	0	0	3,194	1,973	0	48,327	34,631	0
HALL	10,804	8,077	0	0	0	0	28	29	-2	995	790	0	0	0	0	414	289	0	12,241	9,185	0
HANSFORD	236,488	121,492	0	53	46	0	1,331	1,331	0	1,534	1,443	0	0	0	0	6,775	5,192	0	246,181	129,504	0
HARTLEY	378,578	202,232	0	0	0	0	0	0	0	1,213	1,181	0	0	0	0	4,066	4,066	0	383,857	207,479	0
HEMPHILL	4,508	4,377	0	0	4	-4	0	0	0	963	845	0	0	0	0	2,420	1,452	0	7,891	6,678	0
HUTCHINSON	41,758	41,758	0	19,871	19,871	0	690	551	0	5,860	4,442	0	0	0	0	1,104	590	0	69,283	67,212	0
LIPSCOMB	35,132	35,122	0	156	156	0	9	8	0	934	838	0	0	0	0	1,721	1,127	0	37,952	37,251	0
MOORE	200,582	200,579	0	7,238	7,238	0	1,658	810	0	4,223	4,223	0	200	200	0	3,510	3,510	0	217,411	216,560	0
OCHILTREE	56,388	47,300	0	0	0	0	234	228	0	2,730	2,704	0	0	0	0	8,930	6,747	0	68,282	56,979	0
OLDHAM	26,498	26,497	0	0	0	0	554	502	0	2,761	2,761	0	0	0	0	2,120	1,717	0	31,933	31,477	0
POTTER	24,303	24,303	0	6,162	4,614	0	430	430	0	26,608	26,608	0	18,300	18,300	0	834	475	0	76,637	74,730	0
RANDALL	57,491	57,491	0	557	557	0	9	8	0	25,752	25,752	0	0	0	0	3,067	3,067	0	86,876	86,875	0
ROBERTS	11,990	5,755	0	0	0	0	13	11	0	248	248	0	0	0	0	545	525	0	12,796	6,539	0
SHERMAN	195,197	195,197	0	0	0	0	26	26	0	745	745	0	0	0	0	3,813	3,813	0	199,781	199,781	0
WHEELER	5,701	5,698	0	0	0	0	157	102	0	1,257	966	0	0	0	0	2,553	1,529	0	9,667	8,295	0
Grand Total	**1,881,769**	**1,522,985**	**0**	**39,044**	**37,493**	**-4**	**9,207**	**7,817**	**-2**	**88,278**	**84,814**	**0**	**18,500**	**18,500**	**0**	**57,948**	**46,793**	**0**	**2,094,745**	**1,718,402**	**0**

A need is determined if the projected demands exceed the supply. The total need for a county is based on the difference of the total supply and total demands for the county.

While there may be a need for one or more categories, there may be sufficient supply for the county.

Table 4-3

Year 2020 Needs by County and Category

(values in acre-feet per year)

County	Irrigation			Manufacturing			Mining			Municipal			S.E. Power			Livestock			Total		
	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need
ARMSTRONG	16,967	6,753	0	0	0	0	26	25	0	406	357	0	0	0	0	1,159	590	0	18,558	7,725	0
CARSON	110,090	93,020	0	825	825	0	2,183	2,183	0	1,587	1,587	0	0	0	0	1,546	1,084	0	116,231	98,699	0
CHILDRESS	5,416	3,819	0	0	0	0	41	25	0	1,720	1,552	0	0	0	0	609	295	0	7,786	5,691	0
COLLINGSWORTH	26,336	17,811	0	0	0	0	0	0	0	908	841	0	0	0	0	884	608	0	28,128	19,260	0
DALLAM	386,403	386,403	0	235	235	0	0	0	0	1,324	1,324	0	0	0	0	6,973	6,973	0	394,935	394,935	0
DONLEY	17,516	17,031	0	0	0	0	28	24	0	737	690	0	0	0	0	1,711	1,171	0	19,992	18,916	0
GRAY	33,623	22,270	0	3,947	3,947	0	1,790	1,524	0	5,773	4,917	0	0	0	0	3,194	1,973	0	48,327	34,631	0
HALL	10,804	8,077	0	0	0	0	28	29	-2	995	790	0	0	0	0	414	289	0	12,241	9,185	0
HANSFORD	236,488	121,492	0	53	46	0	1,331	1,331	0	1,534	1,443	0	0	0	0	6,775	5,192	0	246,181	129,504	0
HARTLEY	378,578	202,232	0	0	0	0	0	0	0	1,213	1,181	0	0	0	0	4,066	4,066	0	383,857	207,479	0
HEMPHILL	4,508	4,377	0	0	4	-4	0	0	0	963	845	0	0	0	0	2,420	1,452	0	7,891	6,678	0
HUTCHINSON	41,758	41,758	0	19,871	19,871	0	690	551	0	5,860	4,442	0	0	0	0	1,104	590	0	69,283	67,212	0
LIPSCOMB	35,132	35,122	0	156	156	0	9	8	0	934	838	0	0	0	0	1,721	1,127	0	37,952	37,251	0
MOORE	200,582	200,579	0	7,238	7,238	0	1,658	810	0	4,223	4,223	0	200	200	0	3,510	3,510	0	217,411	216,560	0
OCHILTREE	56,388	47,300	0	0	0	0	234	228	0	2,730	2,704	0	0	0	0	8,930	6,747	0	68,282	56,979	0
OLDHAM	26,498	26,497	0	0	0	0	554	502	0	2,761	2,761	0	0	0	0	2,120	1,717	0	31,933	31,477	0
POTTER	24,303	24,303	0	6,162	4,614	0	430	430	0	26,608	26,608	0	18,300	18,300	0	834	475	0	76,637	74,730	0
RANDALL	57,491	57,491	0	557	557	0	9	8	0	25,752	25,752	0	0	0	0	3,067	3,067	0	86,876	86,875	0
ROBERTS	11,990	5,755	0	0	0	0	13	11	0	248	248	0	0	0	0	545	525	0	12,796	6,539	0
SHERMAN	195,197	195,197	0	0	0	0	26	26	0	745	745	0	0	0	0	3,813	3,813	0	199,781	199,781	0
WHEELER	5,701	5,698	0	0	0	0	157	102	0	1,257	966	0	0	0	0	2,553	1,529	0	9,667	8,295	0
Grand Total	**1,881,769**	**1,522,985**	**0**	**39,044**	**37,493**	**-4**	**9,207**	**7,817**	**-2**	**88,278**	**84,814**	**0**	**18,500**	**18,500**	**0**	**57,948**	**46,793**	**0**	**2,094,745**	**1,718,402**	**0**

A need is determined if the projected demands exceed the supply. The total need for a county is based on the difference of the total supply and total demands for the county.

While there may be a need for one or more categories, there may be sufficient supply for the county.

Table 4-4

Year 2050 Needs by County and Category

(values in acre-feet per year)

County	Irrigation			Manufacturing			Mining			Municipal			S.E. Power			Livestock			Total		
	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need	Supply	Demand	Need
ARMSTRONG	16,966	6,753	0	0	0	0	26	26	0	140	300	-160	0	0	0	1,160	880	0	18,292	7,959	0
CARSON	110,089	93,020	0	1,820	1,820	0	1,943	1,358	0	424	1,818	-1,394	0	0	0	1,755	1,446	0	116,031	99,462	0
CHILDRESS	5,300	3,819	0	0	0	0	43	28	0	1,793	1,561	0	0	0	0	609	411	0	7,745	5,819	0
COLLINGSWORTH	26,345	17,811	0	0	0	0	0	0	0	839	764	0	0	0	0	885	795	0	28,069	19,370	0
DALLAM	5,440	386,403	-380,963	3	235	-232	0	0	0	1,176	1,176	0	0	0	0	848	17,644	-16,796	7,467	405,458	-380,963
DONLEY	17,516	17,031	0	0	0	0	34	33	0	566	446	0	0	0	0	1,711	1,531	0	19,827	19,041	0
GRAY	33,232	22,270	0	4,910	4,967	-57	1,459	1,029	0	4,902	3,930	0	0	0	0	3,808	3,808	0	48,311	36,004	0
HALL	10,830	8,077	0	0	0	0	28	34	-6	883	597	0	0	0	0	414	343	0	12,155	9,051	0
HANSFORD	229,557	121,492	0	66	58	0	1,250	1,087	0	1,157	1,260	-103	0	0	0	14,115	14,115	0	246,145	138,012	0
HARTLEY	375,515	202,232	0	0	0	0	0	0	0	1,265	1,236	0	0	0	0	5,912	5,912	0	382,692	209,380	0
HEMPHILL	4,487	4,377	0	0	9	-9	0	0	0	280	731	-451	0	0	0	2,420	2,135	0	7,187	7,252	-65
HUTCHINSON	41,758	41,758	0	29,546	29,203	0	690	95	0	5,360	3,549	0	0	0	0	1,104	915	0	78,458	75,520	0
LIPSCOMB	35,122	35,122	0	200	200	0	9	18	-9	890	733	0	0	0	0	3,906	3,906	0	40,127	39,979	0
MOORE	3	200,579	-200,576	0	9,429	-9,429	1,658	159	0	0	5,923	-5,923	0	200	-200	1,600	11,386	-9,786	3,261	227,676	-224,415
OCHILTREE	56,388	47,300	0	0	0	0	234	155	0	326	2,514	-2,188	0	0	0	11,897	11,897	0	68,845	61,866	0
OLDHAM	549	26,497	-25,948	0	0	0	286	582	-296	144	2,684	-2,540	0	0	0	2,575	2,574	0	3,554	32,337	-28,783
POTTER	10,425	24,303	-13,878	5,975	6,606	-631	0	410	-410	16,653	31,921	-15,268	14,151	30,011	-15,860	842	724	0	48,046	93,975	-45,929
RANDALL	10,277	57,491	-47,214	309	482	-173	2	7	-5	20,689	42,515	-21,826	0	0	0	1,214	4,621	-3,407	32,455	105,116	-72,661
ROBERTS	11,983	5,755	0	0	0	0	12	8	0	223	182	0	0	0	0	782	782	0	13,000	6,727	0
SHERMAN	195,197	195,197	0	0	0	0	31	31	0	601	601	0	0	0	0	8,543	8,543	0	204,372	204,372	0
WHEELER	5,699	5,698	0	0	0	0	157	2	0	584	827	-243	0	0	0	2,553	2,046	0	8,993	8,573	0
Grand Total	**1,202,678**	**1,522,985**	**-668,579**	**42,829**	**53,009**	**-10,531**	**7,862**	**5,062**	**-726**	**58,895**	**105,268**	**-50,096**	**14,151**	**30,211**	**-16,060**	**68,653**	**96,414**	**-29,989**	**1,395,032**	**1,812,949**	**-752,816**

A need is determined if the projected demands exceed the supply. The total need for a county is based on the difference of the total supply and total demands for the county.

While there may be a need for one or more categories, there may be sufficient supply for the county.

4.2 IDENTIFIED NEEDS FOR THE PWPA

A need occurs when currently available supplies are not sufficient to meet projected demands. In the PWPA there are 42 water user groups (accounting for basin and county designations) with identified needs during the planning period. The largest needs are attributed to high irrigation use and limited groundwater resources in Dallam, Moore, Oldham, Potter, Randall and Sherman Counties. Municipal needs are typically associated with growth and limited development of existing groundwater rights. A summary of when the needs begin by county and demand type is presented in Table 4-5. To account for the level of accuracy of the data, a need is defined as a demand greater than the current supply by more than 10 acre-feet.

Table 4-5 Decade Need Begins by County and Category

County	Irrigation	Municipal	Manufacturing	Mining	Steam Electric Power	Livestock
Armstrong	-	2030	-	-	-	-
Carson	-	2020	-	-	-	-
Childress	-	-	-	-	-	-
Collingsworth	-	-	-	-	-	-
Dallam	2030	-	2040	-	-	2040
Donley	-	-	-	-	-	-
Gray	-	2010	2050	-	-	-
Hall	-	-	-	-	-	-
Hansford	-	2010	-	-	-	-
Hartley	-	2020	-	-	-	-
Hemphill	-	2020	-	-	-	-
Hutchinson	-	-	-	-	-	-
Lipscomb	-	-	-	-	-	-
Moore	2020	2030	2030	-	2030	2030
Ochiltree	-	2010	-	-	-	-
Oldham	2040	2050	-	2050	-	-
Potter	2030	2040	2040	2040	2040	-
Randall	2030	2010	2040	-	-	2040
Roberts	-	-	-	-	-	-
Sherman	-	-	-	-	-	-
Wheeler	-	2010	-	-	-	-

Irrigation

Irrigation needs are identified for Dallam, Moore, Oldham, Potter, and Randall counties. Each of these counties relies heavily on the Ogallala for irrigation supplies. Available groundwater supplies from the Ogallala are exhausted by 2030 for Moore County, 2040 for the other counties.

As a result there are irrigation needs of about 21,395 acre-feet per year in 2030, increasing to 863,400 acre-feet per year in 2050.

Municipal

Municipal supplies in the PWPA are typically a combination of groundwater and surface water, depending on the supplier and municipality. For some cities, there is additional groundwater supply, but it is not fully developed. This includes Amarillo, Gruver, and Perryton. Other cities do not appear to have sufficient water rights through the planning period. Although a city may not indicate a need on TWDB Exhibit B Table 7, the city may need to install additional wells to continue to meet its demands as water levels decline and well yields decrease. A list of the municipalities indicating a need is presented in Table 4-6. Most of these cities rely exclusively on groundwater.

Table 4-6 Municipalities with Identified Need

City	Surface Water Supply	Groundwater Supply	Year Need Begins
Amarillo	X	X	2040
Cactus[1]		X	2030
Canadian		X	2020
Canyon	X	X	2040
Claude		X	2030
Dumas[1]		X	2030
Groom		X	2040
Gruver[1]		X	2010
Lake Tanglewood		X	2010
Lefors		X	2010
McLean		X	2020
Panhandle		X	2040
Perryton		X	2010
Shamrock		X	2040
Skellytown		X	2030
Sunray[1]		X	2030
Vega		X	2050
Wheeler		X	2010
White Deer		X	2040

1. A member city of PDRA, but there is no current infrastructure to transmit water from Palo Duro reservoir.

Manufacturing

There are several manufacturing needs identified in PWPA. For the counties of Dallam, Moore, Gray, Potter and Randall, these needs are the result of limited groundwater supplies and competition for the Ogallala aquifer for other needs (especially irrigation).

Mining

Mining is a relatively small demand in the PWPA, and there are few supply needs. Those needs identified are associated with the counties with limited supplies from the Ogallala aquifer. The total mining needs in the region by 2050 is approximately 726 acre-feet per year.

Steam Electric Power

There are two steam electric power needs identified in the PWPA. A small need is projected in Moore County beginning in 2020, and approximately 15,860 acre-feet per year is needed in Potter County by 2040.

Livestock

Livestock needs in the PWPA are due in part to the competition for Ogallala water in those counties with high use and partly due to significant increases in demands. As previously discussed, the livestock water supply from the Ogallala in Dallam, Moore, Potter, and Randall counties is limited because of competition for other needs. Livestock needs for the other counties are relatively small and could be met with additional stock ponds and/or groundwater.

4.3 CONCLUSIONS

On a regional basis, the demands in the PWPA exceed the currently available supplies beginning in 2020. Most of these needs are attributed to large irrigation demands that cannot be met with available groundwater sources. Other needs are due to limitations of contractual agreements, infrastructure, and/or growth. There are supplies in the region that are not fully utilized, such as Palo Duro Reservoir, which could possibly be used for some of the identified needs. The Ogallala in several counties could be further developed. However, often the needed infrastructure is not developed or the potential source is not located near a water supply need. Further review of the region's existing supplies and other options and strategies to meet needs will be explored in more detail in Chapter 5.

5.0 Identified Regional Needs and Evaluation Procedures

5.1 Regional Needs

The comparison of current water supplies to demands presented in Chapter 4 identified 42 different water user groups with needs greater than 10 acre-feet per year. Most of these needs are located in six counties: Dallam, Moore, Oldham, Potter, Randall and Sherman Counties. A list of these users and their respective needs are presented in the following table.

Table 5-1. Identified Needs in the PWPA

Water User Group	County	Projected Need (acre-feet per year)					
		2000	2010	2020	2030	2040	2050
Claude	Armstrong	0	0	0	-150	-268	-267
Groom	Carson	0	0	0	0	-51	-121
Panhandle	Carson	0	0	0	0	-738	-933
Skellytown	Carson	0	0	-44	-64	-61	-59
White Deer	Carson	0	0	0	0	-48	-281
Irrigation	Dallam	0	0	0	-273,976	-380,971	-380,963
Livestock	Dallam	0	0	0	0	-14,742	-16,796
Manufacturing	Dallam	0	0	0	0	-232	-232
Lefors	Gray	0	-19	-95	-85	-80	-78
Manufacturing	Gray	0	0	0	0	0	-57
Mclean	Gray	0	0	-246	-232	-226	-220
Gruver	Hansford	0	-295	-372	-361	-346	-334
Canadian	Hemphill	0	0	-199	-641	-615	-601
Cactus	Moore	0	0	0	-592	-703	-838
County-Other	Moore	0	0	0	-427	-419	-430
Dumas	Moore	0	0	0	-3,418	-3,603	-3,848
Irrigation	Moore	0	0	-21,395	-200,576	-200,576	-200,576
Livestock	Moore	0	0	0	-7,459	-8,546	-9,786
Manufacturing	Moore	0	0	0	-8,269	-8,863	-9,429
Steam Electric Power	Moore	0	0	0	-200	-200	-200
Sunray	Moore	0	0	0	-701	-750	-807
Perryton	Ochiltree	0	-1,518	-2,482	-2,432	-2,370	-2,320
County-Other	Oldham	0	0	0	0	0	-2,295
Irrigation	Oldham	0	0	0	0	-2,428	-25,948

Table 5-1 (continued)

Water User Group	County	Projected Need (acre-feet per year)					
		2000	2010	2020	2030	2040	2050
Mining	Oldham	0	0	0	0	0	-311
Vega	Oldham	0	0	0	0	0	-245
Amarillo	Potter/ Randall	0	0	0	0	-5,585	-28,855
County-Other	Potter	0	0	0	0	-606	-1,528
Irrigation	Potter	0	0	0	-5,385	-13,809	-13,878
Manufacturing	Potter	0	0	0	0	-602	-777
Mining	Potter	0	0	0	0	-367	-410
Steam Electric	Potter	0	0	0	0	-12,294	-15,860
Canyon	Randall	0	0	0	0	-834	-691
County-Other	Randall	0	0	0	0	-4,214	-5,738
Irrigation	Randall	0	0	0	-128	-40,991	-47,214
Lake Tanglewood	Randall	0	-12	-305	-303	-294	-282
Livestock	Randall	0	0	0	0	-2,601	-3,407
Manufacturing	Randall	0	0	0	0	-148	-173
Shamrock	Wheeler	0	0	0	0	-252	-321
Wheeler	Wheeler	0	-22	-275	-272	-268	-268

5.2 Evaluation Procedures

Water supply strategies were developed for municipal and manufacturing needs. Most of these strategies are based on survey responses from the municipalities and previous planning reports. General strategies were developed for mining, steam electric, and irrigation. In most cases, there was only one potentially feasible strategy identified to meet water needs. This is to develop existing groundwater rights or purchase and develop groundwater rights. Due to the large volume of water needs for irrigation, management strategies that would reduce irrigation demands were examined. These included evaluating: the use of the NP-PET network to schedule irrigations; alternative crop types; alternative crop varieties; irrigation delivery systems; conservation tillage practices; and precipitation enhancement.

In accordance with Senate Bill One (SB1) guidance, the potentially feasible strategies were evaluated with respect to:

- Quantity, reliability and cost;
- Environmental factors, including effects on environmental water needs, wildlife habitat and cultural resources;
- Impacts on water resources, such as playas, and other water management strategies;
- Impacts on agriculture and natural resources; and
- Other relevant factors.

The other considerations listed in TAC 357.7(a), such as interbasin transfers and third party impacts due to re-distribution of water rights, were not specifically reviewed because they were not applicable to strategies identified for the Panhandle Water Planning Area (PWPA) needs.

The definition of quantity is the amount of water the strategy would provide to the respective user group in acre-feet per year. This amount is considered with respect to the user's short-term and long-term needs. Reliability is an assessment of the availability of the specified water quantity to the user over time. If the quantity of water is available to the user all the time, then the strategy has a high reliability. If the quantity of water is contingent on other factors, then reliability will be lower. The assessment of cost for each strategy is expressed in dollars per acre-foot per year for water delivered and treated for the end user requirements. Calculations of these costs follow SB1 guidelines for cost considerations, and identify capital and annual costs by decade. Project capital costs are based on 1999 price levels and include construction costs, engineering, land acquisition, mitigation, right-of-way, contingencies and other project costs. Annual costs include power costs associated with transmission, water treatment costs, water purchase (if applicable), operation and maintenance, and other project-specific costs. Debt service for capital improvements was calculated over 30 years at a 6 percent interest rate. In the case of municipal and county-other water needs, the cost estimates are only for development of the supply to deliver it to the user's delivery system. There may be additional costs to actually deliver the water to the end users of the water that are not represented in these estimates.

