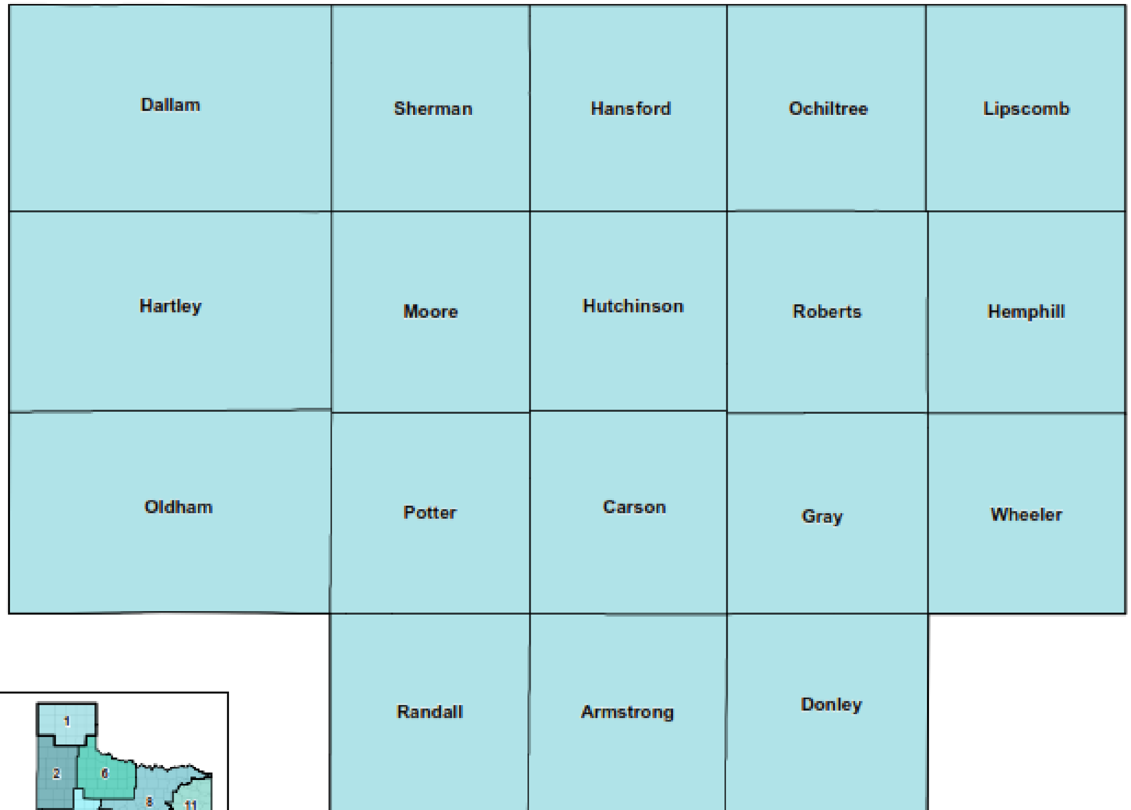

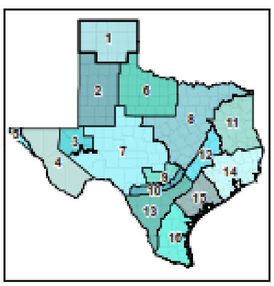

Groundwater Management Area
#1

DESIRED FUTURE CONDITIONS EXPLANATORY REPORT

DECEMBER 12, 2016

PREPARED BY GROUNDWATER MANAGEMENT AREA 1

WITH ASSISTANCE FROM:
INTERA INC.
PANHANDLE REGIONAL PLANNING COMMISSION
STEVEN D. WALTHOUR, PG - NORTH PLAINS GCD.

DESIRED FUTURE CONDITIONS EXPLANATORY REPORT

Prepared for Groundwater Management Area 1

With assistance from

Panhandle Regional Planning Commission

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INTERA Inc.

STEVEN D. WALTHOUR, PG
NORTH PLAINS GCD

NEIL DEEDS, PE
INTERA, INC.

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EXECUTIVE SUMMARY

Groundwater Management Area 1 (GMA 1) Groundwater Conservation Districts (GCDs or Districts) prepared this Explanatory Report for Desired Future Conditions (DFCs) for the Ogallala Aquifer including the Rita Blanca Aquifer, and the Dockum Aquifer to comply with the requirements of Texas Water Code (TWC), Section 36.108. The Districts include all of Hemphill County Underground Water Conservation District (Hemphill UWCD), North Plains Groundwater Conservation District (North Plains GCD), Panhandle Groundwater Conservation District (Panhandle GCD), and part of High Plains Underground Water Conservation District No. 1 (High Plains UWCD). GMA 1 Districts prepared this Explanatory Report to summarize joint planning in compliance with the TWC and administrative rules of the Texas Water Development Board (TWDB) found in Title 31 Texas Administrative Code (TAC) Chapter 356.

The GCDs located in GMA 1 are local political subdivisions of the state pursuant to TWC Chapter 36 and their specific enabling statutes. GMA 1 Districts fulfilled the requirements for adopting DFCs through cooperation and joint planning efforts.

GMA 1 District Representatives considered DFC options based on information provided in the 2011 Panhandle Regional Water Plan (PRWP) incorporated by reference in the 2012 State Water Plan and the 2016 Panhandle Regional Water Plan (PRWP) incorporated by reference in the 2017 State Water Plan, as well as other TWDB data sources, and GMA 1 District information.

On November 2, 2016, GMA 1 Districts Representatives unanimously adopted DFCs for the relevant aquifers within the management area through Resolution 2016-2.

The Ogallala Aquifer and the Rita Blanca Aquifer are combined for joint-planning purposes, any references to the “Ogallala Aquifer” in this document shall also include and apply to any groundwater in the Rita Blanca Aquifer in GMA 1.

GMA 1 District Representatives adopted the following DFCs for the Ogallala Aquifer in the GMA 1 joint-planning area from estimated 2012 year conditions:

- At least 40 percent of volume in storage remaining in 50 years, for the period 2012 – 2062 collectively in Dallam, Hartley, Moore, and Sherman counties;
- At least 50 percent of volume in storage remaining in 50 years, for the period 2012 – 2062 collectively in Hansford, Lipscomb, and Ochiltree counties and that portion of Hutchinson County within North Plains GCD.
- At least 50 percent of volume in storage remaining in 50 years, for the period 2012 - 2062 in Carson, Donley, Gray, Hutchinson, Oldham, Roberts, and Wheeler counties; and portions of Armstrong and Potter counties within the Panhandle GCD;
- At least 80 percent of volume in storage remaining in 50 years for the period 2012 - 2062, within the Hemphill County;
- Approximately 20 feet of total average drawdown in 50 years for the period 2012 -2062, collectively in Randall County and in Armstrong and Potter counties within the High Plains UWCD.

GMA 1 District Representatives adopted the following DFCs for the Dockum Aquifer in the GMA 1 Joint Planning Area:

- At least 40 percent of the available drawdown remaining in 50 years for the period 2012 - 2062 collectively for Dallam, Hartley, Moore, and Sherman counties
- No more than 30 feet average decline in water levels in 50 years for the period 2012 - 2062 collectively in Carson and Oldham counties and in Armstrong and Potter counties within the Panhandle GCD; and
- The total average drawdown is approximately 40 feet in 50 years for the period 2012 - 2062, collectively in Randall County, and in Armstrong and Potter counties within the High Plains UWCD.

Additionally, GMA 1 District Representatives determined that the Blaine Aquifer in Wheeler County is non-relevant for joint planning purposes, as provided by in Title 31, TAC Chapter 356. This Explanatory Report incorporates the requisite documentation regarding the Blaine Aquifer's non-relevant determination by GMA 1.

GMA 1 District Representatives held sixteen meetings over a five-year period for the purposes of joint planning in the management area including: November 8, 2011; August 9, 2012; July 23, 2013; November 7, 2013; February 21, 2014; April 11, 2014; May 30, 2014; August 19, 2014; November 6, 2014; February 18, 2015; August 23, 2015; February 25, 2016; March 17, 2016; April 20, 2016; October 5, 2016; and November 2, 2016.

1 GROUNDWATER MANAGEMENT AREA 1 JOINT PLANNING

TWC Section 36.108(d-2) requires that DFCs proposed as part of joint planning in the management area must provide a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the management area. GMA 1 Districts established different DFCs throughout the management area based on a combination of policy and technical considerations that provide continued economic development of the area while providing for the reasonable long-term management of groundwater resources.

GMA 1 Districts are local political subdivisions of the state pursuant to TWC Chapter 36 and their specific enabling statutes. Each GMA 1 District fulfills the requirements of TWC Section 36.108 through mutual cooperation and joint planning efforts. Oldham County, along with portions of Hartley, Hutchinson, Moore, and Randall counties are not within the jurisdiction of a GCD, but are served for joint planning purposes by the GMA 1 Districts. The GMA 1 Districts last adopted DFCs within GMA 1 for the Ogallala Aquifer in 2009 and the Dockum Aquifer in 2010.

TWC Section 36.108(d-3) requires that district representatives in a groundwater management area adopt DFCs for all relevant aquifers in the groundwater management area and produce an Explanatory Report to be submitted to the TWDB and each GCD in the management area provide proof that notice was posted for the joint planning meeting, a copy of the resolution, and a copy of the Explanatory Report. In addition, TWDB rules require documentation of any groundwater modeling work products that were used during consideration of the proposed DFCs. This Explanatory Report provides documentation that GMA 1 District Representatives considered during this round of joint planning all required Factors included in Texas Water Code Section 36.108(d)(1–9).

TWC Chapter 36 requires GMA Districts every five years to consider groundwater availability models (GAMs) and other data or information for the management area when proposing for adopting DFCs for the relevant aquifers within the management area. GMA 1 proposed DFCs for the relevant aquifers within GMA 1 on April 20, 2016, as required by TWC Section 36.108 (d-5). Consistent with TWC Section 36.108(d), before proposing DFCs as required under TWC Section 36.108(d-2), GMA 1 District Representatives considered Factors as follows:

> (1) aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another;
>
> (2) the water supply needs and water management strategies included in the state water plan;
>
> (3) hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge;
>
> (4) other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water;
>
> (5) the impact on subsidence;

(6) socioeconomic impacts reasonably expected to occur;

(7) the impact on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees and assigns in groundwater as recognized. The legislature recognizes that a landowner owns the groundwater below the surface of the landowner's land as real property; and

(8) the feasibility of achieving the desired future condition.

All information considered by GMA 1 District Representatives was determined to be applicable to one or more of the Factors listed above.

After considering and documenting each of the Factors described above and other relevant scientific and hydrogeological data, if available, at multiple meetings, the Districts can establish different DFCs for:

(1) each aquifer, subdivision of an aquifer, or geologic strata located in whole or in part within the boundaries of the management area; or

(2) each geographic area overlying an aquifer in whole or in part or subdivision of an aquifer within the boundaries of the management area.

This Explanatory Report:

(1) identifies each DFC;

(2) provides the policy and technical justifications for each desired future condition;

(3) includes documentation that the Factors under Section 36.108(d) were considered by the districts and a discussion of how the adopted DFCs impact each Factor;

(4) lists other DFC options considered, if any, and the reasons why those options were not adopted; and

(5) discusses reasons why recommendations from public comments received by the districts were or were not incorporated into the DFCs.

GMA 1 District Representatives held sixteen meetings over a five-year period for the purposes of joint planning including: November 8, 2011; August 9, 2012; July 23, 2013; November 7, 2013; February 21, 2014; April 11, 2014; May 30, 2014; August 19, 2014; November 6, 2014; February 18, 2015; August 23, 2015; February 25, 2016; March 17, 2016; April 20, 2016; October 5, 2016; and November 2, 2016. Table 1.1 tracks GMA 1 District Representatives' consideration and review during these sixteen meetings throughout the joint planning process.

GMA 1 District Representatives relied on their individual District staffs and technical consultants, and legal counsel to produce this Explanatory Report with the assistance of the Panhandle Regional Planning Commission of Amarillo, Texas (PRPC); INTERA Inc.; Steven D. Walthour, P.G., of North Plains GCD; regulatory and administrative guidance documents found in APPENDIX II; the 2011 PRWP; the 2012 State Water Plan; the 2016 PRWP and the 2017 State Water Plan. GMA 1 Districts entered a joint funding interlocal contract with the PRPC to provide administrative services and organizational support during the joint planning process. Kyle Ingham, PRPC Local Government Services Director, is the administrator for GMA 1. INTERA Inc. performed predictive model runs from the High Plains Aquifer System Groundwater Availability Model (HPASGAM) based on proposed and adopted DFCs. Mr.

Walthour, P.G., provided technical assistance throughout the joint planning process and completion of the Explanatory Report. The completion of this joint planning process was successful through the GMA 1 Districts, PRPC, and stakeholder joint efforts.

<u>Table 1.1</u> GMA 1 joint planning process meeting matrix (PRPC).