Potential impacts to sensitive environmental factors were considered for each strategy. Sensitive environmental factors may include wetlands, threatened and endangered species, unique wildlife habitats, and cultural resources. In most cases, since a specific location for groundwater rights is not available, a detailed evaluation could not be completed. Therefore, before a strategy is implemented, a more detailed environmental evaluation will be required.

The impact on water resources considers the effects of the strategy on water quantity, quality, and use of the water resource. A water management strategy may have a positive or negative effect on a water resource. This review also evaluated whether the strategy would impact the water quantity and quality of other water management strategies identified.

A water management strategy could potentially impact agricultural production or local natural resources. Impacts to agriculture may include reduction in agricultural acreage, reduced water supply for irrigation, or impacts to water quality as it affects crop production. Various strategies may actually improve water quality, while others may have a negative impact. The impacts to natural resources may consider inundation of parklands, impacts to exploitable natural resources (such as mining), recreational use of a natural resource, and other strategy-specific factors.

Other relevant factors include regulatory requirements, political and local issues, time requirements to implement the strategy, recreational impacts of the strategy, and other socio-economic benefits or impacts.

Municipal and manufacturing strategies were developed to provide water of sufficient quantity and quality that is acceptable for its end use. Water quality issues affect water use options and treatment requirements. For the evaluations of the strategies, it was assumed that the final water product would meet existing state water quality requirements for the specified use. For example, a strategy that provided water for municipal supply would meet existing drinking water standards, while water used for mining may have a lower quality.

5.3 Strategy Development Assumptions

Strategies were developed for water user groups in the context of their current supply sources, previous supply studies and available supply within the Region. Most of the water supply in the PWPA is from groundwater, and for many of the identified needs, the potentially feasible strategies included development of new groundwater supplies or further developing an existing well field. Where site-specific data was available, this information was used. When specific well fields could not be identified, assumptions regarding well capacity, depth of well and associated costs were developed. The depth of a groundwater supply well was based on the average aquifer saturated thickness and depth to water by county and aquifer. Costs for well installation were developed for different well types (e.g., municipal or industrial) per foot of well installed.

Transmission lines were assumed to follow existing highways or roads where possible. For new well fields that are not specifically identified, an average transmission distance was assumed. For well fields that are partially developed (i.e., entity currently owns wells on the well field), it was assumed that there is infrastructure to transmit the water supply to the entity and no additional transmission costs are included. Also, if a new well was assumed to be located within the city limits, then no transmission costs were assessed. Summaries of the costs developed for each strategy are included in Appendix N.

5.4 Municipal Needs

As shown on Table 5-1, there are 18 cities and four county-other municipal water users that indicate a need during the planning period. Based on a water rights survey conducted as part of this SB1 planning effort, several cities own additional groundwater rights, but they are not fully developed. For cities with projected needs, it was assumed that these rights would be fully developed. If this supply is sufficient to meet the city's needs through 2050, no other strategies were developed. A list of these cities, including their undeveloped water rights and total need through 2050, is shown on the following table.

Table 5-2. Undeveloped Water Rights

City	Undeveloped water rights (acre-feet)	Total need through 2050 (acre-feet)	Need that cannot be met with existing rights (acre-feet)
Gruver	4,633	-13,680	-9,047
Amarillo	1,219,346	-172,200	0
Canyon	8,192	-7,625	0
Lake Tanglewood	1,934	-9,080	-7,146
Perryton	56,473	-87,770	-31,297

Cities with an identified need that are not listed do not have undeveloped water rights. These cities will need to purchase additional water rights or develop an alternative supply.

The cities of Amarillo and Canyon have sufficient supplies through the planning period. For the other 16 cities identified with needs, additional water management strategies were developed. The strategies for each city are discussed in the following sections.

Water supply projects that do not involve the development of or connection to a new water source are consistent with the regional water plan, even though not specifically recommended in the plan. These include, but are not limited to, such projects as repairing plants and pipelines, and constructing new water towers.

5.4.1 City of Amarillo

The city of Amarillo is a major water provider in the PWPA. In addition to meeting the City's needs, Amarillo provides municipal water to the city of Canyon and the Palo Duro State Park. Amarillo also supplies water for manufacturing in both Potter and Randall Counties and steam electric power in Potter County. It is anticipated that the City will continue to provide to its existing customers.

The city of Amarillo currently owns approximately 220,000 acres of groundwater rights in Potter, Carson, Dallam, Hartley, Randall and Roberts Counties. To meet the projected demands, Amarillo will need to develop its undeveloped groundwater rights. For this plan, it is assumed that Amarillo will develop its water rights in Roberts County; however, the City may choose to develop other rights first. The supply from these rights should provide sufficient water to Amarillo and its customers long past the planning period. For this planning effort, it was assumed that a minimum of 30 wells will be installed and a transmission line will be constructed from a well field in Roberts County to Amarillo.

<u>Quantity, Reliability and Cost</u>

The city of Amarillo is expected to have a need of 5,585 acre-feet per year beginning in 2040. By 2050 the projected need for Amarillo is 28,855 acre-feet per year. In addition, Amarillo may be able to provide supply for the increased demands in manufacturing in Potter and Randall Counties and county other in Potter County. Amarillo may also be able to provide for much of the county other need in Randall County, either directly or through the city of Canyon. Accounting for each of these needs, the quantity of supply the City needs to develop by 2050 is approximately 37,800 acre-feet per year. This supply is available from existing water rights and would be very reliable. The cost associated with supplying only the municipal needs for city of Amarillo is approximately $569 per acre-foot/year ($1.75 per 1000 gallons). To supply the other entities, the cost becomes $511 per acre-foot, or $1.57 per 1000 gallons. The assumptions used to develop the costs are included in Appendix N.

<u>Environmental Factors</u>

There should be low to moderate environmental impacts, depending on the final transmission route. However, avoiding environmentally sensitive areas can minimize the potential impacts of the transmission line. Once the route has been chosen, the environmental impacts will need to be further investigated.

<u>Impact on Water Resources and Other Management Strategies</u>

There is adequate supply in the Ogallala Aquifer in Roberts County to support the proposed well field. It should have minimal impacts on this water resource. There are no known other management strategies affected.

Impact on Agriculture and Natural Resources

This strategy should have no to minimal affects on agriculture since the water rights are already owned. The right of way for the transmission line may affect a small amount of agricultural acreage.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.4.2 Palo Duro River Authority Member Cities

There are six member cities of the Palo Duro River Authority who have interests in receiving water from the Palo Duro Reservoir. Four of these cities are projected to have water needs over the planning period: Gruver, Dumas, Cactus and Sunray. The two remaining member cities, Stinnett and Spearman, do not currently indicate needing additional supply. However, these cities may consider joining the PDRA system at the same time as the other cities to extend the life of their groundwater resources.

To meet the water supply needs of its member cities, PDRA is planning to complete a proposed transmission system to deliver water from the Palo Duro Reservoir to these cities by 2030. Based on the projected needs and existing supplies, the amount of water each city is expected to receive from the Palo Duro Reservoir is presented in the following table. Some of this water will be used by the cities for municipal and industrial sales. The PDRA's water rights and the Canadian River Compact allow use of water from the reservoir for manufacturing needs if the supply comes via a municipality.

Table 5-3. Distribution of Water from Palo Duro Reservoir

Water User	Year 2030	
	Peak (MGD)	Acre-feet/Year
Gruver	0.36	200
Sunray	0.90	500
Cactus	2.90	2,000
Dumas	4.54	2,560
Unassigned	1.80	1,013
Total	**10.5**	**6,273**

Peak (MGD) was estimated based on a peaking factor of 2 for municipal use and 1.5 for manufacturing use. Pipelines and pump stations were sized for peak flows.

For Senate Bill One purposes, the supply from the reservoir has been allocated to avoid exceeding the firm yield. However, it is the intention of the Palo Duro River Authority to operate the reservoir on an overdraft basis, using groundwater to supplement supply during drought conditions. It is assumed that these cities will supplement their use of the Palo Duro Reservoir with groundwater. This will allow the cities to conserve their groundwater resources when there is sufficient water in the reservoir. It will also allow them to increase the usage of the reservoir because they are not depending on it for water supply in dry years. A brief discussion of each PDRA member city with identified needs is presented in the following sections.

5.4.2.1 Gruver

Gruver is located in Hansford County and is one of six member cities of the Palo Duro River Authority. Gruver is estimated to have a total need of 13,680 acre-feet over the planning period (ranging from 295 to 372 acre-feet per year). According to a survey conducted by the PWPG, the city of Gruver owns 9,266 acre-feet of groundwater rights. Approximately half are currently developed (including a new 1,000-gpm well). This would provide sufficient supply to meet the City's demands through 2012. Further development of its groundwater rights will provide for the City's needs through 2024. Since the Palo Duro pipeline project is not scheduled for completion until 2030, the City will need to purchase an additional 9,050 acre-feet of water rights. It is assumed that Gruver will need to install at least one new well to further develop their currently owned rights and one new well to develop the additional water rights. After 2030, it is assumed that Gruver will receive approximately 200 acre-feet per year from the Palo Duro Reservoir to supplement its groundwater supplies.

Quantity, Reliability and Cost

The quantity of groundwater would be sufficient. Reliability of groundwater would be moderate, depending on other Ogallala water users. If nearby water users pump greater quantities of water than expected, the supply from the new wells may be affected. The cost of groundwater (assuming 5-mile transmission) would be approximately $261 per acre-foot/year ($0.80/1,000 gallons). The reliability of Palo Duro water would be moderate to high since this is a renewable resource. The costs for Palo Duro water would be approximately $1,028 per acre-foot/year ($3.16/1,000 gallons).

Environmental Factors

The environmental impacts from groundwater development would be low. The Palo Duro Transmission system could cause significant disturbance while under construction. However, it is assumed that the 60-mile pipeline can be routed around potentially environmentally sensitive areas and follow existing rights-of-way. Once the specific locations of additional wells and alignments associated with infrastructure of the Palo Duro Transmission system are identified, a detailed evaluation to determine environmental impacts, if any, will need to be performed.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes. A small amount of agricultural lands may be affected by the transmission system, depending on the final transmission route.

Other Relevant Factors

There are no other relevant factors.

5.4.2.2 Dumas

The city of Dumas is located in Moore County and is the largest member city of the PDRA. It has a projected need of 3,418 acre-feet/year in 2030, increasing to 3,850 acre-feet/year by 2050. Dumas has approximately 27,800 acre-feet of undeveloped groundwater rights that could be used to meet its need in addition to supply from the Palo Duro transmission project, which is expected to be completed in 2030. At that time, it is assumed that the City will use a significant amount of surface water from the Palo Duro Reservoir. As shown on Table 5-3, Dumas is expected to use 2,560 acre-feet per year when PDRA water becomes available in 2030. The remainder of the City's needs will be met with groundwater supplies. It is assumed that the City will install two wells by 2030 to meet its needs and to supplement the PDRA transmission system. These wells will continue to supply the City with groundwater that will be used in conjunction with PDRA water through the planning period.

<u>Quantity, Reliability and Cost</u>

In addition to providing water supply to the city of Dumas, the City is expected to provide part of Moore county-other demands. The county-other needs are projected to be 430 acre-feet per year by 2050. The quantity of water after installing three wells and purchasing water from PDRA would be sufficient for this purpose. Reliability of the combined supplies would be good, because the reservoir is a renewable source of water. The cost of groundwater (assuming 5-mile transmission) for three wells would be approximately $264 per acre-foot/year ($0.81/ 1,000 gallons). After the Palo Duro Transmission System is completed the cost for the water from PDRA would be $1,028 per acre-foot/year ($3.16/1000 gallons).

<u>Environmental Factors</u>

The environmental impacts from groundwater development would be low. The Palo Duro Transmission system could cause significant disturbance while under construction. However, it is assumed that the 60-mile pipeline can be routed around potentially environmentally sensitive areas and follow existing rights-of way. Once the specific locations of additional wells and alignments associated with infrastructure of the Palo Duro Transmission system are identified, a detailed evaluation to determine environmental impacts, if any, will need to be performed.

<u>Impact on Water Resources and Other Management Strategies</u>

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

<u>Impact on Agriculture and Natural Resources</u>

Since this strategy is not anticipated to involve purchasing additional water rights acreage no impacts to agriculture is anticipated. A small amount of agricultural lands may be affected by the transmission system, depending on the final transmission route.

<u>Other Relevant Factors</u>

There are no other relevant factors.

5.4.2.3 Cactus

The city of Cactus in Moore County is another member of the Palo Duro River Authority. The City currently provides for its municipal demands and a large portion of the county's manufacturing demands (2,800 acre-feet/year). The projected needs for the City are 592 acre-feet per year by 2030, increasing to 840 acre-feet/year by 2050. It is expected that the City will continue to provide for manufacturing demands in Moore County at a similar percentage of projected demands (35 to 38 percent). The City has fully developed its existing groundwater rights. By the year 2030, the City is expected to use water from the Palo Duro Reservoir to supply its municipal needs as well as Moore County manufacturing needs. Cactus will need to develop additional groundwater resources to supplement the PDRA supply. It is estimated that Cactus will need to purchase 34,692 acre-feet of water rights and install four new wells to meet its needs through 2050. PDRA water will be used in conjunction with groundwater to ensure an adequate supply.

Quantity, Reliability and Cost
The quantity of water would be sufficient. Reliability would be good, because the reservoir is a renewable source of water. The cost of groundwater (assuming 5-mile transmission) would be approximately $279 per acre-foot/year ($0.86/1,000 gallons). After the Palo Duro Transmission System is completed the cost for water obtained from PDRA would be $1,028 per acre-foot/year ($3.16/1000 gallons).

Environmental Factors
The environmental impacts from groundwater development would be low. The Palo Duro Transmission system could cause significant disturbance while under construction. However, it is assumed that the 60-mile pipeline can be routed around potentially environmentally sensitive areas and follow existing rights-of way. Once the specific locations of additional wells and alignments associated with infrastructure of the Palo Duro Transmission system are identified, a detailed evaluation to determine environmental impacts, if any, will need to be performed.

Impact on Water Resources and Other Management Strategies
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes. A small amount of agricultural lands may be affected by the transmission system, depending on the final transmission route.

Other Relevant Factors
There are no other relevant factors.

5.4.2.4 Sunray
The city of Sunray, also a member of PDRA, is located in Moore County. The projected needs for the City range from 700 to 800 acre-feet/year over the planning period, beginning in 2030. It is also assumed that Sunray will continue to supply Moore county-other needs along with the cities of Dumas and Fritch. By the end of the planning period, it is expected that Sunray will provide just over 200 acre-feet for rural municipal needs. To meet these needs throughout the planning period Sunray will need to purchase 8,795 acre-feet of water rights. By 2030 the City

will need two new wells installed to meet demands. The completion of the PDRA transmission system will allow the City to supplement its groundwater resources with surface water. It is assumed that the city of Sunray will use 500 acre-feet/year of surface water in conjunction with the existing groundwater to meet the needs of the City and county-other through 2050.

<u>Quantity, Reliability and Cost</u>
The quantity of water would be sufficient. Reliability would be good, because the reservoir is a renewable source of water. The cost of groundwater (assuming 5-mile transmission) would be approximately $522 per acre-foot/year ($1.60/1,000 gallons). After the Palo Duro Transmission System is completed the cost would be $1,028 per acre-foot/year ($3.16/1000 gallons) for water obtained from PDRA.

<u>Environmental Factors</u>
Like Cactus and Dumas strategies, the Palo Duro Transmission system could cause significant disturbance while under construction. However, it is assumed that the pipeline can be routed around potentially environmentally sensitive areas and follow existing rights-of way. Once the final alignment for the pipeline is determined, a detailed environmental impact assessment should be performed.

<u>Impact on Water Resources and Other Management Strategies</u>
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

<u>Impact on Agriculture and Natural Resources</u>
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes. A small amount of agricultural lands may be affected by the transmission system, depending on the final transmission route.

<u>Other Relevant Factors</u>
There are no other relevant factors.

5.4.3 Claude
The city of Claude currently receives all of its municipal supply from the Ogallala in Armstrong County. Based on the estimated supply of their existing well fields, the City has sufficient supply to meet its needs through 2030. At that time the City will need to develop additional groundwater sources. The projected needs for Claude range from 150 to 270 acre-feet/year over the planning period, resulting in a total need of 4,180 acre-feet. A study conducted by the Panhandle Groundwater Conservation District in March 1998 indicated the potential for a new well field to the southeast of the City. This area has a saturated thickness between 80 and 100 feet, and could be developed to meet the City’s long-term needs. It is anticipated that the new wells can sustain a pumping rate between 100 and 150 gpm. At this rate, two wells will be required to meet the 2050 peak demands. The transmission distance should be small (less than three miles).

Quantity, Reliability and Cost

The quantity of water should be sufficient to meet the needs through 2050. The reliability of the water is moderate depending on the other users of the aquifer. The cost of the water with the two new wells is $514 per acre-foot /year ($1.58/1,000 gallons).

Environmental Factors

The environmental impacts associated with this project are small. The transmission line could be routed around any sensitive areas. Once the exact area is chosen, a more detailed environmental review should be conducted.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water right acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.4.4 Groom

The city of Groom derives all of its municipal water supply from the Ogallala Aquifer in Carson County from three production wells. The City has approximately 7,461 acre-feet of supply that should meet its needs until 2045. It is expected that an additional well will be needed to meet Groom's projected need of 860 acre-feet (120 acre-feet/year by 2050). A study by the Panhandle Groundwater Conservation District in March 1998 discussed the possibility of a new well within the city limits on the west side of the City. According to this study, the best areas for wells (greatest saturated thickness) appear to be to the west and to the north. Inside the western limits of the City, the saturated thickness is 220 ft. This should provide adequate supply to meet the City's needs through 2050. For this strategy, it is assumed that the City will install one new well and connect directly to the City's distribution system. There is no to minimal transmission distance assumed.

Quantity, Reliability and Cost

There is sufficient water in the aquifer to supply the city of Groom until the end of the period. The reliability of the water will depend on other uses of the Ogallala. The cost of the water (assuming small transmission distance) will be $233 per acre-foot/year ($0.72/1000 gallons).

Environmental Factors

Since this plan involves only the installation of one well and a connection to the existing system, the environmental impacts associated with this project are minimal. Once the final location of the well is determined, a detailed environmental review should be performed.

Impact on Water Resources and Other Management Strategies
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors
Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.4.5 Panhandle
The city of Panhandle is located in Carson County and derives all of its municipal supply from the Ogallala Aquifer. According to the estimated supply from their existing well fields, the City has sufficient supply to meet its needs through 2036. At that time the projected needs are expected to be approximately 900 acre-feet/year, resulting in a total need of 8,400 acre-feet. Additional supply may be gained by drilling new wells in the southern portion of the City. Saturated thickness in that area is estimated to be 360 ft and could sustain a pumping rate between 600 and 700 gpm. At this rate, two additional wells will be needed to meet the peak demand of the City in 2050. It is assumed that these wells will connect directly to the City's distribution system. No transmission system was assumed.

Quantity, Reliability and Cost
The quantity of water is adequate to meet the demands of the City until 2050. The reliability is moderate, depending on other users of the aquifer. The cost of the water is $108 per acre-foot/year ($0.33 per 1,000 gallons).

Environmental Factors
The environmental impacts associated with this project are minimal. The proposed installation of two wells and connection to the existing system poses little threat to natural resources. However, once the final well locations are determined a detailed environmental evaluation should be performed.

Impact on Water Resources and Other Management Strategies
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.4.6 Skellytown

The city of Skellytown in Carson County relies solely on the Ogallala for its municipal water supply. Four production wells are currently used by the City and will provide enough supply to meet the needs until 2014. After that time the projected needs for Skellytown are approximately 60 acre-feet per year, or a total of 1,700 acre-feet over the planning period. According to a study by the Panhandle Groundwater Conservation District in March 1998, the area beneath the City limits has a saturated thickness of between 80 and 100 feet. Additional wells in the southeastern portion of the City may provide 200 gpm each. One well is expected to supply the City's needs until 2050. If drawdown is excessive, an additional well may be needed.

Quantity, Reliability and Cost

The quantity of the water is sufficient to meet the City's needs until 2050. The reliability would be moderate. The cost of the water with one well is $419 per acre-foot/year ($1.29/1,000 gallons).

Environmental Factors

The environmental impacts associated with this project are minimal. The proposed installation of two wells and connection to the existing system poses little threat to natural resources. A detailed environmental review of the project should be performed once the final locations of the wells are determined.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.4.7 White Deer

The city of White Deer lies in Carson County and derives all of its municipal supply from the Ogallala Aquifer. The City has adequate supply from its existing well fields to reach the year 2037. At that time, the City will need to develop other groundwater resources to meet its projected needs of 280 acre-feet/year by 2050, resulting in a total need of 1,650 acre-feet over the planning period. A study by the Panhandle Groundwater Conservation District in March 1998 indicated the potential for a new well field in the southeastern portion of the City, where the saturated thickness is between 300 and 320 ft. It is assumed that two new wells will be installed in this area and there is no transmission distance. The pumping rate for these wells would be sufficient to supply the City's peak demand through 2050.