Meeting	Background Review				DFC	Factors Considered Based on DFC Options									Non Rel
	Statute & Rule Review	Process Development	General Factor Organization	Timeline	Considered DFC Options	Factor 1 - Uses & Conditions	Factor 2 - State Water Plan	Factor 3 - Hydrological Condition	Factor 4 - Environmental Impact	Factor 5 - Subsidence	Factor 6 - Socioeconomic	Factor 7 - Private Rights	Factor 8 - Feasibility	Factor 9 - Other Information	Non Relevant Aquifers
November 8, 2011	X			X											
August 9, 2012		X		X	X										
July 23, 2013	X	X													
November 7, 2013	X	X		X	X										
February 21, 2014		X	X	X											
April 11, 2014		X	X	X	X								X		
May 30, 2014					X	X	X	X							
August 19, 2014						X	X	X	X	X	X				
November 6, 2014					X	X		X					X	X	X - B
February 18, 2015					X			X	X			X			
August 23, 2015	X	X	X	X										X	
February 25, 2016			X	X	X	X		X	X			X	X		X - S
March 17, 2016					X	X	X	X			X	X	X		
April 20, 2016	X		X		X	X	X	X	X	X	X	X	X	X	X
October 5, 2016		X			X									X	X
November 2, 2016		X			X	X	X	X	X	X	X	X	X	X	X

2 GROUNDWATER MANAGEMENT AREA 1 DESCRIPTION

TWC Chapter 36 requires GCDs located entirely or partially within a GMA designated by the TWDB to propose for adoption DFCs for the relevant aquifers within each groundwater management area by May 1, 2016. A DFC is defined as a quantitative description, adopted in accordance with TWC Section 36.108, of the desired condition of the groundwater resources in a management area at one or more specified future times.

GMA 1 includes: Armstrong, Carson, Dallam, Donley, Gray, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Potter, Randall, Roberts, Sherman, and Wheeler counties in the Texas Panhandle.

GMA 1 is located entirely within and consists of 18 out of the 21 counties in TWDB Region A, also referred to as the Panhandle Water Planning Area (PWPA). According to information from the 2012 State Water Plan; and the 2017 State Water Plan, GMA 1 is among the largest groundwater consuming areas in the State, with over 90 percent of water used for agricultural purposes. The area accounted for about thirteen percent of the State's annual water use between 2006 and 2010. According to the 2016 PRWP, less than two percent of the water use in the Canadian River Basin and the Red River Basin was from surface water sources in 2010. Due to the scarcity of locally-developable surface water supplies, any additional water needed for the basin will likely come from groundwater or reuse of existing supplies. Since the 2011 PRWP was completed, the region has experienced record low inflows to Lake Meredith and Palo Duro Reservoir and numerous water providers are considering groundwater options for future supplies.

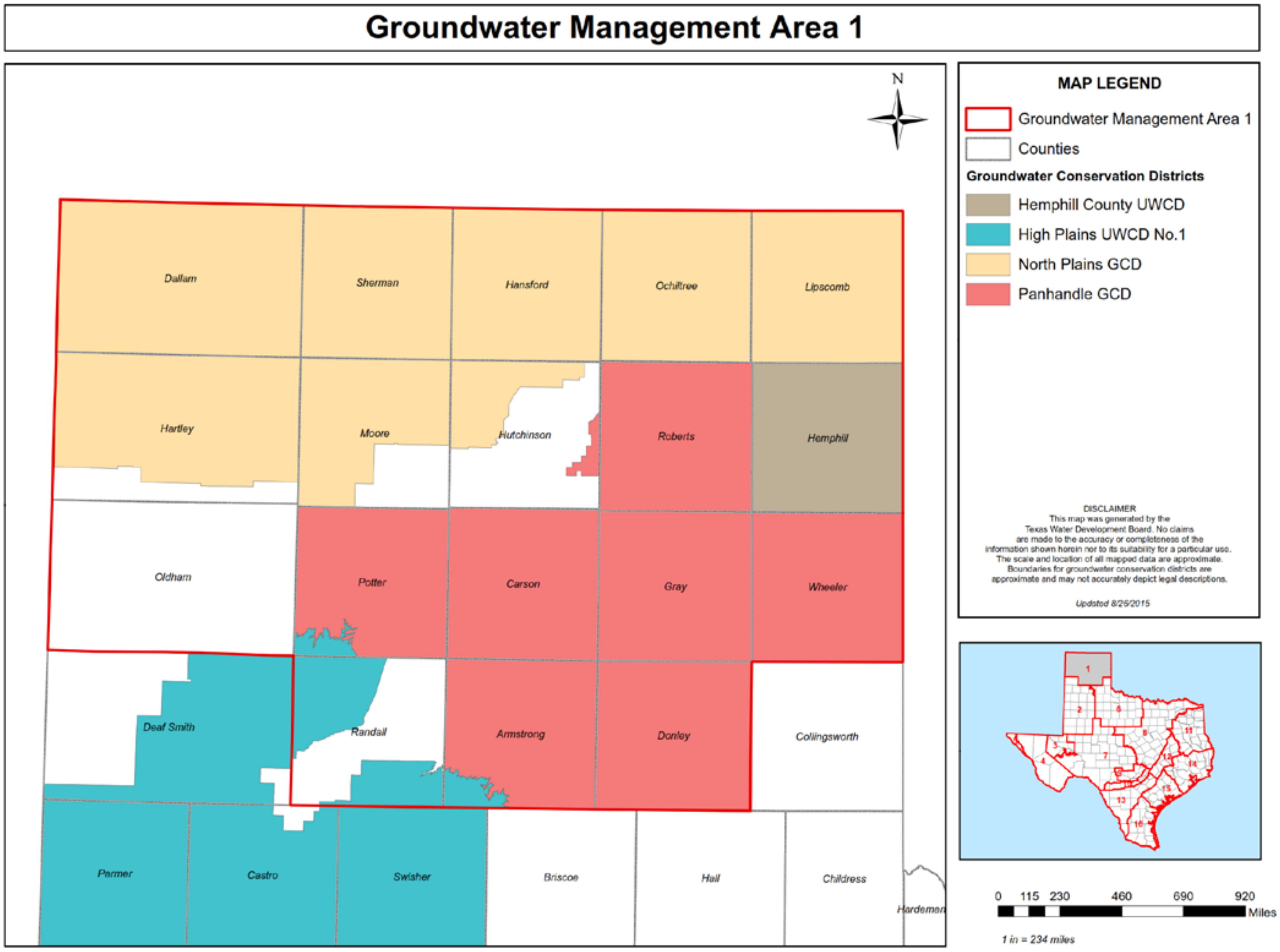
In both the 2012 State Water Plan and the 2017 State Water Plan, the TWDB projects that total water use for GMA 1 primarily due to an expected reduction in agricultural irrigation water requirements. Future irrigation water use is expected to decline due to a combination of factors, including projected insufficient quantities of groundwater to meet irrigation water demands, implementation of conservation practices, implementation of new crop types, and the use of more efficient irrigation technology.

All or parts of seventeen counties in GMA 1 are served by four GCDs as follows:

- Hemphill County Underground Water Conservation District ("Hemphill UWCD"), established in 1997, serving Hemphill County;
- High Plains Underground Water Conservation District No. 1 ("High Plains UWCD"), established in 1951, serving portions of Potter, Randall, & Armstrong counties with the remainder of the district located in Groundwater Management Area 2;
- North Plains Groundwater Conservation District, ("North Plains GCD"), established in 1955, serving all or part of Dallam, Hansford, Hartley, Hutchison, Lipscomb, Moore, Ochiltree, and Sherman counties; and
- Panhandle Groundwater Conservation District ("Panhandle GCD"), established in 1956, serving all or part of Armstrong, Carson, Donley, Gray, Hutchinson, Potter, Roberts, and Wheeler counties.