<u>Quantity, Reliability and Cost</u>
There is sufficient groundwater to provide for the City's needs until 2050. The reliability is moderate. The cost would be $249 per acre-foot ($0.76/1000 gallons).

<u>Environmental Factors</u>
The environmental impacts associated with this project are minimal. The proposed installation of two wells and connection to the existing system poses little threat to natural resources. However, a detailed evaluation of potential impacts to environmental resources should be conducted when the exact location of each of the wells is identified.

<u>Impact on Water Resources and Other Management Strategies</u>
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

<u>Impact on Agriculture and Natural Resources</u>
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

<u>Other Relevant Factors</u>
Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.4.8 Lefors

The city of Lefors is located in the eastern Texas Panhandle in Gray County. The City obtains its water supply from the Ogallala Aquifer from in-city wells. The City recently installed a new well with a production rate of 275 gpm. Based on the supply of this well, the new well and the two other active wells in the City should be able to provide the City’s anticipated need through the planning period (approximately 90 acre-feet/year). Therefore, no additional strategies were developed for this municipality. It should be noted however, that the City is experiencing some problems with elevated chlorides concentrations in some of its wells. The water quality concerns could supersede the quantity issues and require the City to seek alternative locations for groundwater supply.

5.4.9 McLean

The city of McLean is located in Gray County in the eastern Texas Panhandle. All of the municipal supply for the City originates from the Ogallala Aquifer. Five production wells are used by the City and will supply the City's needs through 2020. Based on a projected need of 246 acre-feet/year, additional groundwater resources will be needed by 2020 to provide enough supply to meet the City's needs until 2050. A report by the Panhandle Groundwater Conservation District in March 1998 indicates that the saturated thickness of the Ogallala Aquifer beneath the City is between 30 and 60 ft. There is an area north of town with a saturated thickness of 100 ft. It is estimated that a total of approximately 7,000 acre-feet of water rights will be purchased and two wells will drilled in this area to provide enough supply to meet the City's needs through 2050. The transmission distance to the City is approximately 1.5 miles.

Quantity, Reliability and Cost
There appears to be sufficient groundwater to provide the City's needs until 2050. The reliability is moderate, depending on other Ogallala users and well production rates. The cost would be $429 per acre-foot ($1.32/1,000 gallons).

Environmental Factors
The environmental impacts associated with this project should be minimal. The proposed pipeline is relatively short in length and small in diameter. Therefore, only a small area will be affected. Once the area is chosen, a more detailed analysis should be performed.

Impact on Water Resources and Other Management Strategies
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors
Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.4.10 Canadian
The city of Canadian lies on the Canadian River in Hemphill County in the northeastern Texas Panhandle. Canadian has sufficient water supply through 2020. After 2020, there is a projected need of 200 acre-feet/year, increasing to over 600 acre-feet/year through the remainder of the planning period. To meet these needs it is assumed that the City will obtain additional groundwater rights to supplement their existing supply. It is estimated that the City will need an additional 14,500 acre-feet of groundwater rights and two wells to meet their demand. The transmission distance for this water should be less than five miles.

Quantity, Reliability and Cost
There is sufficient groundwater to provide the City's needs until 2050. The reliability is moderate. The cost would be $327 per acre-foot ($1.00/1000 gallons).

Environmental Factors

This project poses minimal threat to the environment. The installation of the pipeline can minimize adverse impacts by following a road or an existing right-of-way. Additionally, a detailed review of potential impacts should be performed once the alignment and well locations are determined.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.4.11 Vega

The city of Vega is located in Oldham County on the western border of the panhandle. The City currently obtains its water supply from the Ogallala Aquifer in Deaf Smith County and Oldham County. The supply/demand comparison indicates that Vega has enough supply to meet its needs until after 2040. Between 2040 and 2050, the City may need to purchase additional groundwater rights to meet the projected demand of 245 acre-feet/year in 2050. Further review is needed of the available supply from the City’s existing groundwater rights. For this analysis, it is assumed that Vega will purchase a minimum of 1,330 acre-feet of water rights in Deaf Smith County near their existing well field to fulfill the City's needs until 2050. According to the consultant for the Llano Estacado Region (Region O), there is available supply in Deaf Smith County. It is estimated that two new wells will be needed to meet the projected demand.

Quantity, Reliability and Cost

There is sufficient groundwater to provide the City's needs until 2050. The reliability is moderate. The cost would be $623 per acre-foot ($1.91/1000 gallons).

Environmental Factors

This project involves the installation of two wells and the construction of a five-mile pipeline to the city of Vega. Following existing roads and avoiding sensitive areas when constructing the pipeline can minimize potentially harmful impacts to the environment. However, a detailed environmental review should be performed during the project’s design.

Impact on Water Resources and Other Management Strategies

There is available supply from the Ogallala in Deaf Smith County, so there should be minimal impacts to water resources. However, the increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Since there was little available information on the groundwater rights for Vega, there may be sufficient existing supply through the planning period. The supply from Deaf Smith County is from the Llano Estacado Region (Region O), which is a potential source of interregional conflict. However, that is unlikely since the City already obtains groundwater from this county.

5.4.12 Canyon

The city of Canyon is located in Randall County roughly ten miles south of Amarillo. Its water supply is a combination of groundwater from the Ogallala and purchased water from the city of Amarillo. The currently developed supply will last the City until 2040. At this time, the City will need to develop the groundwater rights it already owns. Three more wells will need to be installed to meet the demands until 2050 (100 to 770 acre-feet/year). As an alternative, the City may also be able to purchase additional water from the city of Amarillo. The City's needs can be met with the existing water supply contract in place with the city of Amarillo.

Quantity, Reliability and Cost

There is sufficient groundwater to provide the City's needs until 2050. The reliability is moderate. The cost would be \$313 per acre-foot (\$0.96/1000 gallons).

Environmental Factors

The installation of new wells and a new transmission system has an impact on the environment. Routing the pipeline around environmentally sensitive areas and following existing roads when possible can lessen the impact and a detailed review should be performed to identify potential sensitive areas.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

There are no other relevant factors.

5.4.13 Lake Tanglewood

Lake Tanglewood is located in Randall County approximately six miles southeast of Amarillo. The Village obtains its water from a private water utility, Lake Tanglewood, Inc., which relies on the Ogallala aquifer for its supply. The currently developed supply of water will meet the demands of the Village until 2020. Lake Tanglewood, Inc. currently owns 1,934 acre-feet of undeveloped water rights, which could meet the needs of the Village until 2026. At this time, Lake Tanglewood Inc. will need to purchase additional groundwater rights to meet the projected need of approximately 300 acre-feet/year. To further develop its groundwater supply, Lake Tanglewood, Inc. will need to purchase approximately 7,150 acre-feet of water rights and install three new wells. This will provide adequate supply to meet the Village of Lake Tanglewood water needs through 2050.

Quantity, Reliability and Cost

There is sufficient quantity of groundwater available to the City. The reliability depends on other users of the Ogallala. The cost of developing their own water supply is $342 per acre-foot/year ($1.05/1,000 gallons).

Environmental Factors

The environmental impacts would be low, because the pipeline from the well field to Lake Tanglewood would be relatively small. A detailed environmental review should be performed and the route of the pipeline can be planned around identified potential threats to the environment.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

There are no other relevant factors.

5.4.14 Shamrock

The city of Shamrock is located in the central Texas Panhandle in Wheeler County. The Ogallala aquifer supplies all of the City's municipal water. The eleven production wells used by the City lie outside the City's boundaries, and can supply the City through 2032. A study by the Panhandle Groundwater Conservation District in 1998 suggests that the City should seek new groundwater rights for additional wells in the Ogallala, which lie to the west and to the northwest of the City. Also, it may be possible for the City to utilize two minor aquifers, the Seymour and the Blaine, to blend with water from the Ogallala to extend the supply. Should the City choose to develop more water in the Ogallala, the transmission distance would be around 12 miles. The City needs an additional total of approximately 2,900 acre-feet of water rights to meet its needs through 2050.

Quantity, Reliability and Cost

For SB1 planning it is assumed that Shamrock will develop two new wells in the Ogallala. There is sufficient quantity in the aquifer to meet the demands of the City throughout the planning period. The reliability is moderate, depending on other users. The cost of the water will be $939 per acre-foot/year ($2.88 per 1,000 gallons).

Environmental Factors

The twelve-mile pipeline from the well field to Shamrock may have a slight effect on the environment. When the exact site for a well field is chosen, a more detailed analysis should be performed.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala in Wheeler County will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.4.15 Wheeler

The City of Wheeler lies in Wheeler County in the eastern portion of the Texas Panhandle. The City currently derives its municipal potable water supply from the Ogallala Aquifer from two (2) production wells. It is estimated that these could supply enough water to meet the City's needs through 2009; however, the current lease on groundwater rights for these two wells expires in 2003. The City has first right of refusal for the option to purchase the water rights in 2003. It is unknown if the current lease can be renewed. The City's total water demands by 2050 are 268 acre-feet per year. The total need for the 50-year planning period is 8,400 acre-feet.

The current issue facing the City of Wheeler is not the quantity of the available (leased rights) water but rather, the quality. To satisfy the Texas Natural Resource Conservation Commission primary drinking water regulations for nitrate concentrations, the City is having to blend water from the two production wells since the nitrate concentration in one of the wells exceeds the MCL of 10 mg/l. The practice of blending water from the two wells limits the amount of water taken from the larger of the two production wells, in effect reducing the production capacity of the well. The wells are currently operated on timers to allow adjustments to well run times to achieve the necessary water quality. It is expected that these issues will directly influence the decisions of the City regarding possible purchase of the leased groundwater rights and/or renewal or extension of the current lease.

Nitrate levels in the two existing water wells (leased rights described above) have been steadily increasing since 1983. It is assumed that these levels will continue to rise, eventually rendering the water in the existing two wells non-potable. Should this occur an alternate source of water will have to be found, or the current well water would require post-treatment to reduce the levels of nitrate to below the drinking water standards prior to distribution. Recent exploration (year 2000) for water has revealed a potential source of acceptable groundwater located to the north of the City. Quantity was undetermined at the time of this writing.

For the purposes of SB-1 planning, it is assumed that the City will drill two new wells having a capacity of at least 175 gpm each in the vicinity of Wheeler. Water rights of sufficient quality and quantity will have to be obtained to construct the two new wells. The transmission distance necessary to get water from a quality (low nitrates) water source is assumed to be less than 15 miles.

Short term needs in Wheeler will be met with additional groundwater supplies. However, long-term supplies may originate from an alternate source. The PWPG, at the request of the City of Wheeler and the Wheeler County Surface Water Board will include a recommendation in Task 6 that a previously identified potential surface water reservoir, Sweetwater Creek Reservoir, be eligible to receive funding to conduct feasibility studies to evaluate the potential yield in light of the requirements of the Red River Compact, cost, interstate coordination issues, potential environmental impacts and potential areas or municipalities which could be served by the reservoir. This potential surface water reservoir may provide an alternate source of water (long-term) if groundwater of suitable quality cannot be located or treated to meet primary drinking water standards.

Quantity, Reliability and Cost

The quantity of the groundwater currently available or to be purchased is apparently adequate to supply the City until the end of the planning period. Reliability is moderate to poor depending on nitrate concentration levels and potential movement or expansion of the nitrate contamination in the aquifer. The cost of the water is estimated at $1,116 per acre-foot/year ($3.43/1,000 gallons), assuming water does not have to be treated e.g. reverse osmosis or other membrane type treatment works, or that water does not have to be hauled. Should it become necessary to treat the water to remove high nitrate levels, the cost per thousand would rise proportionately.

Environmental Factors

The development of a new well field for Wheeler involves a pipeline approximately 15 miles long and the construction of at least two (2) wells having a capacity of 175 gpm each.. The degree of impact should be low, assuming the pipeline and well field can be located/routed to avoid environmentally sensitive areas. The construction of pump station(s) and storage tank(s) should have no to minimal environmental impacts. However, an assessment of environmental impacts should be performed prior to implementing the water management strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. It is also expected that the nitrate levels will continue to rise, rendering portions of the aquifer non-potable. This issue may compel the City of Wheeler to look towards additional sources of water.

Impact on Agriculture and Natural Resources

Assuming acceptable quantities and quality of water can be found and transmitted via pipeline to the City, the impact on agriculture is expected to be minimal, although converting to alternate crops requiring less water may be necessary to reduce the depletion of the Ogallala. Agricultural land located in and around the transmission system will be minimally affected as the pipeline should be designed with a sufficient amount of cover to allow deep plowing.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells. In addition, the groundwater quality issues may limit the City's choices for developing new supplies.

5.4.16 Perryton

The city of Perryton is located in Ochiltree County on the northern border of the state. The City currently has enough supply to meet demands until 2010. The projected needs range from 1,500 to nearly 2,500 acre-feet/year between 2010 and 2050. The development of currently owned groundwater rights will provide enough water to meet the City's demands until 2036. It is assumed that between 2030 and 2040 an additional 31,300 acre-feet in groundwater rights will be obtained and five additional wells will be needed to meet the demands throughout the planning period.

Quantity, Reliability and Cost

The quantity of the water should be sufficient to meet the demands until 2050. The reliability is high as there is available groundwater supply in Ochiltree County. The cost of the water with five total additional wells is $216 per acre-foot/year ($0.66 per 1000 gallons).

Environmental Factors

The environmental impacts should be low, depending on the route of the transmission line. The locations of the wells, pump station, and storage tank can most likely be placed to avoid environmentally sensitive areas. A detailed environmental review should be performed once the route of the pipeline and the location of the wells and associated facilities are determined.

Impact on Water Resources and Other Management Strategies

There should be minimal impacts to water resources since groundwater availability is high and current demands are moderate.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

In addition to needing to develop additional quantities of water, the City is experiencing some localized groundwater contamination near its wells. The water quality concerns may require the City to identify alternative locations of well fields.

5.4.17 County-Other, Moore County

The county other demands for Moore County are approximately 430 acre-feet per year. Due to competition for water from the Ogallala, it is anticipated that there will be a rural municipal need beginning in 2030. Approximately half of the supply for the county-other demands appears to come from local wells, with the remaining half supplied by cities within the county. It is assumed that the cities of Fritch, Dumas, Cactus and Sunray will continue to supply county-other water, and will develop sufficient groundwater and surface water (Palo Duro Reservoir) to meet these needs.

5.4.18 County-Other, Oldham County

There is a need of 2,300 acre-feet per year identified for county other in Oldham County beginning in 2050. A review of the historical municipal use in Oldham County indicates that much of the county other demands are attributed to the Cal Farly Boys Ranch. According to the TWDB, most of the reported water use for the Boys Ranch is used for irrigation, and this use has dropped significantly since 1991. The 1991 reported use for the Boys Ranch was 2,234 acre-feet, and the use in 1997 was 246 acre-feet. The other rural municipal users in Oldham County include the city of Adrian and Wildorado Water Supply Corporation. The 1997 reported use for these entities was 106 acre-feet. Therefore, it is likely that the county-other demands for Oldham County would be much less than the 2,400 acre-feet reported in Chapter 2. If that is the case, then there should be sufficient supply from the Ogallala through the planning period.

5.4.19 County-Other, Potter County

The county-other demands in Potter County are approximately 1,528 acre-feet per year by 2050 for both the Red and Canadian basins. Small water supply corporations supply a portion of these demands. The majority of the county-other supply in Potter County is from unincorporated rural wells. It is anticipated that this pattern will continue over the planning period. As a result it is difficult to project a single strategy to meet the projected county-other needs (14,460 acre-feet by 2050). It is assumed that as demands increase, additional rural municipal wells will be installed.

Potter County is in the process of being annexed by the Panhandle Groundwater Conservation District. When this takes place, new wells must comply with the District's well spacing and pumping limitations. To meet the county-other needs identified for Potter County, it is assumed that additional water rights will be purchased and 10 new wells installed by 2050.

Quantity, Reliability and Cost

The quantity of water would be sufficient. Reliability would be moderate, depending on other Ogallala water users. If nearby water users pump greater quantities of water than expected, the supply from the new wells may be affected. The cost of water (assuming minimal transmission) would be approximately $185 per acre-foot/year ($0.57/ 1,000 gallons).

Environmental Factors
There should be no environmental impacts.

Impact on Water Resources and Other Management Strategies
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors
The development of county-other water supply would be implemented as needed over the planning period. Coordination with the Panhandle Groundwater Conservation District will be required to ensure compliance with the District's production limitations and property line setback requirements for well locations.

5.4.20 County-Other, Randall County

The demands in Randall County for county-other municipal supply are expected to increase from approximately 2,900 to 5,800 acre-feet per year. Most of the supply for these demands has historically been provided from the Ogallala aquifer. A small amount of supply comes from the Dockum aquifer, and a small quantity of water is provided from the city of Amarillo to the Palo Duro Canyon State park for municipal use. The remainder of the supply is from small water supply corporations and rural unincorporated wells. To meet the increased demands for county-other, it is assumed that additional water rights will be purchased and wells installed as needed.

The projected needs for county-other in Randall County are 5,738 acre-feet by 2050. This represents nearly the entire demand for the county due to limitations of groundwater availability in the Ogallala. As a result, additional water rights will need to be purchased and 18 new wells installed to provide adequate supply through the planning period. Alternatively, additional supply could possibly be provided by Amarillo, either directly or via the city of Canyon. For SB1 planning, it is assumed that the county-other supply will come from additional wells in Randall County.

Quantity, Reliability and Cost
The quantity of water would be sufficient. Reliability would be moderate, depending on other Ogallala water users. If nearby water users pump greater quantities of water than expected, the supply from the new wells may be affected. The cost of water (assuming minimal transmission) would be approximately $124 per acre-foot/year ($0.38/ 1,000 gallons).

Environmental Factors
No significant environmental impacts are anticipated as a result of the installation of the wells; however, a detailed environmental review should be performed prior to installation of any new infrastructure.

Impact on Water Resources and Other Management Strategies
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors
There are no other relevant factors.

5.5 Manufacturing Needs

Manufacturing needs were identified for Dallam, Gray, Moore, Potter, and Randall counties. The needs identified for Dallam, Moore, Potter and Randall counties are due to competition for Ogallala water with other users in each county. To provide for manufacturing demands in these counties, additional water rights will need to be purchased or alternative supplies developed.

5.5.1 Dallam County

The city of Texline provides supply for the current manufacturing demands in Dallam County. The projected manufacturing need beginning in 2040 is due to competition with irrigation for available supply from the Ogallala. There is sufficient infrastructure to support the projected demands, but long-term supplies may be limited. For the city of Texline to continue to provide supply for manufacturing needs in Dallam County, Texline may need to purchase additional water rights and install a new well. For this plan, it is assumed that Texline will need to purchase 145 acres of additional water rights and install one well to protect both their municipal and manufacturing supplies.

Quantity, Reliability and Cost
Since the demands do not increase, the quantity of water provided by Texline would be sufficient. Reliability would be moderate, depending on other Ogallala water users. The additional cost of water would be approximately $127 per acre-foot/year ($0.39/ 1,000 gallons).

Environmental Factors
There should be no environmental impacts.

Impact on Water Resources and Other Management Strategies
There should be no impacts to water resources or other management strategies since the demands for county-other do not increase.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors
If additional water rights are purchased early in the planning period, it will provide a higher level of protection of existing supplies.

5.5.2 Moore County

The manufacturing demands in Moore County range from 7,200 to 9,400 acre-feet per year over the planning period. The city of Cactus currently provides approximately 2,800 acre-feet of water for industrial use. The remainder of the demands is met with local groundwater wells and treated effluent. The quantity of treated effluent was not included in the initial assessment of available supplies. To meet the manufacturing demands in Moore County, additional manufacturing water rights will need to be purchased and new wells will need to be installed. It is assumed that the city of Cactus will continue to provide industrial water after the Palo Duro Reservoir pipeline is completed. Palo Duro River Authorities' water rights and the Canadian River Compact allow use of water from the reservoir for manufacturing needs if the supply comes via a municipality. It is estimated that approximately 1,500 acre-feet of water from the Palo Duro Reservoir will be used for manufacturing needs, 3,000 acre-feet from wastewater reuse and the remainder from the Ogallala. For this plan, it is assumed that nine new wells will be drilled near the demands.

Quantity, Reliability and Cost
To meet the remainder of the manufacturing needs in Moore County, it is assumed that 84,150 acre-feet of groundwater rights will need to be purchased and approximately 13 new wells installed. Since the locations of the demands are unknown, the transmission system was not included in the costs. The quantity of water would be sufficient. Reliability would be moderate, depending on other Ogallala water users. The cost of groundwater (assuming no transmission) would be approximately $103 per acre-foot/year ($0.32/1,000 gallons). The costs for water from the city of Cactus will depend on the City's rate structure after the Palo Duro transmission project is completed.

Environmental Factors
There should be minimal environmental impacts, depending on location of the demands and transmission lines, if needed. No significant environmental impacts are anticipated as a result of the installation of the wells; however, a detailed environmental review should be performed prior to installation of any new infrastructure.

Impact on Water Resources and Other Management Strategies
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water right acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors
There are no other relevant factors.

5.5.3 Potter County

The manufacturing needs in Potter County are projected to be nearly 800 acre-feet by 2050. Much of the water for manufacturing is currently supplied by the city of Amarillo via contracts to Iowa Beef Processing and ASARCO, Inc. The remainder of the supply is provided by local manufacturing wells in the Ogallala and wastewater effluent. The projected shortage beginning in 2040 is primarily due to limited groundwater availability of the Ogallala. To meet these needs it is assumed that 6,895 acre-feet of additional water rights will be purchased and two new wells installed. Alternatively, the city of Amarillo could provide additional water for manufacturing in Potter County after the Roberts well field is operational.

<u>Quantity, Reliability and Cost</u>

The quantity of water would be sufficient. Reliability would be high. The cost of water (assuming minimal transmission) would be approximately $95 per acre-foot/year ($0.29/1,000 gallons).

<u>Environmental Factors</u>

No significant environmental impacts are anticipated as a result of the installation of the wells; however, a detailed environmental review should be performed prior to installation of any new infrastructure.

<u>Impact on Water Resources and Other Management Strategies</u>

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

<u>Impact on Agriculture and Natural Resources</u>

This strategy may reduce the irrigated acreage for farming as additional water right acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

<u>Other Relevant Factors</u>

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.5.4 Randall County

There is a small water demand for manufacturing use in Randall County, which decreases over the planning period. Approximately half of the supply is provided by the city of Amarillo to Owens-Corning manufacturing. The remainder of the manufacturing supply comes from the Ogallala Aquifer. Due to limited availability of the Ogallala in Randall County, there is a projected manufacturing need of 173 acre-feet in 2050. To meet these needs it is assumed that additional water rights will need to be purchased to protect manufacturing's existing supply. One new well will need to be installed.

Quantity, Reliability and Cost

The quantity of water would be sufficient. Reliability would be moderate, depending on other Ogallala water users. The additional cost of water would be approximately $155 per acre-foot/year ($0.48/1,000 gallons).

Environmental Factors

No significant environmental impacts are anticipated as a result of the installation of the wells; however, a detailed environmental review should be performed prior to installation of any new infrastructure.

Impact on Water Resources and Other Management Strategies

There should be no impacts to water resources or other management strategies since the demands for county-other do not increase.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water right acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.6 Steam Electric Power Needs

There are two needs identified for steam electric power, a small need in Moore County (200 af/y) and a significant need in Potter County by 2050 (15,860 af/y). In Moore County, water from the Ogallala is used for steam electric power demands. The steam electric need beginning in 2030 is the result of competition for this supply with other users. To meet these demands, water could possibly be obtained from Ogallala supplies with the purchase of additional water rights.

In Potter County, steam electric water supply is obtained from the city of Amarillo, the Ogallala, and wastewater reuse. The projected demands in Potter County increase from 18,300 to 30,000 acre-feet per year by 2050. It is assumed that groundwater use from the Ogallala increases to meet the demands until the available supply is exhausted in 2047. To meet the demands for the remainder of the decade and into the next planning period, additional supply will be needed. Wastewater reuse accounts for nearly half of steam electric supply. Additional supply could be obtained from groundwater resources or Amarillo could possibly sell additional treated wastewater effluent for steam electric demands.

5.6.1 Moore County

The strategy for steam electric needs includes purchasing 4,310 acre-feet of additional water rights in Moore County. Since the demands remain the same during the planning period it is assumed that there is adequate infrastructure to meet the demands. However, due to competition with other users it is assumed that one new well will be needed to develop the additional water rights.

Quantity, Reliability and Cost

The quantity of water would be sufficient. Reliability would be moderate, depending on other Ogallala water users. The additional cost of water would be approximately $159 per acre-foot/year ($0.49/ 1,000 gallons).

Environmental Factors

No environmental impacts are anticipated with this strategy.

Impact on Water Resources and Other Management Strategies

There should be no impacts to water resources or other management strategies.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming if additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.6.2 Potter County

As previously discussed, Amarillo provides water from the Amarillo system and approximately 13,000 acre-feet per year of wastewater effluent for steam electric power. There is an additional 6,500 acre-feet of wastewater effluent available, but is not currently used due to the lack of suitable infrastructure to transport the water (e.g. pipeline). The 19,500 acre-feet of effluent represent 44 percent of the City's total water use. If this percentage is applied to the projected demands for Amarillo, there will be a total of 27,500 acre-feet per year of available effluent by 2050. This represents an additional 14,500 acre-feet per year above the currently used 13,000 acre-feet per year for steam electric power. To help meet the projected power needs, it is assumed that Amarillo will continue to sell treated effluent to Southwestern Public Service at 44 percent of their water use. Assuming the infrastructure is in place by 2010, this would provide an additional 405,000 acre-feet for power needs over the planning period. The total need for steam electric power is 98,205 acre-feet, which is considerably less than the total amount provided from the effluent. This means that supply from the Ogallala that was used early in the planning period (2010 – 2020) would become available for use later to meet annual demands. Therefore, no additional strategy will be needed.

Quantity, Reliability and Cost

To provide an additional 14,500 acre-feet per year of treated effluent, a 30-inch pipeline will need to be constructed from the Amarillo wastewater treatment plant to Southwestern Public Service (SPS). The quantity of water would be sufficient. Reliability would be high. The cost of water would be approximately $127 per acre-foot/year ($0.39/ 1,000 gallons).

Environmental Factors

Construction of the pipeline should have minimal impact, especially if it can be routed around environmentally sensitive areas. A detailed environmental review of potential impacts should be performed before the installation of any new infrastructure.

Impact on Water Resources and Other Management Strategies

There should be reduced demands on the Ogallala as a greater percentage of steam electric supply is provided from treated effluent. This will provide potential supply for other users in Potter County.

Impact on Agriculture and Natural Resources

This strategy should have minimal impacts on agriculture. It may increase the available supply for irrigation if groundwater resources are reallocated.

Other Relevant Factors

The historical groundwater use for steam electric from the Ogallala was 2,200 acre-feet per year. By 2020, it was assumed that the supply from the Ogallala increased to 11,400 acre-feet to meet needs. The proposed additional supply from treated effluent beginning in 2010 should reduce the assumed groundwater use to approximately historical use amounts. If a significant increase in groundwater use is needed to provide adequate supply through the planning period, additional water rights will need to be purchased. Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.7 Mining Needs

There are small mining needs identified with counties with limited supplies from the Ogallala: Oldham and Potter counties. To meet these needs local supplies will need to be developed or non-potable water could be used. This may include local mining ponds, shallow groundwater, and local river diversions.

5.7.1 Oldham County

In Oldham County the supply for mining use is obtained from the Dockum and Ogallala Aquifers. There is adequate supply for mining needs in the Canadian Basin, but according to the supply/demand comparison there is a need of 311 acre-feet per year in the Red Basin by 2050. This is due to limitations of availability of the Ogallala in the Red Basin. There is available supply in the Dockum Aquifer in Oldham County to meet this need. [Note: the designation of aquifer availability by river basin is not appropriate. For this analysis, groundwater availability is considered on a county basis.] Therefore, it is assumed that additional wells will be drilled in the Dockum to meet the mining needs.

Quantity, Reliability and Cost

The quantity of water should be adequate, depending on the aquifer transmissivity of local wells. Reliability would be moderate to high since there few other Dockum water users. The cost of water would be approximately $154 per acre-foot/year ($0.47/ 1,000 gallons).

Environmental Factors

There should be minimal environmental impacts associated with the installation of wells and associated facilities. However, a detailed review of the potential environmental impacts should be performed during the project's design.

Impact on Water Resources and Other Management Strategies

There should be no to minimal impacts on water resources since there is available supply in the aquifer. There is no other management strategy identified that would use water from the Dockum aquifer in Oldham County.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Historically, the Dockum Aquifer has not been used for mining needs in the Red Basin portion of the county. Further review of the groundwater availability from this formation in the demand areas is needed. If it is determined that the Dockum is not a viable source of water, then additional water rights from the Ogallala will need to be purchased to continue use of this source.

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.7.2 Potter County

Currently, all of the supply for mining use in Potter County comes from the Ogallala Aquifer. Due to limitation of availability of the Ogallala, there are projected shortages of 410 acre-feet per year by 2050. There is available supply in the Dockum Aquifer to meet these needs, but historically this source has not been used for mining. For this plan, it is assumed that supply for mining will be obtained from the Dockum Aquifer.

Quantity, Reliability and Cost

The quantity of water should be adequate, depending on the aquifer transmissivity of local wells. Reliability would be moderate to high since there few other Dockum water users. The cost of water would be approximately $188 per acre-foot/year ($0.58/ 1,000 gallons).

Environmental Factors

There should be minimal environmental impacts associated with the installation of wells and associated facilities. However, a detailed review of the potential environmental impacts should be performed during the project's design.

Impact on Water Resources and Other Management Strategies

There should be no to minimal impacts on water resources since there is available supply in the aquifer. There is no other management strategy identified that would use water from the Dockum aquifer in Potter County.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

Historically, the Dockum Aquifer has not been used for mining needs in the county. Further review of the groundwater availability from this formation in the demand areas is needed. If it is determined that the Dockum is not a viable source of water, then other alternatives need to be explored.

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

5.8 Irrigation Needs

There are substantial irrigation needs identified in the PWPA region due to limitations of the available supply of the Ogallala Aquifer. By 2050 these needs are projected to be 863,420 acre-feet per year. There is no readily available water supply in or near the high demand irrigation counties that could be developed to fully meet these needs. Therefore, water management strategies for reducing irrigation demands in the Ogallala aquifer for all 21 counties in the PWPG area were examined. These strategies focus on Dallam, Moore, Oldham, Potter, and Randall Counties, which are the only counties in this Region showing water demands that cannot be met with existing supplies (see Table 5-4). It needs to be emphasized that all of the water used for irrigated agriculture within this Region comes from groundwater. When a projected need indicates a negative amount, this is a demand which at this time cannot be met with currently available supplies. Hopefully, the use of irrigation management strategies and local groundwater rules will prolong the life of irrigated agriculture within this Region. The negative amounts of projected need should not be considered as a demand which will be met. The use of groundwater will be reduced as well. One strategy in the future will have to be the conversion from irrigated agriculture to dryland agriculture. This conversion will have an impact on the economic value of agriculture to this Region. The numerical groundwater model simulations indicate that there may be other counties, in addition to the five noted above, that will experience localized shortages, although the tables in TWDB's Exhibit B may not reflect that. Although the focus on this section of the regional water supply plan is on the five counties with identified needs, the PWPG is encouraging the irrigators of the Region to adopt the following water management strategies in all of the Region's irrigated counties.

The irrigation management strategies include the use of the North Plains Potential Evapotranspiration Network (NPPET) to schedule irrigation, changes in crop variety, irrigation equipment efficiency improvements, changes in crop types, implementation of conservation tillage methods and precipitation enhancement. A detailed evaluation of these strategies was performed by the Texas Agricultural Experiment Station and their report is included as Appendix O.

Table 5-4. Irrigation Needs Identified in the PWPA

Water User Group	County	Projected Need (acre-feet per year)					
		2000	2010	2020	2030	2040	2050
Irrigation	Dallam	0	0	-293,412	-380,930	-380,971	-381,008
Irrigation	Moore	0	0	-31,264	-200,576	-200,576	-200,576
Irrigation	Oldham	0	0	0	0	-2,188	-25,948
Irrigation	Potter	0	0	0	-5,704	-9,382	-13,877
Irrigation	Randall	0	0	0	-67	-40,991	-47,214

Each of the water management strategies is presented in Table 5-5. Included are the anticipated annual water savings in acre-feet per acre per year and the expected percentage of acres by decade that would be shifted to these methods.

In addition to these strategies, water contractors are pursuing the development of transporting water from counties within the region to areas outside of the PWPA. Economic feasibility of the use of this water for irrigation is discussed in section 5.6.7.

The irrigated acres that are utilized in the water management strategies for Dallam, Moore, Oldham, Potter, and Randall Counties are obtained from the Texas Agricultural Statistics Service (TASS, 1998). The total 1997 irrigated acres for the PWPA is 1,363,438 acres, as shown in Table 5-6.

Table 5-5. Possible Water Management Strategies for Reducing Irrigation Demands

Water Management Strategy	Assumed Annual Regional Water Savings (acre-feet/ac/yr)	Assumed Baseline Use Year 2000	Goal for Adoption 2010	Goal for Adoption 2020	Goal for Adoption 2030	Goal for Adoption 2040	Goal for Adoption 2050
Use of NPPET	0.167	20%	70%	90%	90%	90%	90%
Change in Crop Variety	0.167	10%	40%	70%	70%	70%	70%
Irrigation Equipment Changes	0.25	55%	75%	95%	95%	95%	95%
Change in Crop Type	0.42	0%	20%	40%	40%	40%	40%
Convert Irrigated Land to Dryland	1.2	0%	5%	10%	15%	15%	15%
Implement Conservation Tillage Methods	0.167	50%	60%	70%	70%	70%	70%
Precipitation Enhancement	0.08	0%	100%	100%	100%	100%	100%

Table 5-6. Irrigated Acres for Selected Crops in 1997[1]

County	Corn	Cotton	Hay	Pasture	Peanuts	Sorghum	Soybeans	Wheat	Total Acres
Armstrong	1,200	800	60	316	0	2,100	0	5,000	9,476
Carson	15,200	0	200	14,410	0	23,400	3,700	36,100	93,010
Childress	0	1,700	410	350	459	467	0	100	3,486
Collingsworth	750	5,200	670	969	10,200	1,600	0	1,400	20,789
Dallam	157,000	0	8,000	14,588	0	8,000	700	96,300	284,588
Donley	2,500	1,200	1,336	2,705	2,800	1,400	225	377	12,543
Gray	7,100	0	730	711	0	5,100	1,500	19,900	35,041
Hall	1,500	10,700	609	560	2,100	163	0	155	15,787
Hansford	49,000	0	1,500	5,017	0	21,800	9,400	106,400	193,117
Hartley	87,400	0	2,200	9,990	0	8,200	900	30,600	139,290
Hemphill	0	425	449	1,241	0	206	0	2,100	4,421
Hutchinson	14,500	0	25	2,113	0	4,200	915	6,500	28,253
Lipscomb	2,200	0	9,190	2,570	0	1,900	880	7,900	24,640
Moore	87,800	0	0	13,805	0	22,000	1,900	45,900	171,405
Ochiltree	17,000	0	259	0	0	12,300	4,400	23,500	57,459
Oldham	862	0	0	520	0	10,500	0	18,300	30,182
Potter	971	0	0	2,948	0	1,500	0	22,800	28,219
Randall	5,500	100	2,185	6,570	0	14,800	0	17,700	46,855
Roberts	2,100	0	0	832	0	2,000	0	3,400	8,332
Sherman	70,700	300	1,072	6,283	0	20,500	50	53,300	152,205
Wheeler	960	600	100	642	807	906	0	325	4,340
Total	524,243	21,025	28,995	87,140	16,366	163,042	24,570	498,057	1,363,438

[1] **Source: Texas Agricultural Statistics Services, 1998**

5.8.1 Use of the Potential Evapotranspiration Network for Scheduling Irrigation

It is assumed that by utilizing the North Plains Potential Evapotranspiration Network (NPPET), 0.167 acre-ft of groundwater per irrigated acre will be saved annually. Additionally, it is assumed that in the baseline year of 2000 that 20 percent of the irrigated acres utilize the potential evapotranspiration (PET) crop water use information. The expectation is that 70 percent of the irrigated acres from 2010 to 2019 and 90 percent of the irrigated acres from 2020 to 2050 will use the PET irrigation recommendations. The anticipated annual water savings using the NPPET is shown, by county and decade, in Table 5-7. This strategy would reduce irrigation demands on the Ogallala in the five counties by approximately 7 percent in 2010, and nearly 10 percent between 2020 and 2050.

Table 5-7. Annual Water Savings Using NPPET for Scheduling Irrigation

County	Irrigated Acres[1]	Annual Water Savings (acre-feet) During Each Decade				
		2010	2020	2030	2040	2050
Armstrong	9,476	790	1,106	1,106	1,106	1,106
Carson	93,010	7,751	10,851	10,851	10,851	10,851
Childress	3,486	291	407	407	407	407
Collingsworth	20,789	1,732	2,425	2,425	2,425	2,425
Dallam	284,588	23,716	33,202	33,202	33,202	33,202
Donley	12,543	1,045	1,463	1,463	1,463	1,463
Gray	35,041	2,920	4,088	4,088	4,088	4,088
Hall	15,787	1,316	1,842	1,842	1,842	1,842
Hansford	193,117	16,093	22,530	22,530	22,530	22,530
Hartley	139,290	11,608	16,251	16,251	16,251	16,251
Hemphill	4,421	368	516	516	516	516
Hutchinson	28,253	2,354	3,296	3,296	3,296	3,296
Lipscomb	24,640	2,053	2,875	2,875	2,875	2,875
Moore	171,405	14,284	19,997	19,997	19,997	19,997
Ochiltree	57,459	4,788	6,704	6,704	6,704	6,704
Oldham	30,182	2,515	3,521	3,521	3,521	3,521
Potter	28,219	2,352	3,292	3,292	3,292	3,292
Randall	46,855	3,905	5,466	5,466	5,466	5,466
Roberts	8,332	694	972	972	972	972
Sherman	152,205	12,684	17,757	17,757	17,757	17,757
Wheeler	4,340	362	506	506	506	506
Total Region A	1,363,438	113,621	159,067	159,067	159,067	159,067

[1]Irrigated acres were calculated and obtained from Task 2.

The cost to implement this strategy is based on the need to expand the network to provide the most accurate information to irrigators. There are currently 10 stations located throughout the Region. The network would need to have an additional six stations, at an estimated cost of $76,000 or $0.06 per acre. The annual cost for maintaining all stations has been estimated at $171,500 or $0.13 per acre. This results in an amortized cost to implement this strategy of

$0.1347 per acre per year resulting in an estimated cost of $0.81 per acre-foot/acre/year of water savings.

5.8.2 Change in Crop Variety

It is assumed that 0.167 acre-ft per year of irrigation water will be conserved per acre by shifting from a long season crop to a short season crop. The two crops examined in this analysis are corn and sorghum. For both crops, it is assumed in the baseline year of 2000 that 10 percent of the acres will be planted using the short season variety. It is expected that from 2010 to 2019 and from 2020 to 2050, 40 percent and 70 percent, respectively, of the irrigated acres will be planted with the short season varieties. The respective water savings are shown in Tables 5-8 and 5-9.

To develop the estimated costs associated with the changes in crop varieties, it was assumed that there would be a 15 percent loss in yield and a 15 percent savings on fertilizer costs. The net loss of income for moving from long season corn to short season corn has been estimated at $17.97 per acre. Hence, the cost of water saved is $107.82 per acre-foot. Shifting long season sorghum to short season sorghum resulted in a net loss in income of $2.76 per acre and an estimated cost of water saved of $16.56 per acre-foot.

Table 5-8. Water Savings by Changing from Long Season Corn to Short Season Corn Varieties

County	Irrigated Corn Acres[1]	Annual Water Savings (acre-feet) During Each Decade				
		2010	2020	2030	2040	2050
Armstrong	1,200	60	120	120	120	120
Carson	15,200	760	1,520	1,520	1,520	1,520
Childress	0	0	0	0	0	0
Collingsworth	750	38	75	75	75	75
Dallam	157,000	7,850	15,700	15,700	15,700	15,700
Donley	2,500	125	250	250	250	250
Gray	7,100	355	710	710	710	710
Hall	1,500	75	150	150	150	150
Hansford	49,000	2,450	4,900	4,900	4,900	4,900
Hartley	87,400	4,370	8,740	8,740	8,740	8,740
Hemphill	0	0	0	0	0	0
Hutchinson	14,500	725	1,450	1,450	1,450	1,450
Lipscomb	2,200	110	220	220	220	220
Moore	87,800	4,390	8,780	8,780	8,780	8,780
Ochiltree	17,000	850	1,700	1,700	1,700	1,700
Oldham	862	43	86	86	86	86
Potter	971	49	97	97	97	97
Randall	5,500	275	550	550	550	550
Roberts	2,100	105	210	210	210	210
Sherman	70,700	3,535	7,070	7,070	7,070	7,070
Wheeler	960	48	96	96	96	96
Total	524,243	26,213	52,424	52,424	52,424	52,424

[1]Irrigated corn acres were calculated and obtained from Task 2.

Table 5-9. Water Savings by Changing from Long Season Sorghum to Short Season Sorghum Varieties

County	Irrigated Sorghum Acres[1]	Annual Water Savings (acre-feet) During Each Decade				
		2010	2020	2030	2040	2050
Armstrong	2,100	105	210	210	210	210
Carson	23,400	1,170	2,340	2,340	2,340	2,340
Childress	467	23	47	47	47	47
Collingsworth	1,600	80	160	160	160	160
Dallam	8,000	400	800	800	800	800
Donley	1,400	70	140	140	140	140
Gray	5,100	255	510	510	510	510
Hall	163	8	16	16	16	16
Hansford	21,800	1,090	2,180	2,180	2,180	2,180
Hartley	8,200	410	820	820	820	820
Hemphill	206	10	21	21	21	21
Hutchinson	4,200	210	420	420	420	420
Lipscomb	1,900	95	190	190	190	190
Moore	22,000	1,100	2,200	2,200	2,200	2,200
Ochiltree	12,300	615	1,230	1,230	1,230	1,230
Oldham	10,500	525	1,050	1,050	1,050	1,050
Potter	1,500	75	150	150	150	150
Randall	14,800	740	1,480	1,480	1,480	1,480
Roberts	2,000	100	200	200	200	200
Sherman	20,500	1,025	2,050	2,050	2,050	2,050
Wheeler	906	45	91	91	91	91
Total	163,042	8,151	16,305	16,305	16,305	16,305

[1]Irrigated sorghum acres were calculated and obtained from Task 2.