Oldham County and portions of Hartley, Hutchinson, Moore, and Randall counties are not served by a GCD. The GCDs are collectively referenced in this report as "GMA 1 Districts" and a map of GMA 1 Districts boundaries is shown in Figure 2.1.

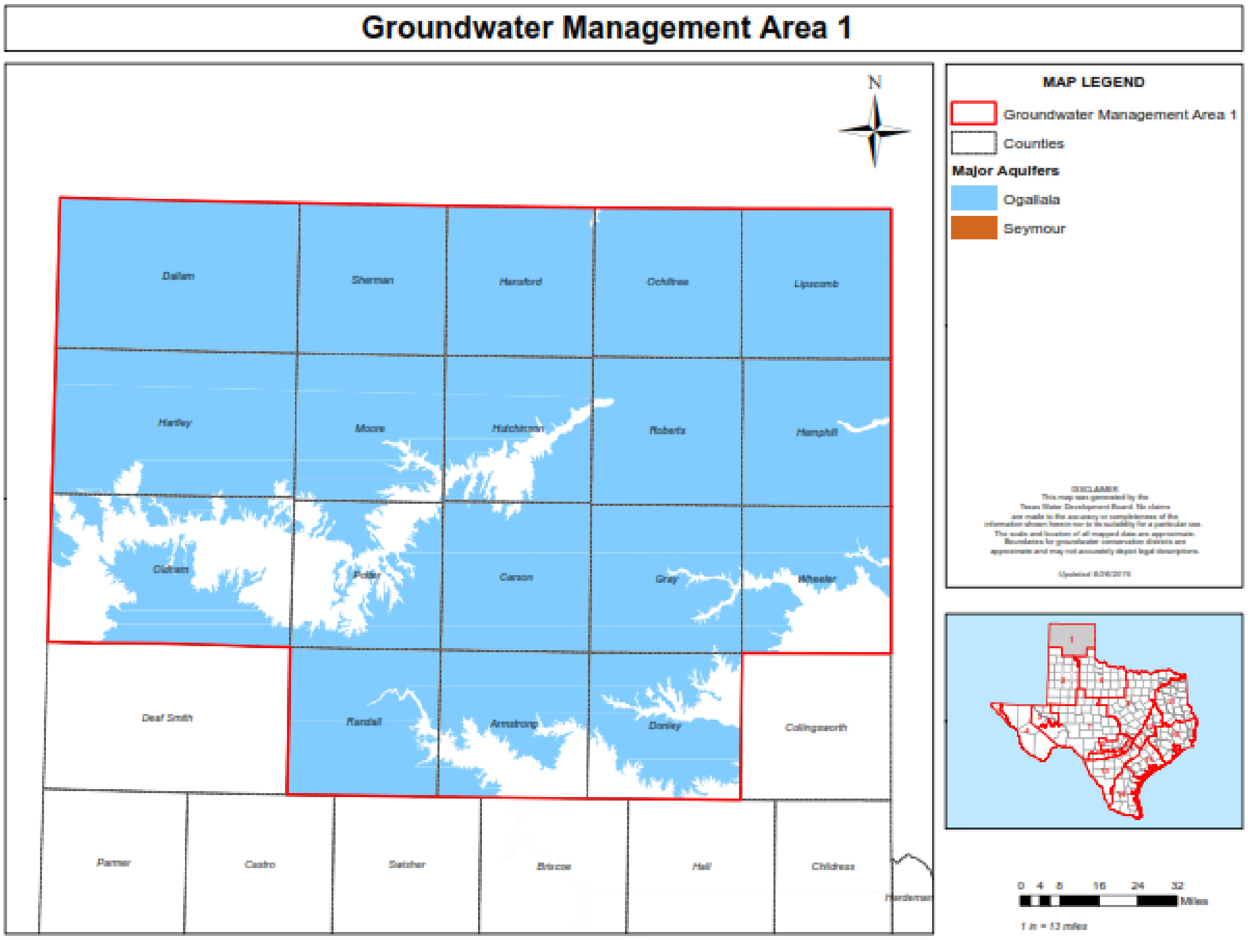
Figure 2.1 GMA 1 District administrative boundaries, (TWDB, 2015).



Source: TWDB http://www.twdb.texas.gov/groundwater/management_areas/maps/GMA1_GCD.pdf

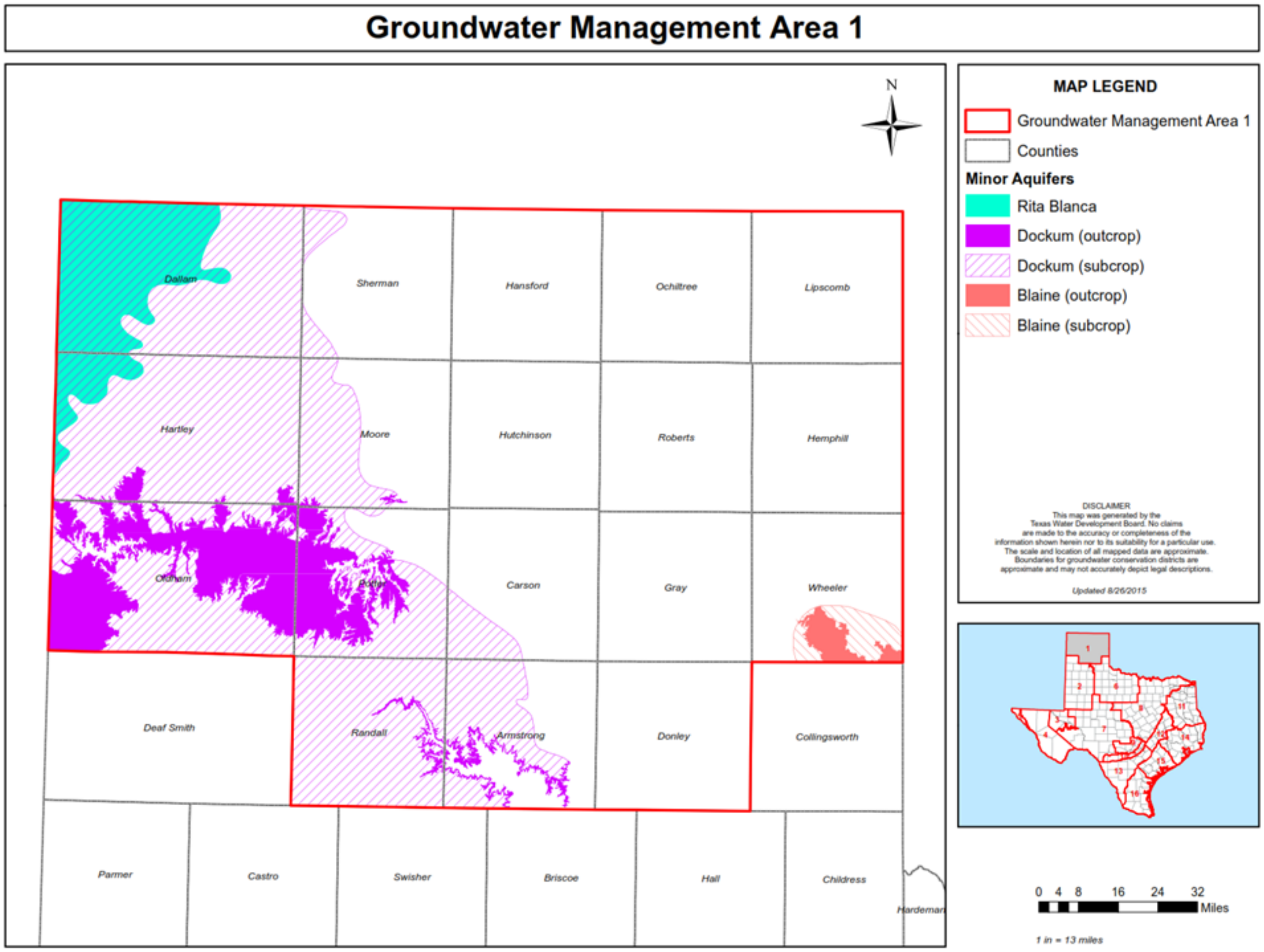
The TWDB has identified one major aquifer (Ogallala Aquifer) and three minor aquifers (Blaine, Dockum and Rita Blanca aquifers) in GMA 1. With relatively very little surface water available in the area, these aquifers provide the primary water resource and most often are the sole sources of water**.** Figure 2.2 is a map of the major aquifers and Figure 2.3 is a map of the minor aquifers in GMA 1.