5.8.3 Irrigation Equipment Changes

It is assumed that the incorporation of more efficient irrigation equipment/technology in a farming/ranching operation would provide another method of conserving groundwater. The application efficiencies are as follows: furrow irrigation – 60 percent, surge flow – 75 percent, low elevation sprinkler application (LESA) – 88 percent, low energy precision application (LEPA) – 95 percent, and drip irrigation – 97 percent (New, 1999). The system with the higher efficiency rating is considered more efficient because it leads to less water usage.

It is assumed in the baseline year of 2000 that 55 percent of irrigated agriculture is already utilizing the more efficient distribution systems. It is expected that between years 2010 to 2019 an additional 20 percent of the farming/ranching operations will use methods such as LESA and

LEPA. In the years 2020 to 2050, it is anticipated that 95 percent of the irrigated crops will be under the more efficient methods. For drip irrigation, a lower conversion rate was assumed. Only 5 percent of the acreage is expected to convert to drip irrigation by 2010. This is assumed to increase to 10 percent by 2020 and 15 percent by 2030.

Furrow-irrigated acres for corn, cotton, hay, pasture, peanuts, sorghum, soybeans and wheat in the Region's counties in 1997 are located in Table 5-10 (Almas, et al., 2000). The analysis of irrigation equipment changes was conducted for corn, pasture, sorghum, soybeans (except for Sherman County) and wheat. The conversion of irrigated cotton, hay and peanuts, and soybeans in Sherman County was not evaluated because of the small number of irrigated acres.

Table 5-10. Furrow-irrigated Acres in 1997

County	Corn	Cotton	Hay	Pasture	Peanuts	Sorghum	Soybeans	Wheat	County Totals
Armstrong	913	609	46	241	0	1,598	0	3,805	7,212
Carson	10,827	0	142	10,264	0	16,667	2,635	25,713	66,249
Childress	0	0	0	0	0	0	0	0	0
Collingsworth	218	1,511	195	281	2,963	465	0	407	6,039
Dallam	46,662	0	2,378	4,336	0	2,378	208	28,622	84,583
Donley	193	97	101	212	212	102	19	29	965
Gray	4,104	0	422	411	0	2,948	867	11,504	20,257
Hall	0	0	0	0	0	0	0	0	0
Hansford	31,446	0	963	3,220	0	13,990	6,032	68,282	123,932
Hartley	1,548	0	50	175	0	150	25	549	2,497
Hemphill	0	71	75	207	0	34	0	350	736
Hutchinson	6,011	0	10	876	0	1,741	379	2,695	11,713
Lipscomb	96	0	393	107	0	85	43	341	1,065
Moore	30,242	0	0	4,755	0	7,578	654	15,810	59,040
Ochiltree	9,029	0	138	0	0	6,533	2,337	12,482	30,519
Oldham	795	0	0	480	0	9,682	0	16,875	27,832
Potter	950	0	0	2,884	0	1,468	0	22,307	27,609
Randall	4,119	75	1,636	4,921	0	11,085	0	13,257	35,093
Roberts	391	0	0	155	0	373	0	633	1,552
Sherman	3,252	13	49	289	0	943	2	2,452	7,000
Wheeler	0	0	0	0	0	0	0	0	0
Total Region A	150,796	2,376	6,598	33,814	3,175	77,820	13,201	226,113	513,893

Two methodologies are used for calculating water savings in acre-feet when shifting from furrow-irrigated crops to surge flow, LESA, LEPA, and DRIP. One approach utilizes the potential evapotranspiration (PET) irrigation water use estimates by crop and county developed in Task 2. These estimates incorporate the application efficiency rating for each. The water use estimates are presented in the TAES irrigation report in Appendix O. The second approach uses a standard water savings of 0.25 acre-ft per crop, per season. The water savings by crop and equipment type for each county are also located in Appendix O. A summary of the average water savings per converted irrigated acre is presented in Table 5-11.

Table 5-11. Water Savings When Shifting from Furrow Irrigation

County	Furrowed Acres	Average water savings per acre converted (acre-feet/acre/year)			
		Surge Flow	LESA	LEPA	DRIP
Armstrong	6,557	0.21	0.33	0.36	0.09
Carson	66,107	0.30	0.47	0.51	0.13
Childress	0	0.00	0.00	0.00	0.00
Collingsworth	1,371	0.33	0.52	0.56	0.15
Dallam	82,205	0.40	0.62	0.67	0.17
Donley	555	0.43	0.68	0.73	0.19
Gray	19,835	0.18	0.28	0.30	0.08
Hall	0	0.00	0.00	0.00	0.00
Hansford	122,969	0.19	0.29	0.32	0.08
Hartley	2,447	0.43	0.67	0.73	0.18
Hemphill	590	0.25	0.38	0.42	0.11
Hutchinson	11,703	0.44	0.69	0.75	0.19
Lipscomb	672	0.22	0.33	0.36	0.10
Moore	59,040	0.35	0.55	0.59	0.15
Ochiltree	30,381	0.24	0.38	0.42	0.11
Oldham	27,832	0.26	0.41	0.45	0.12
Potter	27,609	0.26	0.40	0.44	0.12
Randall	33,382	0.34	0.53	0.58	0.15
Roberts	1,552	0.21	0.33	0.35	0.09
Sherman	6,938	0.38	0.60	0.65	0.17
Wheeler	0	0.00	0.00	0.00	0.00

There is an increase of over 56 percent in water savings when changing from surge flow irrigation to LESA. This increases to nearly 70 percent when acreage is converted from surge to LEPA. DRIP irrigation provides the greatest efficiency for water use, but has other disadvantages. During a dry spring, there may be problems germinating crops when using DRIP irrigation. There are also relatively high investment costs associated with DRIP. The major advantages for sprinkler-type systems (LESA and LEPA) and DRIP are the labor efficiencies. These types of systems can save between two and five field operations, which result in reduced labor costs. Also the farmer/rancher can chemigate with sprinkler systems. Furrow or surge systems require alternative methods for applications of chemicals. Surge systems also have a tendency to crust the surface soil that may reduce irrigation efficiency and require more management.

The estimated water savings by county and decade for each type of equipment are presented in Tables 5-12 through 5-15. These savings (reduction in irrigation demands) assume the percentage of acres converted as proposed in Table 5-5.

Table 5-12. Water Savings When Shifting Furrow Irrigated Crops to Surge Flow[1]

County	Furrow Irrigated Acres	Annual Water Savings for selected years					Total for 50 years
		2010	2020	2030	2040	2050	
Armstrong	6,557	276	552	552	552	552	24,840
Carson	66,107	3,953	7,907	7,907	7,907	7,907	355,810
Childress	0	0	0	0	0	0	0
Collingsworth	1,371	90	181	181	181	181	8,140
Dallam	82,205	6,516	13,032	13,032	13,032	13,032	586,440
Donley	555	48	95	95	95	95	4,280
Gray	19,835	708	1,416	1,416	1,416	1,416	63,720
Hall	0	0	0	0	0	0	0
Hansford	122,969	4,567	9,133	9,133	9,133	9,133	410,990
Hartley	2,447	209	417	417	417	417	18,770
Hemphill	590	29	57	57	57	57	2,570
Hutchinson	11,703	1,036	2,073	2,073	2,073	2,073	93,280
Lipscomb	672	29	57	57	57	57	2,570
Moore	59,040	4,120	8,240	8,240	8,240	8,240	370,800
Ochiltree	30,381	1,483	2,967	2,967	2,967	2,967	133,510
Oldham	27,832	1,467	2,934	2,934	2,934	2,934	132,030
Potter	27,609	1,427	2,855	2,855	2,855	2,855	128,470
Randall	33,382	2,266	4,533	4,533	4,533	4,533	203,980
Roberts	1,552	64	129	129	129	129	5,800
Sherman	6,938	529	1,058	1,058	1,058	1,058	47,610
Wheeler	0	0	0	0	0	0	0
Total	501,745	28,817	57,636	57,636	57,636	57,636	2,593,610

[1] 20 percent additional furrow irrigated acres to be converted to surge flow by 2010 and 40 percent by 2020.

Table 5-13. Water Savings When Shifting Furrow Irrigated Crops to LESA[1]

County	Furrow Irrigated Acres	Annual Water Savings for selected years					Total For 50 years
		2010	2020	2030	2040	2050	
Armstrong	6,557	433	865	865	865	865	38,930
Carson	66,107	6,191	12,383	12,383	12,383	12,383	557,230
Childress	0	0	0	0	0	0	0
Collingsworth	1,371	142	283	283	283	283	12,740
Dallam	82,205	10,200	20,400	20,400	20,400	20,400	918,000
Donley	555	75	150	150	150	150	6,750
Gray	19,835	1,110	2,220	2,220	2,220	2,220	99,900
Hall	0	0	0	0	0	0	0
Hansford	122,969	7,146	14,292	14,292	14,292	14,292	643,140
Hartley	2,447	327	654	654	654	654	29,430
Hemphill	590	45	90	90	90	90	4,050
Hutchinson	11,703	1,624	3,248	3,248	3,248	3,248	146,160
Lipscomb	672	45	90	90	90	90	4,050
Moore	59,040	6,454	12,908	12,908	12,908	12,908	580,860
Ochiltree	30,381	2,324	4,649	4,649	4,649	4,649	209,200
Oldham	27,832	2,297	4,594	4,594	4,594	4,594	206,730
Potter	27,609	2,236	4,473	4,473	4,473	4,473	201,280
Randall	33,382	3,551	7,102	7,102	7,102	7,102	319,590
Roberts	1,552	101	202	202	202	202	9,090
Sherman	6,938	828	1,657	1,657	1,657	1,657	74,560
Wheeler	0	0	0	0	0	0	0
Total	501,745	45,129	90,260	90,260	90,260	90,260	4,061,690

[1] 20 percent additional furrow irrigated acres to be converted to LESA by 2010 and 40 percent by 2020.

Table 5-14. Water Savings When Shifting Furrow Irrigated Crops to LEPA

County	Furrow Irrigated Acres	Annual Water Savings for selected years					Total for 50 years
		2010	2020	2030	2040	2050	
Armstrong	6,557	469	938	938	938	938	42,210
Carson	66,107	6,716	13,431	13,431	13,431	13,431	604,400
Childress	0	0	0	0	0	0	0
Collingsworth	1,371	154	307	307	307	307	13,820
Dallam	82,205	11,066	22,131	22,131	22,131	22,131	995,900
Donley	555	81	162	162	162	162	7,290
Gray	19,835	1,203	2,406	2,406	2,406	2,406	108,270
Hall	0	0	0	0	0	0	0
Hansford	122,969	7,760	15,519	15,519	15,519	15,519	698,360
Hartley	2,447	355	709	709	709	709	31,910
Hemphill	590	49	97	97	97	97	4,370
Hutchinson	11,703	1,763	3,526	3,526	3,526	3,526	158,670
Lipscomb	672	49	98	98	98	98	4,410
Moore	59,040	7,003	14,007	14,007	14,007	14,007	630,310
Ochiltree	30,381	2,523	5,045	5,045	5,045	5,045	227,030
Oldham	27,832	2,491	4,983	4,983	4,983	4,983	224,230
Potter	27,609	2,424	4,849	4,849	4,849	4,849	218,200
Randall	33,382	3,855	7,710	7,710	7,710	7,710	346,950
Roberts	1,552	109	219	219	219	219	9,850
Sherman	6,938	899	1,798	1,798	1,798	1,798	80,910
Wheeler	0	0	0	0	0	0	0
Total	501,745	48,969	97,935	97,935	97,935	97,935	4,407,090

[1] 20 percent additional furrow irrigated acres to be converted to LEPA by 2010 and 40 percent by 2020.

Table 5-15. Water Savings When Shifting Furrow Irrigated Crops to DRIP[1]

County	Furrow Irrigated Acres	Annual Water Savings for selected years					Total for 50 years
		2010	2020	2030	2040	2050	
Armstrong	6,557	122	244	366	366	366	14,640
Carson	66,107	1,753	3,506	5,259	5,259	5,259	210,360
Childress	0	0	0	0	0	0	0
Collingsworth	1,371	40	80	121	121	121	4,830
Dallam	82,205	2,811	5,623	8,434	8,434	8,434	337,360
Donley	555	21	42	63	63	63	2,520
Gray	19,835	310	620	929	929	929	37,170
Hall	0	0	0	0	0	0	0
Hansford	122,969	2,005	4,010	6,016	6,016	6,016	240,630
Hartley	2,447	90	180	270	270	270	10,800
Hemphill	590	13	26	39	39	39	1,560
Hutchinson	11,703	449	897	1,346	1,346	1,346	53,840
Lipscomb	672	13	25	38	38	38	1,520
Moore	59,040	1,785	3,571	5,356	5,356	5,356	214,240
Ochiltree	30,381	647	1,294	1,941	1,941	1,941	77,640
Oldham	27,832	657	1,315	1,972	1,972	1,972	78,880
Potter	27,609	640	1,280	1,920	1,920	1,920	76,800
Randall	33,382	1,009	2,018	3,028	3,028	3,028	121,110
Roberts	1,552	28	56	85	85	85	3,390
Sherman	6,938	229	459	688	688	688	27,520
Wheeler	0	0	0	0	0	0	0
Total	501,745	12,622	25,246	37,871	37,871	37,871	1,514,810

[1]Five percent furrow irrigated acres to be converted to drip by 2010, 10 percent by 2020, and 15 percent by 2030.

The additional investment in dollars for converting furrow irrigation to surge flow, LESA, LEPA, and drip is $20.00, $303.98, $317.28, and $666.92 per acre, respectively. The corresponding annualized cost per acre for each strategy is $1.56, $23.78, $24.82, and $52.17, respectively. The estimated water saving in acre-foot/acre/year from furrow to surge flow is 0.34, from furrow to LESA is 0.54, from furrow to LEPA is 0.59, and from furrow to drip is 0.66. The estimated cost of water saving for each alternative is $4.60, $44.04, $42.07, and $79.05 per acre-foot/acre/year, respectively. The results indicate that surge flow has the lowest investment cost and the lowest water saving. However, it is more labor intensive than LESA, LEPA and DRIP. That is the reason for low adoption rate of surge flow. Drip irrigation has the highest investment cost and the highest water savings, but it is the most expensive method in terms of cost of water saved. The cost of water saved using sprinkler irrigation is approximately half of the cost of water saved from drip. Sprinkler irrigation has benefits of savings from field operations, labor, and chemigation in addition to water savings. These are some of the reasons for the accelerated adoption rate of center pivot irrigation in the region.

5.8.4 Change in Crop Type

It is assumed that one method of reducing groundwater use is to change from a high water use crop to a lower water use crop type. The assumption is that corn acres will be converted to sorghum, cotton, or soybean acres; soybean acres will be diverted to wheat acres; and sorghum acres will be shifted to wheat acres. In the 2000 baseline year, it is assumed that none of the acres will have undergone this transition. It is expected that 20 percent of the acres for the years 2010 to 2019 and 40 percent of the acres for the years 2020 to 2050 will undergo crop type changes. In addition, irrigated acres will be changed to dryland acres at a rate of 5 percent by 2010, increasing to 10 percent by 2020 and 15 percent by 2030.

Two methodologies for calculating water savings in acre-feet were examined for six cropping alternatives. One approach utilizes the difference in PET irrigation water use estimates by crop and county developed in Task 2 that incorporates the application efficiency rating. The water use estimates are presented in Appendix N. The second approach uses a standard water savings of 0.42 acre-foot per year irrespective of crop type. These computations are located in Appendix O, and are summarized by county and decade in Tables 5-16 through 5-21.

Table 5-16. Water Savings When Converting from Irrigated Corn to Irrigated Sorghum

County	Irrigated Corn Acres	Annual Water Savings for Selected Years					Total for 50 Years
		2010	2020	2030	2040	2050	
Armstrong	1,200	195	390	390	390	390	17,550
Carson	15,200	2,348	4,697	4,697	4,697	4,697	211,360
Childress	0	0	0	0	0	0	0
Collingsworth	750	138	275	275	275	275	12,380
Dallam	157,000	23,864	47,728	47,728	47,728	47,728	2,147,760
Donley	2,500	422	844	844	844	844	37,980
Gray	7,100	1,065	2,130	2,130	2,130	2,130	95,850
Hall	1,500	218	437	437	437	437	19,660
Hansford	49,000	6,378	12,756	12,756	12,756	12,756	574,020
Hartley	87,400	13,867	27,735	27,735	27,735	27,735	1,248,070
Hemphill	0	0	0	0	0	0	0
Hutchinson	14,500	2,811	5,621	5,621	5,621	5,621	252,950
Lipscomb	2,200	358	715	715	715	715	32,180
Moore	87,800	13,814	27,628	27,628	27,628	27,628	1,243,260
Ochiltree	17,000	2,839	5,678	5,678	5,678	5,678	255,510
Oldham	862	153	305	305	305	305	13,730
Potter	971	169	339	339	339	339	15,250
Randall	5,500	969	1,938	1,938	1,938	1,938	87,210
Roberts	2,100	293	587	587	587	587	26,410
Sherman	70,700	11,654	23,307	23,307	23,307	23,307	1,048,820
Wheeler	960	171	342	342	342	342	15,390
Total	524,243	81,726	163,452	163,452	163,452	163,452	7,355,340

Table 5-17. Water Savings When Converting From Irrigated Corn To Irrigated Cotton

County	Irrigated Corn Acres	Annual Water Savings for Selected Years					Total for 50 Years
		2010	2020	2030	2040	2050	
Armstrong	1,200	220	441	441	441	441	19,840
Carson	15,200	2,792	5,583	5,583	5,583	5,583	251,240
Childress	0	0	0	0	0	0	0
Collingsworth	750	141	282	282	282	282	12,690
Dallam	157,000	28,783	57,567	57,567	57,567	57,567	2,590,510
Donley	2,500	469	938	938	938	938	42,210
Gray	7,100	1,266	2,532	2,532	2,532	2,532	113,940
Hall	1,500	256	511	511	511	511	23,000
Hansford	49,000	7,807	15,615	15,615	15,615	15,615	702,670
Hartley	87,400	15,878	31,755	31,755	31,755	31,755	1,428,980
Hemphill	0	0	0	0	0	0	0
Hutchinson	14,500	3,207	6,414	6,414	6,414	6,414	288,630
Lipscomb	2,200	403	807	807	807	807	36,310
Moore	87,800	15,248	30,496	30,496	30,496	30,496	1,372,320
Ochiltree	17,000	3,222	6,443	6,443	6,443	6,443	289,940
Oldham	862	170	339	339	339	339	15,260
Potter	971	188	376	376	376	376	16,920
Randall	5,500	1,074	2,149	2,149	2,149	2,149	96,700
Roberts	2,100	354	708	708	708	708	31,860
Sherman	70,700	13,268	26,536	26,536	26,536	26,536	1,194,120
Wheeler	960	200	401	401	401	401	18,040
Total	524,243	94,946	189,893	189,893	189,893	189,893	8,545,180

Table 5-18. Water Savings When Converting from Irrigated Corn to Irrigated Soybeans

County	Irrigated Corn Acres	Annual Water Savings for Selected Years					Total for 50 Years
		2010	2020	2030	2040	2050	
Armstrong	1,200	247	494	494	494	494	22,230
Carson	15,200	3,063	6,126	6,126	6,126	6,126	275,670
Childress	0	0	0	0	0	0	0
Collingsworth	750	154	309	309	309	309	13,900
Dallam	157,000	31,008	62,015	62,015	62,015	62,015	2,790,680
Donley	2,500	518	1,037	1,037	1,037	1,037	46,660
Gray	7,100	1,381	2,762	2,762	2,762	2,762	124,290
Hall	1,500	272	544	544	544	544	24,480
Hansford	49,000	8,003	16,007	16,007	16,007	16,007	720,310
Hartley	87,400	17,320	34,640	34,640	34,640	34,640	1,558,800
Hemphill	0	0	0	0	0	0	0
Hutchinson	14,500	3,284	6,569	6,569	6,569	6,569	295,600
Lipscomb	2,200	443	887	887	887	887	39,910
Moore	87,800	16,565	33,130	33,130	33,130	33,130	1,490,850
Ochiltree	17,000	3,417	6,834	6,834	6,834	6,834	307,530
Oldham	862	193	385	385	385	385	17,330
Potter	971	216	431	431	431	431	19,400
Randall	5,500	1,230	2,460	2,460	2,460	2,460	110,700
Roberts	2,100	376	752	752	752	752	33,840
Sherman	70,700	14,894	29,788	29,788	29,788	29,788	1,340,460
Wheeler	960	208	415	415	415	415	18,680
Total	524,243	102,792	205,585	205,585	205,585	205,585	9,251,320