Figure 2.2 Map of GMA 1 Major Aquifers (TWDB, 2015)



Source: TWDB http://www.twdb.texas.gov/groundwater/management_areas/maps/GMA1_MajorAquifer.pdf

Figure 2.3 Map of GMA 1 Minor Aquifers (TWDB, 2015).



Source: TWDB http://www.twdb.texas.gov/groundwater/management_areas/maps/GMA1_MinorAquifer.pdf

3 OGALLALA AQUIFER DESCRIPTION AND DESIRED FUTURE CONDITIONS

3.1 Ogallala Aquifer and Rita Blanca Aquifer Description

3.1.1 Ogallala Aquifer

The Ogallala Aquifer is the largest water resource in the Great Plains. It is primarily an unconfined or water table aquifer that extends approximately 174,000 square miles from South Dakota, through Wyoming, Nebraska, Colorado, Kansas, New Mexico, and Oklahoma, to the Texas South Plains. In Texas, the Ogallala covers about 36,000 square miles through all or parts of 48 counties contains approximately 366.7 million acre-feet of groundwater in storage (Oliver, 2010a). The TWDB estimates that the Ogallala Aquifer stores 233.7 million acre-feet of groundwater within GMA 1 (Kohtrenken, 2015).

As the Southern Rocky Mountains began to uplift and the Cretaceous seas retreated, streams flowing east and southeast from the mountains cut channels into the pre-Ogallala surface of Permian, Triassic, Jurassic and Cretaceous strata. These streams along with eolian processes transported large sediment quantities east and southeast from the Rocky Mountains filling in the channels and creating a thick blanket of coalescing clay, silt and sand deposits of the Ogallala and associated formations. Eventually, a combination of the climate becoming more arid and the Pecos River incising northward through the Ogallala Formation in New Mexico, isolated the Ogallala in Texas from its Southern Rocky Mountains water and sediment source. Uplift continued and the Texas High Plains surface tilted southeastward (Knowles et.al., 1984). Today, the Ogallala formation’s thickness ranges from zero to more than 900 feet in the Texas High Plains and is controlled, in part, by the depth of the sediment filled channels (paleochannels) at the base of the formation as well as by dissolution of salt in older rock strata below the formation. Today, the Ogallala’s greatest sediment thicknesses and groundwater saturated thicknesses occur in the northeastern part of the Texas Panhandle.

Interbedded sequences of unconsolidated to poorly consolidated clay, silt, and sands with minor sequences of gravel constitute most of the sediment deposited in the Ogallala Formation. The sands are generally tan, cream, yellow, or reddish brown, very fine to coarse-grained, sub-angular to sub-rounded, and poorly to well sorted. The gravel is usually associated with sand, silt, and clay. On the Texas High Plains, the Ogallala Formation is generally capped by caliche near the surface. In addition to these caliche layers, caliche also occurs at depth and may represent older soil horizons.

Driller’s logs describe Permian and Triassic sediment beneath the Ogallala formation as a combination of red clay, red sand and silt or red beds. Where Cretaceous sediment underlies the Ogallala, widespread yellow, blue, or black clay marks the unconformity. In local areas, the base of the Ogallala can be obscured by pre-Ogallala sediment with similar characteristics to basal Ogallala sand and gravel. The Ogallala Aquifer is partially hydraulically connected to underlying sandstones of the Cretaceous and Jurassic age Rita Blanca Aquifer in Dallam and Hartley counties; to the Santa Rosa sandstone at the base of the Triassic age Dockum Group and to Cretaceous age limestone of the Edwards Trinity Aquifer near Lubbock.

The Ogallala Aquifer is segregated into northern and southern portions by the Palo Duro Canyon and a groundwater divide; both located along the Prairie Dog Town Fork of the Red River.

Groundwater in the aquifer's northern portion generally flows eastward and discharges through wells, into the Canadian and tributaries of the Red River in the eastern Panhandle, or flows into Oklahoma. The aquifer is laterally hydraulically connected except where the Canadian River has eroded through the formation. The northern portion's saturated thickness ranges from less than 50 to over 550 feet and depth to water ranges from zero to over 400 feet. Well capacities range from a few gallons per minute (gpm) to over 1000 gpm. The aquifer extends throughout all 18 counties in GMA-1. Figure 3.1 shows the extent of the northern and southern Ogallala Aquifer in Texas.

3.1.2 Rita Blanca Aquifer

The Rita Blanca Aquifer, in Texas, is in northwest Dallam and Hartley counties. The aquifer is composed of Jurassic to Cretaceous age sediments that subcrop or truncate below the Ogallala sediments and overlie the older Dockum sediments. Christian (1989) described the sediments within the Rita Blanca Aquifer as follows:

- Graneros Shale: Marine shale with fine grained mixed clastic sediment and limestone. (Cretaceous);
- Dakota Group: (Undifferentiated, Glencairn Formation & Lytle Sandstone) fine- to coarse-grained sandstone, variegated clay, and pebbly beds. (Cretaceous);
- Morrison Formation: mudstone, sandstone, siltstone and limestone (Jurassic); and
- Exeter Sandstone: Coarse, evenly laminated, sandstone. (Jurassic).