Table 5-19. Water Savings When Converting from Irrigated Sorghum to Irrigated Wheat

County	Irrigated Sorghum Acres	Annual Water Savings for Selected Years					Total for 50 Years
		2010	2020	2030	2040	2050	
Armstrong	2,100	167	334	334	334	334	15,030
Carson	23,400	1,513	3,026	3,026	3,026	3,026	136,170
Childress	467	43	86	86	86	86	3,870
Collingsworth	1,600	134	267	267	267	267	12,020
Dallam	8,000	455	909	909	909	909	40,910
Donley	1,400	128	256	256	256	256	11,520
Gray	5,100	409	818	818	818	818	36,810
Hall	163	6	13	13	13	13	580
Hansford	21,800	0	0	0	0	0	0
Hartley	8,200	421	842	842	842	842	37,890
Hemphill	206	19	38	38	38	38	1,710
Hutchinson	4,200	537	1,074	1,074	1,074	1,074	48,330
Lipscomb	1,900	166	331	331	331	331	14,900
Moore	22,000	1,082	2,163	2,163	2,163	2,163	97,340
Ochiltree	12,300	779	1,558	1,558	1,558	1,558	70,110
Oldham	10,500	611	1,222	1,222	1,222	1,222	54,990
Potter	1,500	99	199	199	199	199	8,950
Randall	14,800	1,019	2,037	2,037	2,037	2,037	91,670
Roberts	2,000	94	188	188	188	188	8,460
Sherman	20,500	1,220	2,440	2,440	2,440	2,440	109,800
Wheeler	906	106	212	212	212	212	9,540
Total	163,042	9,008	18,013	18,013	18,013	18,013	810,600

Table 5-20. Water Savings When Converting from Irrigated Soybeans to Irrigated Wheat

County	Irrigated Soybeans Acres	Annual Water Savings for Selected Years					Total for 50 Years
		2010	2020	2030	2040	2050	
Armstrong	0	0	0	0	0	0	0
Carson	3,700	65	131	131	131	131	5890
Childress	0	0	0	0	0	0	0
Collingsworth	0	0	0	0	0	0	0
Dallam	700	8	16	16	16	16	720
Donley	225	12	24	24	24	24	1080
Gray	1,500	54	107	107	107	107	4820
Hall	0	0	0	0	0	0	0
Hansford	9,400	0	0	0	0	0	0
Hartley	900	11	21	21	21	21	950
Hemphill	0	0	0	0	0	0	0
Hutchinson	915	87	174	174	174	174	7830
Lipscomb	880	42	85	85	85	85	3820
Moore	1,900	34	68	68	68	68	3060
Ochiltree	4,400	129	258	258	258	258	11610
Oldham	0	0	0	0	0	0	0
Potter	0	0	0	0	0	0	0
Randall	0	0	0	0	0	0	0
Roberts	0	0	0	0	0	0	0
Sherman	50	1	1	1	1	1	50
Wheeler	0	0	0	0	0	0	0
Total	24,570	443	885	885	885	885	39,830

The anticipated water savings by decade (2000-2050) and by county when shifting the 701,797 irrigated acres to dryland acres for the Region's counties are presented in Table 5-21. As previously discussed, up to 15 percent of the acreage is assumed converted to dryland farming by 2030. Dallam County has the largest number of irrigated acres (276,588), and Childress County has the smallest number of irrigated acres (917). Subsequently, the largest estimated water savings will occur in Dallam County at 2,190,914 acre-feet for the 50 years and the smallest water savings will result in Childress County at 6,720 acre-feet.

Table 5-21. Water Savings When Converting from Irrigated Crops to Dryland Farming

County	Irrigated Acres	Annual Water Savings for Selected Years					Total for 50 Years
		2010	2020	2030	2040	2050	
Armstrong	8,616	302	605	907	907	907	36,280
Carson	92,810	4,623	9,246	13,869	13,869	13,869	554,760
Childress	917	56	112	168	168	168	6,720
Collingsworth	4,719	195	390	585	585	585	23,400
Dallam	276,588	18,258	36,515	54,773	54,773	54,773	2,190,920
Donley	7,207	514	1,027	1,541	1,541	1,541	61,640
Gray	34,311	1,021	2,042	3,062	3,062	3,062	122,490
Hall	2,378	130	260	391	391	391	15,630
Hansford	191,617	5,928	11,856	17,784	17,784	17,784	711,360
Hartley	137,090	9,786	19,572	29,358	29,358	29,358	1,174,320
Hemphill	3,547	143	286	430	430	430	17,190
Hutchinson	28,228	2,084	4,168	6,253	6,253	6,253	250,110
Lipscomb	15,450	556	1,112	1,668	1,668	1,668	66,720
Moore	171,405	9,969	19,939	29,908	29,908	29,908	1,196,320
Ochiltree	57,200	2,328	4,657	6,985	6,985	6,985	279,400
Oldham	30,182	1,324	2,649	3,973	3,973	3,973	158,920
Potter	28,219	1,216	2,431	3,647	3,647	3,647	145,880
Randall	44,570	2,523	5,046	7,569	7,569	7,569	302,760
Roberts	8,332	288	575	863	863	863	34,520
Sherman	150,833	9,579	19,159	28,738	28,738	28,738	1,149,520
Wheeler	2,833	203	406	609	609	609	24,360
Totals	1,297,052	71,026	142,053	213,081	213,081	213,081	8,523,220

The total water savings over the 50-year planning period from changing crop types are summarized in Table 5-22 by each crop conversion. Estimated water savings due to conversion of irrigated crop acres to dryland farming in the PWPA with irrigation needs are also given in Table 5-22. It is anticipated that conversion of irrigated land into dryland farming will result in estimated total water savings of 8,523,236 acre-feet over next 50 years.

Table 5-22. Total Water Savings for the Next 50 Years (2000-2050) for Different Crop Conversions

Water Savings Approach/Crop Change Scenario	Corn Converted to Sorghum	Corn Converted to Cotton	Corn Converted to Soybeans	Sorghum Converted to Wheat	Soybeans Converted to Wheat	Irrigated Converted to Dryland Crop acres
	--------------------------cumulative acre-feet---------------------------					
Using PET Water	7,355,293	8,545,154	9,251,212	810,575	39,823	8,523,236
Using 5 ac-in/yr.	3,931,823	3,931,823	3,931,823	1,222,815	184,275	3,242,630

It is assumed that value of irrigated land with good and fair water is $1,050 and $600 per acre, respectively (Texas Chapter of American Society of Farm Managers and Rural Appraisers, 2000). Composite of irrigated acres in six counties indicates 52 percent of high water use and 48 percent medium water use. The value of dry cropland is $250 per acre. The net loss in value of land for high and medium water use is $800 and $350 per acre, respectively. Using the composite, net loss in value of land is estimated at $584 per acre. The net loss in land value is the cost of water saving from converting irrigated land to dryland farming. This amount is amortized for 25 years at 6 percent interest to assess annualized cost.

The net loss of income from corn to sorghum, corn to cotton, corn to soybeans, sorghum to wheat, soybeans to wheat, and irrigated to dryland farming has been estimated at $102.26, $46.36, $105.50, $20.53, $17.29, and $45.68 per acre/year, respectively. The estimated water savings for these crop type changes are 0.75, 0.92, 0.96, 0.27, 0.06, and 0.98 acre-foot/acre/year, respectively. Hence, the cost of water saved is $136.35, $50.57, $110.09, $76.99, $296.40, and $46.61 per acre-foot/acre/year. These results indicate that conversion of irrigated land to dryland farming is the most economical option in terms of cost of water savings. The second and third economical crop type changes are moving from corn to cotton and sorghum to wheat, respectively. However, both of these alternatives face limited feasibility since cotton may not be able to be successfully grown on corn ground and sorghum and wheat do not compete for the same water with respect to pumping season. Converting soybean acres to wheat results in a negligible quantity of water saved per acre. Hence, it is the most expensive alternative to save water.

5.8.5 Implementing Conservation Tillage Methods

Implementing conservation tillage methods is assumed to save 0.167 acre-ft/acre of groundwater annually. In the initial year of 2000, it is assumed that 50 percent of the acres are utilizing these conservation practices. It is also anticipated that 60 percent of the acres in the years 2010 to 2019 and 70 percent of the acres in the years 2020 to 2050 will be under conservation tillage (Table 5-23).

Table 5-23. Water Savings via Implementation of Conservation Tillage

County	Irrigated Acres[1]	Annual Water Savings (acre-feet)				
		2010	2020	2030	2040	2050
Armstrong	9,476	158	316	316	316	316
Carson	93,010	1,550	3,100	3,100	3,100	3,100
Childress	3,486	58	116	116	116	116
Collingsworth	20,789	346	693	693	693	693
Dallam	284,588	4,743	9,486	9,486	9,486	9,486
Donley	12,543	209	418	418	418	418
Gray	35,041	584	1,168	1,168	1,168	1,168
Hall	15,787	263	526	526	526	526
Hansford	193,117	3,219	6,437	6,437	6,437	6,437
Hartley	139,290	2,322	4,643	4,643	4,643	4,643
Hemphill	4,421	74	147	147	147	147
Hutchinson	28,253	471	942	942	942	942
Lipscomb	24,640	411	821	821	821	821
Moore	171,405	2,857	5,714	5,714	5,714	5,714
Ochiltree	57,459	958	1,915	1,915	1,915	1,915
Oldham	30,182	503	1,006	1,006	1,006	1,006
Potter	28,219	470	941	941	941	941
Randall	46,855	781	1,562	1,562	1,562	1,562
Roberts	8,332	139	278	278	278	278
Sherman	152,205	2,537	5,074	5,074	5,074	5,074
Wheeler	4,340	72	145	145	145	145
Total	1,363,438	22,725	45,448	45,448	45,448	45,448

[1]Irrigated acres were calculated and obtained from Task 2.

It is assumed that the conservation tillage costs 25 percent above the cost of conventional tillage. It is important to note that the cost of conservation tillage relative to conventional tillage is highly variable depending on recurrent weed pressure, conservation practices utilized, and fuel prices. The cost of conservation tillage is assumed to be $6.25 per acre/year. This results in a cost of water saved of $37.43 per acre-foot/acre/year.

5.8.6 Precipitation Enhancement

The remaining water management strategy is precipitation enhancement. It is assumed that there are no acres utilizing precipitation enhancement in the baseline year of 2000. However, it is expected that 100 percent of the acres will be using this technology for the years 2010 to 2050. It is estimated that 2,414,193 acre-feet of water would be conserved for this time period, and these results are presented in Table 5-24.

Table 5-24. Water Savings for 2010-2050 via Precipitation Enhancement

County	Total Irrigated Acres	Annual Water Savings, 100% Acres Converted (acre-feet/year)	Total Water Savings from 2010-2050 (acre-feet)
Armstrong	9,476	790	31,600
Carson	93,010	7,751	310,040
Childress	3,486	291	11,640
Collingsworth	20,789	1,732	69,280
Dallam	284,588	23,716	948,640
Donley	12,543	1,045	41,800
Gray	35,041	2,920	116,800
Hall	15,787	1,316	52,640
Hansford	193,117	16,093	643,720
Hartley	139,290	11,608	464,320
Hemphill	4,421	368	14,720
Hutchinson	28,253	2,354	94,160
Lipscomb	24,640	2,053	82,120
Moore	171,405	14,284	571,360
Ochiltree	57,459	4,788	191,520
Oldham	30,182	2,515	100,600
Potter	28,219	2,352	94,080
Randall	46,855	3,905	156,200
Roberts	8,332	694	27,760
Sherman	152,205	12,684	507,360
Wheeler	4,340	362	14,480
Total	1,363,438	113,621	4,544,800

Precipitation enhancement efforts are being implemented in seven areas of Texas. There are two water districts in the PWPA in the early phases of development. The budget analysis of existing programs indicates an average cost around nine cents per acre, the basis used for this cost analysis. The cost of water saved from this strategy is $1.08 per acre-foot/acre/year.

5.8.7 Economic Value of Transfer of Water to Deficit Counties for Irrigation Use

The transfer of water among counties within PWPG can provide a partial solution in meeting water needs. To determine the economic feasibility of using this water for irrigation, an economic evaluation was conducted. However, an accurate assessment of the value of water or an irrigated producer's ability to pay for the water is very difficult without knowing the producer's specific situation. An individual producer's ability to pay for water depends on the crop grown, well depth, fuel cost, age and type of equipment used, tillage systems employed, market price, soil productivity among other factors. Therefore, this assessment should be viewed as approximate and not definitive.

As part of the economic evaluation, two breakeven water prices were calculated by crop, each with a specific significance. The first breakeven price is the price of water that makes gross receipts equal to out-of-pocket expenditures after adjusting for the best dryland alternative ("variable costs"). At this price a producer is indifferent whether he irrigates or not in a given crop season. The second breakeven price calculated refers to the price a producer could pay for water and cover total cost. Total cost includes all out-of-pocket expenses and the fixed cost associated with depreciation and repairs of farming and irrigation equipment and land costs. Paying above this breakeven over the long term jeopardizes the producer's ability to remain a viable irrigated operation.

Two scenarios were considered in this economic analysis. Scenario 1 assumed five-year average prices and moderate natural gas prices ($2.71 per mcf). Scenario 2 assumed crop prices 10 percent below the five-year average and higher natural gas prices ($4.00 per mcf). The results of these two scenarios are given in Table 5-25.

In Scenario 1, the breakeven price producers could pay for an acre-foot ranged from $97 for soybeans to $277 for peanuts before it became profitable to go to the best dryland alternative. These breakeven prices represent the prices producers could pay to end up with the same return over out-of-pocket expenses (variable costs) as a dryland producer. The relatively large difference between the projected pumping cost ($49) and the breakeven costs suggest little curtailing of pumping would occur.

Table 5-25. Estimated Breakeven Water Prices for Irrigated Crop Producers in the PWPA.

Crop	Scenario 1[a]				Scenario 2[b]			
	Break-even VC Water Price	Estimated VC of water	Break-even TC Water Price	Estimated TC of water	Break-even VC Water Price	Estimated VC of water	Break-even TC Water Price	Estimated TC of water
	$/acre-feet				$/acre-feet			
Peanuts	$277	$49	$168	$98	$217	$64	$101	$113
Cotton	$158	$49	$68	$98	$117	$64	$18	$113
Corn	$156	$49	$115	$98	$127	$64	$82	$113
Wheat	$105	$49	$116	$98	$93	$64	$63	$113
Hay-alfalfa	$198	$49	$131	$98	$154	$64	$102	$113
Soybeans	$97	$49	$69	$98	$82	$64	$48	$113
Sorghum	$116	$49	$126	$98	$97	$64	$44	$113

[a] Scenario 1 assumes 5-year average prices and natural gas price at $2.71/mcf.
[b] Scenario 2 assumes commodity prices 10 percent below 5-year price averages and natural gas price at $4.00/mcf.
VC - variable costs TC - total costs

The second breakeven price calculated in Scenario 1 refers to the maximum an irrigated producer could pay for water to recover total cost. As previously discussed, total cost includes all variable costs and fixed costs associated with replacement of farming equipment, irrigation equipment and land charges. Most of the crops analyzed had a breakeven total cost between $115-$168 per acre-foot. The estimated total cost per acre-foot of $98 for water suggests producers receive between $17 and $70 per acre-foot premium for irrigating over the long-term.

The economic feasibility of importing water for irrigation would need to consider the estimated variable costs of water and the profitability of the crops. For average cost conditions, most irrigated crop producers appear to receive $17-$70 per acre-foot return beyond the cost of irrigating. The out-of-pocket expenses to irrigate are $49 per acre-foot. Of this amount, $31 is attributed to fuel costs and $18 to well and pump costs. Assuming the producer continues to pump from his wells and uses imported water to supplement his irrigation supply, the producer could pay $31 per acre-foot for imported water delivered to the pivot or a maximum of $48-$101 ($31 plus profits) per acre-foot before it would not pay to irrigate. The amount a producer may be willing to pay could increase approximately $18 per acre-foot if the producer totally depends on imported water thus not having the well and pump costs. Therefore, for imported water to be potentially economically feasible for irrigation, the costs would need to be less than $120 per acre-foot delivered.

The second scenario is presented to reflect the impact of lower commodity prices and higher gas prices on the cost of water, similar to what is occurring this year. Again the variable cost breakeven for water is above the estimated variable cost of pumping water ($64) suggesting producers will still irrigate. However, the relative narrow difference in these values suggests that marginally productive acreage may leave production. If the conditions presented in Scenario 2 persisted for an extended period of time, additional irrigated agriculture may also leave production. The breakeven price producers could pay for water to cover total cost ($18 - $102 per acre-foot) was below the estimated cost of water ($113 per acre-foot) for every crop analyzed suggesting the long-term viability of irrigating these crops is questionable under a low priced commodity and high fuel price scenario.

5.8.8 Summary of Irrigation Strategies

The water savings estimated for the different strategies could potentially reduce the irrigation demands in counties with projected irrigation needs. Two different combinations of strategies for irrigation needs are presented in Tables 5-26 and 5-27.

Table 5-26. Water Demand Reductions for Irrigation Strategies with Change in Crop Variety for Years 2020 - 2050 (in acre-feet/year)

County	NP-PET[a]	Short-season corn[b]	Short-season sorghum[c]	LEPA[d]	Tillage[e]	Precip Enhance.[f]	Total Demand Reduction
Armstrong	1,106	120	210	938	316	790	3,480
Carson	10,851	1,520	2,340	13,431	3,100	7,751	38,993
Childress	407	0	47	0	116	291	861
Collingsworth	2,425	75	160	307	693	1,732	5,392
Dallam	33,202	15,700	800	22,131	9,486	23,716	105,035
Donley	1,463	250	140	162	418	1,045	3,478
Gray	4,088	710	510	2,406	1,168	2,920	11,802
Hall	1,842	150	16	0	526	1,316	3,850
Hansford	22,530	4,900	2,180	15,519	6,437	16,093	67,659
Hartley	16,251	8,740	820	709	4,643	11,608	42,771
Hemphill	516	0	21	97	147	368	1,149
Hutchinson	3,296	1,450	420	3,526	942	2,354	11,988
Lipscomb	2,875	220	190	98	821	2,053	6,257
Moore	19,997	8,780	2,200	14,007	5,714	14,284	64,982
Ochiltree	6,704	1,700	1,230	5,045	1,915	4,788	21,382
Oldham	3,521	86	1,050	4,983	1,006	2,515	13,161
Potter	3,292	97	150	4,849	941	2,352	11,681
Randall	5,466	550	1,480	7,710	1,562	3,905	20,673
Roberts	972	210	200	219	278	694	2,573
Sherman	17,757	7,070	2,050	1,798	5,074	12,684	46,433
Wheeler	506	96	91	0	145	362	1,200
Total	159,067	52,424	16,305	97,935	45,448	113,621	484,800

Footnotes: a – From Table 5-7
b – From Table 5-8
c – From Table 5-9
d – From Table 5-14
e – From Table 5-23
f – From Table 5-24

Table 5-27. Water Demand Reductions for Irrigation Strategies with Change in Crop Type for Years 2020 - 2050 (in acre-feet/year)

County	NP-PET[a]	Corn to sorghum[b]	LEPA[c]	Tillage[d]	Precip Enhance.[e]	***Total Demand Reduction***
Armstrong	1,106	390	938	316	790	3,540
Carson	10,851	4,697	13,431	3,100	7,751	39,830
Childress	407	0	0	116	291	814
Collingswort	2,425	275	307	693	1,732	5,432
Dallam	33,202	47,728	22,131	9,486	23,716	136,263
Donley	1,463	844	162	418	1,045	3,932
Gray	4,088	2,130	2,406	1,168	2,920	12,712
Hall	1,842	437	0	526	1,316	4,121
Hansford	22,530	12,756	15,519	6,437	16,093	73,335
Hartley	16,251	27,735	709	4,643	11,608	60,946
Hemphill	516	0	97	147	368	1,128
Hutchinson	3,296	5,621	3,526	942	2,354	15,739
Lipscomb	2,875	715	98	821	2,053	6,562
Moore	19,997	27,628	14,007	5,714	14,284	81,630
Ochiltree	6,704	5,678	5,045	1,915	4,788	24,130
Oldham	3,521	305	4,983	1,006	2,515	12,330
Potter	3,292	339	4,849	941	2,352	11,773
Randall	5,466	1,938	7,710	1,562	3,905	20,581
Roberts	972	587	219	278	694	2,750
Sherman	17,757	23,307	1,798	5,074	12,684	60,620
Wheeler	506	342	0	145	362	1,355
Total	159,067	163,452	97,935	45,448	113,621	579,523

Footnotes: a – From Table 5-7
b – From Table 5-16
c – From Table 5-9
d – From Table 5-23
e – From Table 5-24

As shown in the above tables, the aggregate demand reductions from the different irrigation strategies can significantly reduce the irrigation demands. In the first scenario, the total demand reduction in the Region over the 30-year period is over 14,544,000 acre-feet. In the second scenario the demand reductions over the period are just under 17,385,690 acre-feet.