Cross-sections of geologic strata that comprise the Rita Blanca Aquifer modified from Christian (1989) are shown in Figure 3.3. The irregular lines between the rock strata in the cross-sections show unconformities, buried erosional surfaces where part of the geologic record has been removed. The cross-sections illustrate the paleochannels (ancient sediment filled stream and river channels) created at the base of the Ogallala sediments.

According to TWDB Report 380 (George et.al., 2011), groundwater production occurs from the coarse-grained sand and gravel layers of the Lytle and Dakota sediments as well as in the Exeter Sandstone and the Morrison Formation. In places, the Rita Blanca Aquifer is hydraulically connected to the overlying Ogallala Aquifer and the underlying Dockum Aquifer. Though the report goes on to say that irrigation accounts for most of the groundwater use from this aquifer, it notes that Texline is the only community that uses the aquifer for municipal water supply.

Figure 3.1 Ogallala Aquifer map showing its varying 2004 saturated thickness, and two aquifer portions that are segregated by a groundwater divide in Texas (modified from Center for Geospatial Technology, 2007). The bold line represents the approximate groundwater divide.

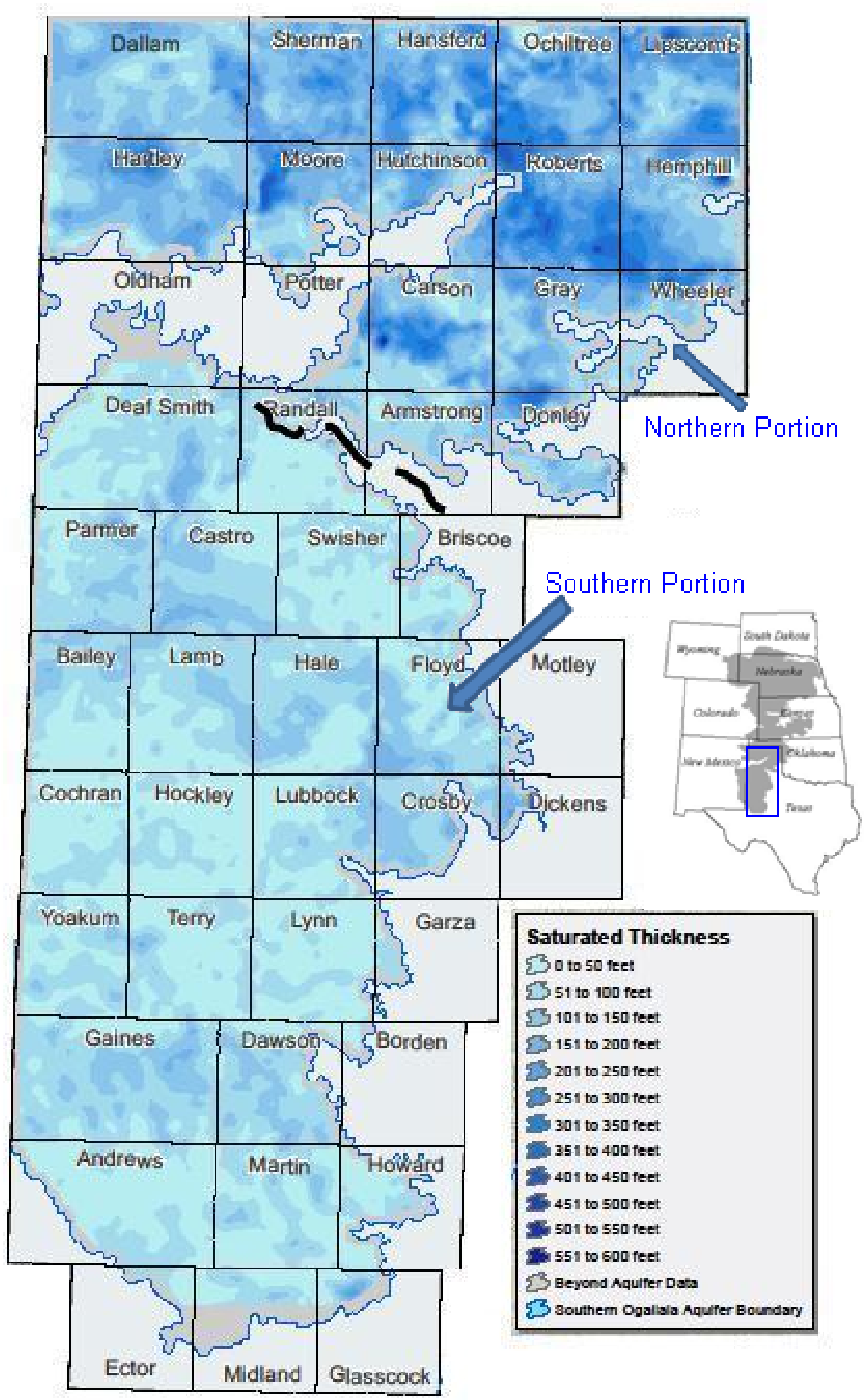
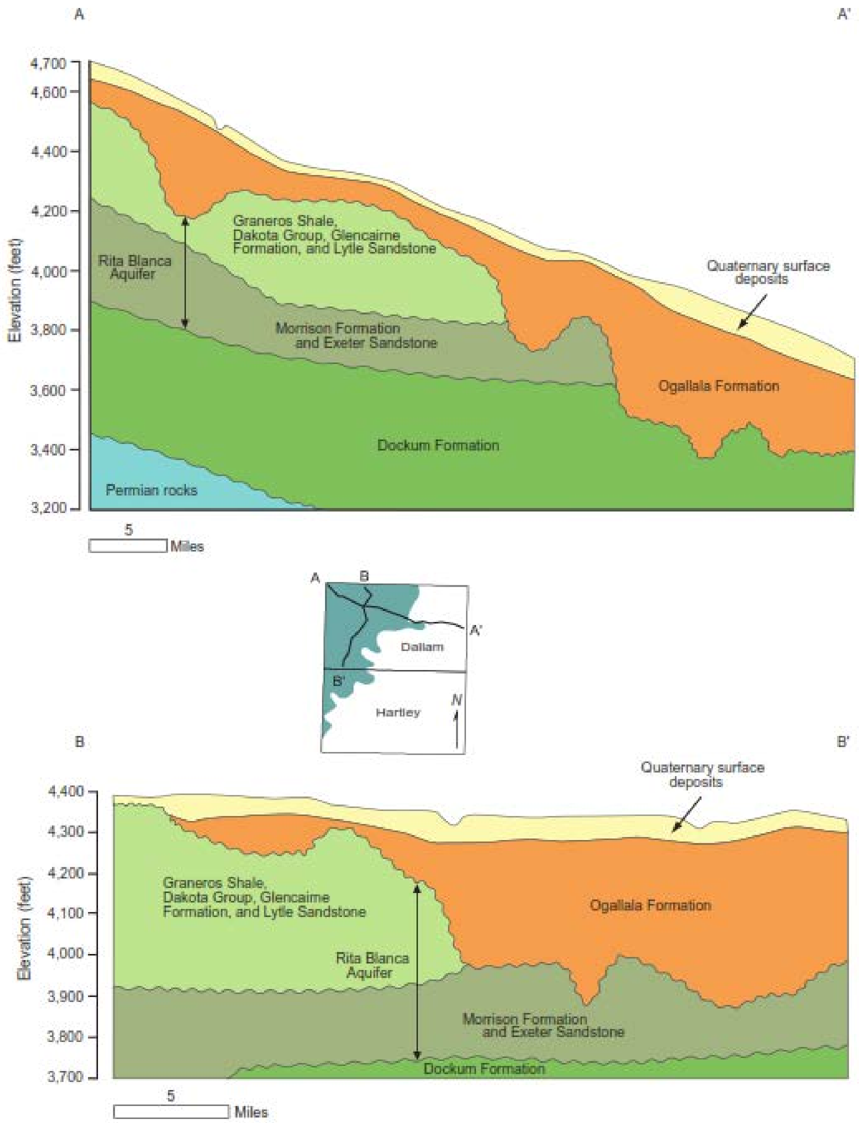