Assuming the first scenario combination (includes change in crop variety), the revised irrigation demands over the planning period are shown in Table 5-28.

Table 5-28. Revised Irrigation Demands

Revised Irrigation Demands (acre-feet/year)							Total Revised Demands (acre-feet)	Total Original Demands (acre-feet)
County	2000	2010	2020	2030	2040	2050		
Armstrong	6,753	4,381	3,273	3,273	3,273	3,273	242,260	337,650
Carson	93,020	67,322	54,027	54,027	54,027	54,027	3,764,500	4,651,000
Childress	3,819	3,156	2,958	2,958	2,958	2,958	188,070	190,950
Collingsworth	17,811	13,729	12,419	12,419	12,419	12,419	812,160	890,550
Dallam	386,403	314,912	281,368	281,368	281,368	281,368	18,267,870	19,320,150
Donley	17,031	14,456	13,553	13,553	13,553	13,553	856,990	851,550
Gray	22,270	14,033	10,468	10,468	10,468	10,468	781,750	1,113,500
Hall	8,077	5,099	4,227	4,227	4,227	4,227	300,840	403,850
Hansford	121,492	74,787	53,833	53,833	53,833	53,833	4,116,110	6,074,600
Hartley	202,232	171,559	159,461	159,461	159,461	159,461	10,116,350	10,111,600
Hemphill	4,377	3,508	3,228	3,228	3,228	3,228	207,970	218,850
Hutchinson	41,758	33,881	29,770	29,770	29,770	29,770	1,947,190	2,087,900
Lipscomb	35,122	30,351	28,865	28,865	28,865	28,865	1,809,330	1,756,100
Moore	200,579	156,661	135,597	135,597	135,597	135,597	8,996,280	10,028,950
Ochiltree	47,300	32,778	25,918	25,918	25,918	25,918	1,837,500	2,365,000
Oldham	26,497	17,905	13,336	13,336	13,336	13,336	977,460	1,324,850
Potter	24,303	16,581	12,622	12,622	12,622	12,622	913,720	1,215,150
Randall	57,491	44,030	36,818	36,818	36,818	36,818	2,487,930	2,874,550
Roberts	5,755	3,914	3,182	3,182	3,182	3,182	223,970	287,750
Sherman	195,197	161,833	148,764	148,764	148,764	148,764	9,520,860	9,759,850
Wheeler	5,698	4,809	4,498	4,498	4,498	4,498	284,990	284,900
Total	1,038,185	1,038,185	1,038,185	1,038,185	1,038,185	1,038,185	66,844,770	76,149,250

These revised irrigation demands are derived from the reductions outlined in Table 5-26. The total revised demand is the total amount of water needed over the fifty-year planning period to meet the irrigation demands. The total original demands for irrigation from the Ogallala are based on the demands reported in Chapter 2. Oldham, Potter, and Randall Counties have sufficient supplies to meet the reduced demands on a county wide basis. However, localized shortages within the counties may remain. For Dallam and Moore Counties approximately 56 and 75 percent of the total irrigation demands can be met assuming the management strategies are implemented as shown in Table 5-26. With the implementation of these management strategies, supplies in all counties in the PWPG, except for Dallam and Moore, can meet the projected revised irrigation demands through the year 2050.

Additional demand reductions can be realized as irrigated acreage is converted to dryland farming. However, the implementation of each of these strategies will most likely be driven by economics rather than the amount of demand reductions.

5.9 Livestock Needs

Livestock needs were identified for Dallam, Moore, Randall, and Sherman counties. These needs are the result of limited supplies from the Ogallala in these counties and projected growth in concentrated animal feeding operations (CAFOs). The total water demand for livestock use within the region is expected to increase to 96 thousand acre-feet by 2050, and CAFOs are expected to require roughly 82 percent of this total water use by 2050. Stock ponds and/or existing developed groundwater rights in the Ogallala will not be able to meet the projected needs. Livestock producers will need to develop water rights as the livestock demands increase. It may also be economically feasible to import water from nearby counties to individual or clusters of CAFOs (swine, beef, dairy, etc.) to accommodate the projected growth.

5.10 Water Transfers and Water Marketing Companies

Water users who have deficits and are considering alternate strategies for meeting those needs may consider purchasing water from other counties or nearby areas. To facilitate these water transfers, public and/or private water marketing companies will probably be formed. The PWPG recognizes that as it becomes economically feasible, there will be opportunities for public and/or private water marketing companies to transfer water from counties with developable groundwater supplies to counties currently showing deficits or counties outside of the Panhandle Water Planning Region. The economic feasibility of these transfers will depend on the distance the water must be transported and the ability of the water user group consuming the water to pay for the water.

The PWPG received preliminary ideas on several water transfer concepts. None of those transfer concepts were included in this plan because they were not considered as a preferred water management strategy for meeting the needs of any water user in the Panhandle Water Planning Area. The PWPG expects to study and evaluate several water transfer concepts during the next planning cycle.

5.11 Brush Control

In 1985, the Texas State Soil and Water Conservation Board (TSSWCB) conducted a study of the effect of brush control in the Canadian River watershed on surface and ground water availability. Two major categories of brush, mesquite and mixed brush, were identified for the study. The study was conducted on the premise that shifting the vegetation composition from species with high evapotranspiration potential (i.e. trees, brush) to plants with lower evapotranspiration potential (i.e. grass) to increase average water availability. The analysis focused on brush control options and benefits in Hartley, Moore, Oldham, and Potter counties. According to the study, removal of moderate to heavy concentrations of mesquite and mixed brush would increase water availability by an average of 0.067 acre-feet per acre per year. Brush removal treatment would be necessary approximately every twelve years to maintain this level of benefit.

5.12 Socioeconomic Impact of Not Meeting Needs

The socioeconomic impact analysis report, located in Appendix M, has been prepared by the Texas Water Development Board to meet the rules governing Regional Water Planning that require a social and economic impact analysis of not meeting regional water supply needs. The report details what would happen if identified water needs in the region were to go unmet. The report is based on regionally generated data that have been analyzed through the IMPLAN model. The regional data is coupled with state level multipliers to produce the impacts presented.

The Panhandle Water Planning Group would like to note the following points for the reader to consider when reviewing this report:

- The impacts contained in this report represent a worst-case scenario. In order to produce the identified impacts, all identified water needs per user group for the entire region would have to go un-met. The report does not allow the consideration of meeting partial needs per user group.

- The impacts presented are cumulative in nature throughout the 50-year planning horizon. Needs are considered to be un-met in their entirety from the first point identified in the Regional Water Plan and continue to be entirely un-met through the year 2050.

- The methodology employed does not allow for recognition of the fact that, in the Panhandle Water Planning Area, the predominant groundwater supply is a finite resource.

- As noted in the body of the report, the impacts presented in the report do not indicate a prediction or forecast of future water disasters.

- The report assumes that no management strategies to meet any identified needs are employed or implemented.

- No alternatives, as in the case of conversion of irrigated land to dryland, are considered.

6.0 REGULATORY, ADMINISTRATIVE OR LEGISLATIVE RECOMMENDATIONS

As the Panhandle Water Planning Group (PWPG) has proceeded through the preparation of the regional water supply plan, several items have been identified which the PWPG recommends be considered before the next planning cycle. Title 31 of the Texas Administrative Code (TAC) §357.7(a)(9) states that the Senate Bill One sponsored regional water plans will include: "regulatory, administrative, or legislative recommendations that the regional water planning group believes are needed and desirable to: facilitate the orderly development, management, and conservation of water resources and preparation for and response to drought conditions in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of the state and regional water planning area." Following is a list of recommendations for the TWDB to consider.

6.1 REGULATORY ISSUES

- *TWDB should evaluate the notification requirements for amending the regional water supply plan.* The current TWDB rules require the same notification process for amending a regional water supply plan as the original adoption of the plan. This is a burdensome requirement which discourages entities from requesting amendments. The notification requirements to amend a plan should be revised to provide for notices being posted only in the county(ies) where affected entities are located and rather than a 30-day notification period, have a 15-day notification period at the discretion of the RWPG's discretion. The process for TWDB approval of the amendments should also be modified.
- *Evaluate the rules governing reuse of wastewater effluent.* The current regulatory environment provides a number of barriers to encouraging the reuse of wastewater effluent. TNRCC should re-evaluate the current rules and change the rules to provide more incentives for municipalities, industries and agriculture to reuse wastewater effluent.
- *TNRCC should encourage utilities to monitor unaccounted for water losses.* There is no current regulatory guidance to provide incentives for utilities to monitor un-accounted for water losses. TNRCC should review its current rules and evaluate ways to provide encouragement for utilities to more closely monitor and reduce un-accounted for water losses.
- *TWDB should evaluate the definition of major water provider.* The current definition of major water provider is "an entity which delivers and sells a significant amount of raw or treated water for municipal and/or manufacturing use on a wholesale and/or retail basis." This definition is limiting and does not provide for protection or incentives for agricultural and agri-business related interests.
- *TWDB should evaluate the development of irrigation demands.* The current irrigation demand projections have been developed assuming 50 years of below normal rainfall. The PWPG believes that the development of irrigation demand numbers should be performed individually by each planning region.

- *TWDB/TNRCC should evaluate the issue of groundwater rights vs. surface water rights.* The current rules and planning guidelines do not differentiate between handling surface water rights and groundwater rights. A surface water right is a renewable right that can be anticipated to be available every year. A groundwater right may not be necessarily available every year, especially in the case of the Ogallalla aquifer which has limited effective annual recharge.
- TWDB should submit plans for and results of reservoir feasibility studies to the appropriate Compact Commission (Red River or Canadian River Compact Commission) for review.

6.2 LEGISLATIVE ISSUES

- *Interim funding for regional water planning.* The PWPG recommends that the state of Texas provide interim funding for the regional water planning process to continue between 5-year planning cycles. The funds are needed for administration, maintenance and amendment of the regional water supply plan and the RWPG.
- *State-sponsored water availability modeling.* It is recommended that the state of Texas give high priority to funding water availability modeling projects, including the water availability modeling projects sponsored under Senate Bill One and the ground water availability projects sponsored by TWDB. This information is vital to the preparation of regional water plans. Particular emphasis should be placed upon areas where regional water plans have identified new surface water projects or new well fields. This information is particularly important in the evaluation of the minor aquifers in the Panhandle. There was extremely limited information available regarding supplies which are anticipated to be available from the Dockum, Rita Blanca, Blaine and Whitehorse aquifers.
- *Data on agricultural water use.* It is recommended that the State sponsor information gathering programs that accurately measure number of irrigated acres, types of crops, and water used for irrigated agriculture, as well as water used for livestock production. Current information on water use by agriculture may not be sufficiently accurate for water planning.
- *Funding for implementation of water supply strategies.* Many water supply strategies, particularly those associated with brush control, water conservation and irrigated agriculture, have limited means of implementation other than public outreach and education. It is recommended that the State sponsor programs to help implement these strategies and that the funding provided be specific to a region.
- *Create Groundwater Districts to manage groundwater resources through local districts across the state.* There remain certain areas of the Panhandle Water Planning Area, as well as other parts of the state, that are not within the boundaries of a groundwater district. This creates an unequal situation with regard to groundwater management.
- *Create a water conservation reserve program for irrigated acreage management.* A water conservation reserve program should be created to make it economically feasible for farmers to convert irrigated acreage to dryland.
- *Provide funding for utilities to replace/repair aging infrastructure.* There is currently not a good source for utilities to obtain funds to upgrade/replace aging infrastructure (esp. distribution lines) which contribute to unaccounted for water losses.
- *Provide funding for expansion of the NP-PET network and integration into a statewide network* . The State should provide funding to allow enhancement, expansion and/or cost

sharing of operating costs of the NP-PET network and its integration into a statewide network. This would enable more farms to use the information provided by the network to schedule irrigations, thus using the water more efficiently.

- *Evaluate legislative barriers to using playa lakes.* The State should evaluate the current legislative barriers to using playa lakes. The barriers should be removed or reduced to allow using the playas for aquifer recharge or other beneficial water supply purposes.
- *Provide funding for conducting feasibility studies for the Sweetwater Creek Reservoir project.*
- *Evaluate and clarify authority for reasonable and equitable export fees for groundwater districts.*
- *The PWPG requests that the Legislature requires coordination between Regional Water Planning Groups and State agencies regarding the development of the GAM and WAM models to ensure that the two models are not developed independently of or counter to each other.*

6.3 RECOMMENDATIONS FOR FUTURE STATE WATER PLANS

- *TWDB should establish clear guidelines for eligibility for funding and needs assessment for very small cities and unincorporated areas.* As it currently stands, it is unclear as to how to address potential needs for very small municipalities or water supply systems (profit/non-profit). Present rules have these various water supply systems included in the county-other section of the various planning tasks. In many cases, these water supply systems may exhibit a need at some point in the planning horizon that is not documented in county-other due to the nature of using county-wide availability numbers for groundwater. Clarification or statements to the effect that those "entities which fall under the planning limits retain eligibility for state funding assistance for water-related projects without having specific individual needs identified in the appropriate Regional Water Plan" would greatly enhance the ability of these small systems to provide their users with a safe and adequate supply of water.
- *TNRCC should be made at least an ex-officio member of the RWPGs to provide input on known water quality/quantity problems.*
- *Clarification of the significance of designating unique reservoir sites and stream segments.* It is recommended that the purpose of designating a unique stream segment or reservoir site be defined before the next planning cycle. It is unclear what the implications are of such a designation.
- *Allow development of alternative near-term scenarios.* Current planning rules require a single scenario be developed for meeting near-term needs. Since future permits must be consistent with the regional plan, a single State-approved scenario may hamper the ability of a community to make its own choice among viable sources of additional water supply.
- *Alternative definitions of the reliable supply from a reservoir.* The current water plan requires the use of firm yield as the definition of water availability in a reservoir. It is recommended that in future water plans the definition of supply from a reservoir match the owner's operational criteria or definition of supply. For example, a reservoir that is used for steam-electric power generation must maintain a minimum pool level in order to effectively dissipate heat. Another example is the case where the water rights of a reservoir are less than

the firm yield of the reservoir. In addition, many owners of reservoirs prefer to use the more conservative safe yield as the definition of reliable supply from their reservoirs to allow for more severe droughts than those experienced in the past.

- *Include reservoir sites in future water plans.* The PWPG proposes that the TWDB continue to include potentially feasible surface water supply projects in the Panhandle Water Planning Area, including, but not limited to, the potential Sweetwater Creek Reservoir site and the potential Lelia Lake Creek reservoir site. In addition, proposed flood control/aquifer recharge structures in the Red Deer Creek watershed should be included in future state water plans (PWPG Resolutions passed on February 29, 2000 and March 27, 2000).

- *Separate water conservation from demand projections so conservation can be evaluated as a strategy.* Water conservation should be the number one strategy in any water supply plan. However, in the current planning cycle water conservation was automatically included in the demand projections as a demand reduction. This makes it very difficult to evaluate demand reduction strategies, since it is not clear what elements were included in the present demand projections. It has also been confusing for the RWPG members and members of the public who are involved in the planning process. Many believe that we are not addressing water conservation because they are not aware that it has been included in the projections. It is recommended that in future plans water conservation be explicitly addressed as a strategy.

- *Clarification of relationship between drought contingency planning and regional water supply planning.* Historically drought contingency planning has not been part of regional water supply planning. It is not clear what role drought contingency planning has in the regional planning process. Also, since one of the goals of drought contingency planning is demand reduction, it is particularly difficult to analyze conservation strategies because conservation is already included in the demand projections.

- *Simplification of required tables and better guidance for populating the tables.* The required tables outlined in Exhibit B of the TWDB regional contracts were not available at the time that scopes and budgets were developed for the regional plans. Guidance for these tables did not appear until well into the planning process and, when it was available, the guidance did not sufficiently define what information was required in the tables. The tables require considerable effort to populate and are not an effective tool for the planning process. It is recommended that (a) the tables be simplified, (b) the guidance for these tables be clarified and (c) the TWDB provide draft versions of these tables for future water supply plans. In addition, some of the data required to be included in the tables are not particularly applicable to groundwater usage (data to be divided by county and surface water basin) and planning for agricultural water demands. TWDB should review the information required by each region and make adjustments to the tables to facilitate the planning process for each region.

- *Allow complete access to TWDB and TNRCC database files by consultants.* Although the State did an excellent job assembling information for the regional plans in a short period of time, there remained a large amount of information that was not readily accessible by the consultants, including databases of historical water use by water right, historical return flows, and complete TWDB water survey information. It is recommended that a method be developed that allows complete access to these databases by contracted consultants in future water plans.

- *Include an economic impact analysis for the result of implementing water management strategies.* The current planning rules provide for an economic analysis of not meeting water demands. However, there is no provision for economic analysis of implementing a water management strategy. The analysis should include impacts on water suppliers, users and major economic sectors. For example, if irrigated acreage is converted to dryland production, there is no provision for developing an economic impact of implementing that water management strategy. A municipal example would be the effects of water/sewer rates charged to each homeowner if a water management strategy is developed to provide for projected future needs.

- *Salinity control projects for the Canadian River and/or Red River Basin.* Although there have been salinity control projects recently implemented in the Canadian and Red River Basins, future State Water Plans should continue to plan for future salinity control projects and their funding to continue to improve water quality in the basins.
- *Water quality should play a more important role in future planning efforts.* Although there are some provisions for assessing water quality and its impact on available water quantity, the planning process makes it difficult to assess the use of water for a specific water use category. For example, although the firm yield of a surface water supply source is to be used for determining the available supply, that water source may not be suitable for all uses without significant treatment. Additionally, localized groundwater contamination may have an equally detrimental impact on the available supply of groundwater for drinking water without significant treatment.
- *Interbasin/Intrabasin water transfers.* Future state water plans should provide for a detailed assessment of the potential for transporting water into the Panhandle Water Planning Area from outside regions as well as the potential for transferring groundwater from counties within the region with potentially developable supplies to counties which are showing significant deficits.
- *Brush control.* TWDB guidance is needed on how to account for brush control projects in the context of a source of "new surface water" for municipal, industrial, agricultural, and other uses. The Canadian River watershed has more than 50% cover of mixed brush species that are amenable to control for rangeland improvement and water enhancement purposes. A brush control feasibility study is being prepared using funding by the 1999 Legislative Session, pursuant to SB 1083 enacted in 1985. Estimated water yields on subbasins in the Canadian River watershed upstream of Lake Meredith are being determined as a function of brush control practices appropriate to brush species and canopy densities. Estimated costs of brush control/management practices will be developed, together with a proposed cost share allocation between landowners and the state, or perhaps other public entities. The recommendations of this feasibility study and results in other watersheds should be taken into account in preparing future water plans.

7.0 Plan Adoption and Public Participation

The first purpose of this chapter is to describe the various public participation, information, outreach, and education activities conducted by the Panhandle Water Planning Group (PWPG). All activities and events discussed in this section were performed in direct support of the Regional Water Planning Effort and serve to support the PWPG's dedication and commitment to ensuring that the public is provided with timely, accurate information regarding the planning process and that opportunities to provide input to the planning process are available as often as possible.

The second purpose of this chapter is to detail the plan adoption process followed by the PWPG. The process explains the required hearing, receipt of comment, comment response, and final adoption of the Panhandle Water Planning Area's Regional Water Plan.

7.1 Panhandle Water Planning Group

The Panhandle Water Planning Group was created in accordance with and operates under the auspices of Senate Bill 1 (1997). The enabling legislation and subsequent Texas Water Development Board planning rules and guidelines established the basis for the creation and composition of the regional planning groups. The original statute listed eleven required interest groups that must be represented at all times on the planning groups. To these original eleven interest groups, the PWPG has elected to add an additional group to adequately ensure that the interests of the region are fully protected. The following lists the twelve interest groups represented by the twenty-two voting members of the PWPG:

- General Public
- Counties
- Municipalities
- Industrial
- Agricultural
- Environmental
- Small Business
- Electric Generating Utilities
- River Authorities
- Water Districts
- Water Utilities
- Higher Education (added interest group)

Table 7-1 lists the voting members of the Panhandle Water Planning Group, their respective interest groups, and their principle county of interest. Table 7-2 lists the three former members of the Panhandle Water Planning Group who also participated in the planning process. The PWPG appreciates the contributions of these individuals and would like for their efforts to be recognized along with the current members.

Table 7-1. Panhandle Water Planning Group - Voting Members

PWPG Member	Interest Group	County of Interest
Therese Abraham	General Public	Hemphill
Vernon Cook	Counties	Roberts
Dan Coffey	Municipalities	Potter/Randall
David Landis	Municipalities	Ochiltree

Table 7-1. Panhandle Water Planning Group – Voting Members (cont.)

Bill Hallerberg	Industrial	Gray
Mike Page	Industrial	Hutchinson
Frank Simms	Agricultural	Carson
Rudie Tate	Agricultural	Collingsworth
Janet Tregellas	Agricultural	Lipscomb
B.A. Donelson	Agricultural	Sherman
Dr. Nolan Clark	Environmental	Potter/Randall
Grady Skaggs	Environmental	Oldham
Inge Brady	Environmental	Potter/Randall
Rusty Gilmore	Small Business	Dallam
Gale Henslee	Electric Generating Utility	Region
Jim Derington	River Authorities	Hansford
Richard Bowers	Water Districts	Moore
C.E. Williams	Water Districts	Carson
John Williams	Water Districts	Hutchinson
Bobbie Kidd	Water Districts	Donley
Charles Cooke	Water Utilities	Hutchinson
Dr. John Sweeten	Higher Education	Region

Table 7-2. Panhandle Water Planning Group - Former Members

PWPG Member	Interest Group	County of Interest
Robert Jacobson	Environmental	Oldham
Trish Neusch	Environmental	Potter
Michael Nelson	Industrial	Hutchinson

In addition to the 22 voting members, the PWPG has four ex-officio positions in accordance with the appropriate regulations governing the process and one additional ex-officio position established to ensure appropriate representation of regional interests. Table 7-3 lists the five ex-officio positions on the Panhandle Water Planning Group and their respective interests:

Table 7-3. Panhandle Water Planning Group Ex-Officio Positions

PWPG Member	Ex-Officio Position	Interest Group
Stefan Schuster	Texas Water Development Board	TWDB (Rules)
Ronald Bertrand	Texas Department of Agriculture	TDA (Rules)
Bobbie Kidd (Voting Member)	Region B Liaison	Water Districts
Kent Satterwhite	Region O Liaison & 357.4G4	Water Districts
Mickey Black	USDA/NRCS	Agricultural
Charles Munger	Texas Parks and Wildlife Department	TPWD (Rules)

7.1.1 Panhandle Water Planning Group Public Information and Education Commitment

The Panhandle Water Planning Group (PWPG) is firmly committed to ensuring the activities of the Planning Group are open and accessible to all interested parties. In addition, the PWPG has worked diligently to ensure that the public throughout the region is afforded every opportunity to participate in Planning Group activities and to receive timely information regarding the planning process. These efforts are spearheaded by the Public Participation Committee chaired by Judge Vernon Cook, Roberts County. Committee members are Charles Cooke, Janet Tregellas, Dr. John Sweeten, Kent Satterwhite, B.A. Donelson, Bill Hallerberg, Danelle Barber, B.A. Donelson and Trish Neusch (Inge Brady). Participation in the Regional Water Planning Effort by local entities and the public was excellent throughout the process.

Public Participation opportunities were afforded to the region through the following broad categories. The Committee targeted efforts towards public involvement in the following broad categories:

- Special Regional Water Planning Presentations – Working primarily through the Panhandle Regional Planning Commission, the PWPG provided speakers to over 70 interest groups throughout the planning process. Presentations were given throughout the region and no invitations to speak were declined.

- Media – Media throughout the region were provided notification of all Planning Group activities. Participation by the media was excellent throughout the process, with Planning Group representatives appearing on more than 15 media events as well as routine press in all regional newspapers. In addition, regional radio stations provided public service announcements of relevant events.

- Electronic Communication – Web Access to Planning Information - The Panhandle Water Planning Group has developed and placed on-line a dedicated project website. The site, www.panhandlewater.org, has been available to the public 24 hours a day since June of 1999. The site is updated on a regular basis and provides the general public with quick, reliable access to planning data at any time.

- Public Information Meetings – The PWPG held four targeted public information meetings at key points in the plan development process. Two of these public meetings featured the use of an interactive video-teleconferencing system that allowed interested parties to participate from their choice of four locations. The remaining two public information meetings were held at different locations in the region to maximize participation. These two meetings featured the same material in order to maximize the dissemination of relevant information.

- Workshops & Surveys – The PWPG has provided technical expertise to several workshops during the planning process. Included among these are Drought Contingency Workshops and Municipal Water Planning workshops.

- Required Public Hearings – Two formal hearings were conducted during the planning process. The first hearing was held in June of 1998 to present the proposed Scope of Work to the region and the second was held in September of 2000 to present the Initially Prepared Plan to the Region.

- Panhandle Water Planning Group Meetings – The Panhandle Water Planning Group conducted 21 meetings. While most meetings were held in Amarillo at the offices of the Panhandle Regional Planning Commission, meetings were also conducted in Bushland, White Deer, and Dumas. Sub-groups of the PWPG met 57 times throughout the planning process. All meetings of the PWPG are conducted as open meetings and public attendance has been as high as 60 plus people at one time.

7.2 Public Participation Activities

Specific details on public participation activities conducted during the Regional Water Planning Process are summarized and detailed in this section. Appendix Q contains a detailed listing and graphical representation of the various public participation activities discussed below.

7.2.1 Special Regional Water Planning Presentations

Special Regional Water Planning Presentations - The PWPG, through the direction and oversight of the Public Participation Committee, delivered 76 presentations to various interest groups throughout the region. The scope and content of these presentations was tailored specifically to each unique interest group. In order to accurately document that special presentations are reaching the appropriate interests, all presentations were tracked by category to ensure that the public outreach activities being conducted are achieving maximum effectiveness. To this end, special presentations have been broken down and analyzed in the following specific categories: Civic Groups; Special Interest Groups; Agricultural Groups; and Government Entities.

A. Civic Groups: This category is comprised of traditional civic clubs, organizations, and other similar entities. Organizations of this nature provide an excellent vehicle to reach a broad segment of the general public in each particular location. Examples of organizations in this category include Rotary Clubs, Lions Clubs, Kiwanis Clubs, and Chambers of Commerce. An interesting accomplishment under this category for the PWPG included being a feature presentation at three Chamber Outreach Tours sponsored by the Amarillo Chamber of Commerce. These Outreach tours are unique in that each tour involves representatives from not only the Amarillo Chamber, but also two other Chambers throughout the region. Cities directly reached through these Outreach tours included Shamrock, Wellington, Perryton, Borger, Stratford, and Guymon, Oklahoma. Attendance at these events was approximately 30 per location for the local chambers and approximately 20 for the Amarillo Chamber. Total individuals reached through these three events equals approximately 240. Total number of presentations in this category was 21.

B. Special Interest Groups: This category is comprised of those organizations with a broader reach or constituency than typically found in a traditional civic group. Many groups in this category are regional or semi-regional in nature and include organizations that deal with large-scale issues. Examples of organizations in this category include: Panhandle Conference of Mayors (2), TAES/TAEX Community Futures Forum (7), North Rolling Plains and High Plains RC&D Councils, Texas Municipal League Quarterly Meetings (Region I), Panhandle City Management Association (TCMA Chapter), and the Panhandle County Judges & Commissioners Annual Meeting (2). 23 presentations were given to organizations in this category.

C. Agricultural Groups: The largest single water user group in the Panhandle Water Planning Area is the Agricultural sector, which accounts for approximately 89% of all water used. The PWPG felt that outreach to this segment was vital to ensure that the plan adequately addressed all issues and protected all interests. In order to reach the agricultural sector, the PWPG targeted ag-specific groups for special presentations. Entities and organizations reached through this targeted effort included: County Extension services, Farm Bureau local and regional meetings, Texas and Southwestern Cattle Raisers Association, Texas Cattle Feeders Association, Panhandle Farm Management Symposium (Amarillo Farm Show), County Agriculture Days, as well as other events, such as the Cooperative Research Education and Extension Triangle (CREET) Ag-Day at Bushland. Agricultural groups were provided with 24 specific, regional water planning presentations throughout the planning process. In addition, regional water planning was covered at many other agriculturally related events during the process, including TAEX Field Days, House Agricultural Subcommittee tours, etc. Overall, more presentations were provided to this segment of the region than to any other.

D. Government Entities: As a key focus of Senate Bill 1 was on municipal water use, the PWPG also undertook an effort to reach those entities with specific responsibility to provide water for municipal use. Examples of governmental entities receiving presentations on regional water planning include: various city councils, county commissioners courts, and river authorities governing boards. 8 presentations were given to various government entities.

7.2.2 Media Events and Coverage

Media Events: The PWPG made a commitment early in the planning process to enlist the support and interest of the local media. Overall, this effort was a great success and yielded several excellent coverage items for the water planning process. The detail below summarizes several of the many media events undertaken by the PWPG. The PWPG would like to specifically thank the many local media outlets which provided excellent assistance and coverage of this effort.

A. Television Features: PWPG representatives were fortunate to appear on two special television feature shows on water planning. In November of 1998, the local ABC affiliate, KVII-TV, featured the PWPG on a local current issues show, *Impact*. This 30-minute feature provided an excellent coverage boost to the regional water planning process.

B. In July of 2000, the local public access television station, KACV, produced a 30 minute feature which again highlighted regional water planning and initial results. This show was quite successful and was aired multiple times throughout the region.

C. Television Coverage of Events/Interviews: All local television stations in the region have provided event coverage for the PWPG. All public information meetings, hearings, and several Planning Group meetings have been covered. KAMR, KVII, and KFDA (NBC, ABC, and CBS) are all to be thanked for their coverage of the planning process. In addition to coverage by local television, the state-wide news show, *News of Texas*, also produced an interview with PWPG representatives.

D. Radio Coverage: Radio coverage of PWPG activities has been excellent. Several stations throughout the region have provided event notification, including KGNC, KEYE, and KGRO. KGNC-AM has also produced several call-in shows and feature interviews throughout the process.

E. Newspaper Coverage: Regional newspapers have been a great assistance to the PWPG in providing notice and coverage of events. In addition, the largest regional circulation newspaper has provided editorials, feature reports, and a week-long series on water issues in the region. Smaller newspapers throughout the region have also provided articles, publication notices, and features on water planning.

7.2.3 Electronic Outreach

Electronic Communications: The Panhandle Water Planning Group recognizes the importance of electronic communications as a means to keep the public informed and provided with regional planning documents. Accordingly, the PWPG included the development and maintenance of a project website as a public participation goal. The website was developed and placed online in June of 1999 and has been in operation continuously since that time. The website has proved to be an excellent communications tool and has been updated an average of at least twice per month since its inception. Information contained on the website includes general descriptions of Senate Bill 1, listings of all PWPG members, regional water demand and projections information, an on-going calendar of events, and a large download section. The download section contains meeting minutes, regional maps, aquifer maps, public presentations, and the entire Initially Prepared Plan, including references, appendices, and the Executive Summary. The website contains links to numerous water-related entities and has produced responses from as far away as Canada. The PWPG's project website is located at www.panhandlewater.org.

In addition to the project website, the PWPG has also taken advantage of other electronic communication options to assist in keeping the public involved in the regional planning process. Several public information meetings have been conducted throughout the region using a video-teleconference network known as the Panhandle Information Network (PIN). The PWPG has used this network for three separate public information events, and has thus been able to conduct meetings at up to four remote locations simultaneously. Additional detail on the use of this innovative technology will be discussed further under the section on Public Information Meetings.

7.2.4 Formal Public Information Meetings

Public Information Meetings: The PWPG has conducted periodic public information meetings throughout the planning process. These meetings have been conducted at key milestones in the process and were designed to keep the region informed and to solicit input at important junctures in the plan. Two main methodologies were employed to reach the public. First, the PIN network was used to reach as many people as possible while minimizing travel time for individuals desiring to participate. Second, the PWPG conducted two public information meetings at different locations in the region. Under this scenario, the same meeting was conducted twice, once at each of two bcations. For the purposes of this section, the Public Hearing conducted during the Scope of Work process is also included.

A. Scope of Work Hearing: The PWPG conducted its required Public Hearing on the proposed Scope of Work on June 30, 1998. The Hearing was the first one conducted using the PIN network, and was held simultaneously in Amarillo (main location), Clarendon, Dalhart, and Canadian. Total attendance at the Hearing was 78 individuals, including members of the Panhandle Legislative Delegation. The success of this hearing, plus the benefit of allowing members of the public from remote areas to participate without having to travel extensive distances, provided further encouragement to the PWPG to continue use of the PIN network.

B. Public Information Meeting: The first Public Information Meeting conducted to relay information regarding Regional Water Plan milestones was conducted by the PWPG on June 15, 1999. Again, the PWPG took advantage of the video teleconference facilities of the PIN Network. The topic of this meeting was to present the public with information relating to Tasks 1 and 2 and to solicit input. The meeting was conducted using sites in Amarillo, Spearman, Dalhart, and Clarendon. Total attendance at this meeting was approximately 36.

C. Public Information Meetings: For the next set of Public Information Meetings, the PWPG elected to conduct two meetings at remote sites in the region. The purpose of these meetings was to relay the results of tasks 3, and 4. The meetings were conducted in Dumas and Pampa, with both locations receiving the same presentation. Total attendance between the two meetings was approximately 50.

D. Public Information Meeting: The final formal public information meeting was conducted on July 27, 2000. Once again, the PWPG opted to use the facilities offered by the PIN network in order to reach the maximum audience with the minimum inconvenience to the public. The purpose of this meeting was to present the results of Tasks 5 and 6 to the public and to solicit input. The meetings were conducted in Amarillo, Stratford, Childress, and Canadian. Total attendance from the four locations was 68.

7.2.5 Workshops and Surveys

Workshops and Surveys: In addition to the activities described above, the PWPG also undertook a series of surveys to assist local entities in participating in the planning process and also to relay relevant information to various professional groups through workshops.

A. Surveys: Throughout the planning process, the PWPG conducted three surveys. The first, conducted during the preparation of Task 2, was designed to present to local water user groups with a summary of their projected populations and water use demands. Surveys were prepared for each identified municipal water user group in the region and were hand-delivered to each individual user. The information obtained during this process was used to either validate pre-existing population and water demand data or to provide a reference to use in requesting revisions to individual municipal numbers where appropriate.

The second survey conducted by the PWPG was during the process of preparing Task 4. The purpose of this survey was to solicit water rights data from the various municipal water use groups in the region. Information obtained from this survey was used to provide accurate data for inclusion in Tasks 3 and 4.

The third survey conducted by the PWPG was targeted towards discussing water management strategies with those municipal water use groups which showed a potential need at some point in the planning horizon. The purpose of this survey was to provide all municipal use groups an opportunity to review and accept or modify the strategies proposed to meet future water needs.

B. Workshops: The PWPG participated in workshops throughout the planning process. Planning Group representatives participated in two drought contingency planning workshops hosted by the TNRCC in the region. Information regarding Task 2 was presented to those in attendance at the first meeting and information on total water use and available supply was presented at the second TNRCC workshop. Other workshops attended included a session with a local chapter of the AWWA and information on participation and implications of regional water planning was presented to those in attendance.

7.3 Panhandle Water Planning Group Functions

Members of the PWPG have been quite active and very committed to the planning process. Through the course of the 79 functions detailed below, Planning Group members have contributed approximately 3,600 non-reimbursed hours of time. In addition, PWPG members have traveled over 75,000 miles. This level of participation by these Planning Group members speaks very highly of not only the commitment of the people of the region to the water planning process but also to the intense effort and dedication being dedicated to the process. As mentioned previously, the PWPG has not reimbursed any members for the time they have committed to the process and only a very small amount (less than approximately 2,500) of the miles traveled have been reimbursed through use of local funds. This fact becomes quite important when the membership of the PWPG is analyzed. Of the 27 members, three are from either state or federal agencies and seven represent entities whose primary responsibilities are water resources. Three members represent entities who provide end-user water. The remaining 14 members do not hold employment with organizations who traditionally provide water to end-users or who are normally involved in water resource management or planning. Appendix R details the 79 functions conducted by the PWPG or their committees while Appendix S details the commitment in terms of hours and miles traveled of the PWPG members.

7.3.1 Panhandle Water Planning Group Meetings

Through the 34 month planning process, the PWPG has conducted 21 formal, Planning Group meetings. Attendance at the meetings by the 27 member Panhandle Water Planning Group has been excellent, with appropriate quorums in attendance at all meetings. PWPG meetings have been conducted in White Deer, Dumas, Amarillo, and Bushland, with the majority of the meetings being held in the office of the political subdivision, the Panhandle Regional Planning Commission. Frequency of PWPG meetings has averaged one per 1.6 months.

7.3.2 Panhandle Water Planning Group Committee Activities

To further enhance the regional planning process, the PWPG has established a committee structure to assist in evaluating planning progress and to provide recommendations to the PWPG. The committees, as authorized, serve only in an advisory capacity. In addition, committee membership includes, where appropriate, PWPG members as well as non-members.

The PWPG has authorized five active and three standing but non-active committees. The active committees are composed of the Executive Committee, Public Participation Committee, Municipal and Industrial Demands & Projections Committee, Agricultural Demands & Projections Committee, and Groundwater Model Committee. The three additional standing committees are the Consultant Selection Committee, Scope of Work Committee, and Contact Committee (local funding). The committee structure as described has been very effective in assisting the Regional Planning Process. Throughout the process, 58 committee meetings have been held, for a frequency of approximately two per month.

Appendix T contains a full listing of the PWPG committees and their membership.

7.4 Plan Adoption Process

Plan Adoption: In accordance with Senate Bill 1 and the relevant rules governing the water planning process, the PWPG conducted a formal process for the adoption of the Regional Water Plan. Activities under this section are primarily along two main lines. The first series of activities are directly related to the adoption of the Initially Prepared Plan and the second series of activities are related to final adoption of the completed Regional Water Plan.

7.4.1 Public Hearing

Required Public Hearing: The PWPG conducted its required public hearing on September 19, 2000. The Hearing was held at the Texas A&M Research and Extension facility in Amarillo, Texas. All required notifications for the hearing were posted prior to the 30-day cut-off. Over 650 direct mail notices were sent to interested parties, interest groups, agencies, individuals, water rights holders, etc. Copies of the Initially Prepared Regional Plan were placed in the County Clerks office of each of the 21 counties in the region and were also placed in public libraries or alternate locations in each of the 21 counties. In addition, full posting requirements regarding Secretary of State, County Clerk, and all interested parties were conducted.

Attendance at the Hearing totaled 154 individuals. Oral comments were received at the hearing and written comments were received through Friday, September 22.

7.4.2 Initially Prepared Plan Adoption

IPP Adoption: The PWPG conducted a formal Planning Group meeting immediately following the Public Hearing on September 19, 2000. 25 of the 27 Planning Group members were in attendance and the IPP was given unanimous approval for submission to the Texas Water Development Board.

7.4.3 Response to Comments

Response to Comments: Overall, the PWPG received 37 comments regarding the IPP. Thirteen oral comments were received at the public hearing and 24 written comments were subsequently submitted. Comments were broken out on a line-item basis and distributed to the PWPG. Specific members were assigned the task of addressing particular comments, and all comments and proposed responses were returned to the entire Planning Group. The PWPG carefully considered the comments and proposed responses at two meetings, resulting in the adoption of formal responses to all comments received. Overall, comments received from the public were generally favorable, and many covered items already addressed in relevant sections of the IPP. In addition to the comments from the public, the PWPG also addressed comments provided by the TWDB on the various plan components submitted previously as well as the IPP submission.

Comment responses were handled by the entire Planning Group, and approved comments are included in the Regional Water Plan. A summation of the comments received and the approved responses is included in Appendix U.

7.4.4 Final Regional Water Plan Adoption

The PWPG adopted the final Regional Water Plan for the Panhandle Water Planning Area on December 12, 2000 and approved the same for submission to the TWDB. The Plan was adopted by a unanimous vote.

7.5 Local Participation in the Regional Water Planning Process

Participation by local entities in the Regional Water Planning process was quite commendable. After the revisions to the funding rules that resulted in the 100/100 rule, the PWPG was faced with attempting to secure funds from local entities and organizations to fund the non-state funded planning elements. Local funds were necessary to provide for the maintenance and operation of the PWPG, fiscal accountability, meeting costs, posting costs, etc. The PWPG estimated that $125,000 in local funds would be needed to cover these costs. Working through the contact committee, a formula was devised to attempt to spread these costs equally throughout the region. Possible participants were divided into the following categories: municipalities, counties, water utilities, groundwater districts, surface water districts, and solicited contributions. Entities and organizations in each of these categories were contacted by mail requesting their pro-rata share of the local planning cost. Solicitations were made once, and these various entities and organizations provided over $115,000 of the needed $125,000. This equates to over a 92% success rate in raising the needed funds. Once again, the PWPG believes this is a strong indicator of the commitment to water resource planning throughout the region.

The PWPG would like to thank and recognize all those entities and organizations who contributed funds to the Regional Water Planning Effort.

In addition to the local funds received, the PWPG adopted a policy whereby all local water use groups are considered to have participated in the Regional Water Plan by virtue of their inclusion in the Plan.

Appendix V contains a full listing of 110 entities and organizations who voluntarily contributed to the Regional Planning Process.

7.6 Conclusion

The Panhandle Water Planning Group has maintained a high level of commitment to public participation throughout the planning process. Overall, more than 177 opportunities for public participation were provided to residents of the region. In addition, numerous television, radio, and print media opportunities were available as well as the on-going efforts of the project website. The PWPG believes that public information and participation activities are at least as important to the success of regional planning initiatives as is the data accumulated and analyzed. A key recommendation of the PWPG is to continue to fund and encourage public information activities throughout all subsequent planning processes.

Appendix Q
Public Participation Activities
Chart
Detailed Listing

Appendix R
PWPG Functions
Chart
Detailed Listing

Appendix S
Panhandle Water Planning Group
Summary of Hours and Travel

Appendix X
Sample Website Page