Figure 3.2 Cross Sections of the Rita Blanca Aquifer compared to the Ogallala Aquifer and Dockum Aquifer(modified from Christian, 1989).



3.2 Desired Future Conditions

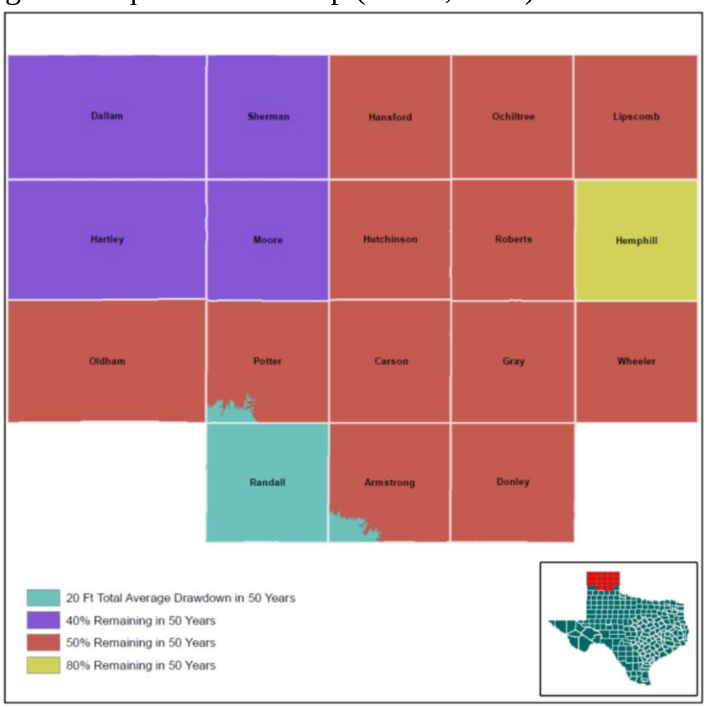
GMA 1 District Representatives unanimously adopted DFCs for the Ogallala Aquifer by resolution (Resolution 2016-2) on November 2, 2016.

The Ogallala Aquifer (Inclusive of Rita Blanca) DFCs adopted by Groundwater Management Area 1 are as follows:

- At least 40 percent of volume in storage remaining in 50 years, for the period 2012 – 2062 collectively in Dallam, Hartley, Moore, and Sherman counties;
- At least 50 percent of volume in storage remaining in 50 years, for the period 2012 – 2062 collectively in Hansford, Lipscomb, and Ochiltree counties and that portion of Hutchinson County within North Plains GCD.
- At least 50 percent of volume in storage remaining in 50 years, for the period 2012 - 2062 in Carson, Donley, Gray, Hutchinson, Oldham, Roberts, and Wheeler counties; and portions of Armstrong and Potter counties within Panhandle GCD ;
- At least 80 percent of volume in storage remaining in 50 years for the period 2012 - 2062, within Hemphill County;
- Approximately 20 feet of total average drawdown in 50 years for the period 2012 -2062, collectively in Randall County and in Armstrong and Potter counties within the High Plains UWCD No. 1.

Resolution 2016-2 is provided in Appendix I – DFC Documents. Documentation for this meeting including meeting postings, agenda package, and meeting supplements, including the resolution, are provided in Appendix III- Meeting Documentation.

Figure 3.3 GMA 1 Ogallala Aquifer DFCs Map (PRPC, 2016)



3.3 <u>Policy and Technical Justification</u>

TWC Section 36.108(d-2) requires that DFCs proposed as part of joint planning in the management area must provide “a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the management area.” GMA 1 District Representatives established different DFCs throughout the management area based on a combination of policy and technical considerations that provide continued economic development of the area, while providing for the reasonable long-term management of groundwater resources consistent with the management goals under Section 36.1071(a).

3.3.1 Policy justification

GMA 1 Districts are local political subdivisions of the state pursuant to Chapter 36 and their specific enabling statutes created under Section 52, Article III, or Section 59, Article XVI, Texas Constitution. GMA 1 Districts collectively average over 50 years of management to provide for the conservation, preservation, protection, recharging, and prevention of waste of groundwater, and of groundwater reservoirs or their subdivisions consistent with the objectives of the Texas Constitution within their jurisdiction. In consideration of DFCs, each of the GMA 1 Districts reviewed their management plans and regulatory structures used in each of their jurisdictional areas based on their collective groundwater management experience. Each GMA 1 District fulfills the requirements of TWC Section 36.108 through mutual cooperation and joint planning efforts with other GCDs in the GMA. Oldham County and portions of Hartley, Hutchinson, Moore, and Randall counties are not within the jurisdiction of a GCD but are served for joint planning purposes by the GMA 1 District Representatives. The GMA 1 Districts last adopted DFCs within GMA 1 for the Ogallala Aquifer in 2009.

The GMA 1 Districts view the relevance of the different adopted DFCs for the management area and understand the concept that DFCs are not just numbers. The Ogallala Aquifer is the only groundwater supply in eight out of eighteen counties and is the primary water supply in the remaining ten counties in GMA 1. The aquifer essentially provides the only reliable water source for most of GMA 1, as well as a water source for water transported out of the management area. The development of different Ogallala DFCs across the management area strike a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste.

The DFCs balance the need for water regarding agriculture, municipal and industrial uses as well as address spring flow and ecotourism, all drivers for the Texas Panhandle economy. GMA 1 Districts are aware of the relationship of water to current and future property values as well as the economic and social value of leaving water for future generations when the GMA 1 Districts address current and future needs.

3.3.2 Technical justification

GMA 1 District Representatives combine the Rita Blanca Aquifer and Ogallala Aquifer because of their functional relationship from a hydrogeological perspective. Any references to the “Ogallala Aquifer” in this report shall also include and apply to any groundwater in the Rita Blanca Aquifer. GMA 1 District Representatives adopted an Ogallala DFC for Dallam, Hartley, Moore and Sherman counties, collectively, based on at least 40 percent of volume in storage remaining in 50 years because those counties are experiencing;

- High agriculture usage of the aquifer,
- Above average rate of decline,
- Very limited stream flow, and
- High agriculture economic impacts.

Setting a higher percent of volume in storage remaining would require massive reductions in agriculture groundwater pumping, increasing the adverse economic impacts to the area and individual property owners.

GMA 1 Districts adopted an Ogallala Aquifer DFC of at least 50 percent of the volume in storage remaining in 50 years in Hansford, Hutchinson, Lipscomb, Ochiltree, Carson, Donley, Gray, Roberts, Wheeler, and Oldham counties because these areas are experiencing and are projected to continue to experience:

- Moderate agriculture usage of the aquifer,
- Significant municipal well fields in the area,
- Average rates of decline,
- Minimal stream flow, and
- Moderate agriculture and municipal economic impact.

GMA 1 District Representatives adopted an Ogallala Aquifer DFC in Randall County and within the High Plains UWCD in Armstrong and in Potter counties, collectively, of approximately 20 feet of total average drawdown in 50 years for the same conditions listed above and to provide the same consistent management framework that is used within the High Plains UWCD in Groundwater Management Area 2 (GMA 2). Based on current water use and projected future WUG demand and needs, the adopted DFCs for these counties collectively should provide adequate water available for current and future growth while encouraging conservation.

GMA 1 District Representatives adopted an Ogallala Aquifer DFC in Hemphill County of at least 80 percent of volume in storage remaining in 50 years because of its profound differences from the rest of the management area. Some of these conditions include;

- Minimal agriculture usage of the aquifer,
- Minimal rate of decline,
- Relatively extensive stream flow for the planning area, and
- Water related ecotourism economic impact.

Hemphill County groundwater use is generally far less than use in adjacent counties and that of most of the rest of management area. Hemphill County contains more spring and other natural discharge to streams and rivers than any other county in the GMA because of local hydrogeological conditions. The adopted DFC allows the largest potential percent growth in groundwater demand over the next fifty years, while protecting spring discharge, stream flow and ecotourism. The higher DFC will provide groundwater availability at least two times higher than the TWDB estimated water use in the area, while protecting springs and seeps that enhance Canadian River flow.

Except for Randall County and portions of High Plains UWCD in Potter and Armstrong counties, GMA 1 District Representatives adopted "percent of volume in storage remaining in 50 years" similar to previous Region A water planning goals. Today, over 80 percent of all non-exempt aquifer withdrawals are volumetrically measured in GMA 1. GMA 1 Districts have incorporated DFCs into management plans, rules, and procedures for monitoring and tracking the achievement of adopted DFCs.

GMA 1 District Representatives adopted aquifer drawdown for those portions of the High Plains UWCD, and all of Randall County. Aquifer drawdown is the preferred measurement method for groundwater management in GMA 2 where over 90 percent of the High Plains UWCD is located. GMA 1 District Representatives adopted different DFCs to allow for future growth while promoting conservation. In considering the nine Factors under TWC Section 36.108(d), GMA 1 District Representatives utilized numerous information sources while considering DFC options and before adopting final DFCs. To evaluate the DFC options and the adopted DFCs, INTERA Inc. used the HPASGAM (Deeds and Jigmond, 2015) that it developed for the TWDB. The HPASGAM is a regional groundwater flow model that incorporates the Ogallala, Rita Blanca, Edwards-Trinity (High Plains), and Dockum aquifers.

In December 2015, TWDB accepted as the official GAM for the region the HPASGAM along with the HPAS Report (Final Report for the High Plains Aquifer System Groundwater Availability Model); and HPAS Numerical Model Report. The final predictive model run based on the adopted DFCs and Technical Memorandum were prepared by INTERA Inc. at the request of GMA 1 GCDs. The Technical Memorandum, provided in Appendix VI, provides a summary of the adopted DFC simulations. The purpose of this memorandum is to provide the model input files to the TWDB so that the Executive Administrator can evaluate the feasibility of the adopted DFCs and to confirm predictive run results to estimate modeled available groundwater (MAG).

Because 2012 was the last year of the transient model, 2012 was used as the reference year for comparison to a future aquifer condition. For comparison to a condition 50 years in the future, hydraulic heads at the end of the stress period corresponding to 2062 were compared to the initial calculated hydraulic heads (from the end of 2012). For the predictive simulation, the last simulated year was 2070, so the run was comprised of a total of 58 annual stress periods. To perform the HPASGAM predictive run for the adopted DFCs, INTERA assumed 2015 pumping rates are identical to the last year of the calibrated model (2012) except in North Plains GCD where annual pumping rates were provided by North Plains GCD staff. The HPASGAM predictive run input file shows that to achieve the adopted DFCs in GMA 1 the Ogallala Aquifer (and Rita Blanca Aquifer) predicted modeled available groundwater will decline from 3,161,039 acre-feet/year in 2016 to 2,236,421 acre-feet/year by 2062 (the DFC planning horizon) and 2,027,388 acre-feet/year in 2070. Over the fifty-year planning horizon, this represents a 29 percent reduction in pumping levels necessary to achieve adopted DFCs. When compared to the 2016 PRWP, predicted modeled available groundwater will exceed projected water demand in GMA 1 by approximately 1.87 million acre-feet/year in 2020, but this surplus will decline to 887,500 acre-feet/year in 2070. Though the predicted modeled available groundwater regionally shows more than enough Ogallala Aquifer availability in total to meet the total projected water demand and needs to provide for growth, localized and county-wide areas will experience needs/shortages that cannot be met by the Ogallala Aquifer alone. As identified in the PRWP, those areas will need to implement water management strategies such as transporting water from other areas within the GMA, conservation, changing land use, or developing additional water supplies potentially from other aquifers. The PRWP anticipates that agriculture water needs will be addressed primarily through conservation measures; whereas, municipal and industrial needs can be met through transport of water from other areas within the PRWP and GMA 1. Table 3.1 is a compilation of modeled pumping levels based on the adopted DFCs. The 2015 rates are estimated production rates identical to the last year of the transient model (2012) except where more current rates were provided by North Plains GCD. The 2016 rate is the first year of the HPASGAM modeled pumping levels based on the DFCs, which provides almost 68 percent more total water available than was estimated withdrawn in 2015.

Table 3.1 Ogallala Aquifer modeled pumping levels based on the adopted DFCs in acre-feet/year (Appendix VI).

COUNTY	2015	2016	2020	2030	2040	2050	2062	2070
ARMSTRONG	8,568	59,153	59,431	54,461	49,170	44,183	38,671	35,303
CARSON	129,714	181,368	192,661	184,263	170,395	153,767	134,054	121,448
DALLAM	311,591	402,024	388,532	287,203	226,189	166,890	103,256	70,950
DONLEY	39,476	69,404	75,012	76,288	73,162	67,872	60,901	56,275
GRAY	41,540	171,475	181,601	175,267	163,099	148,713	131,744	121,136
HANSFORD	169,191	276,822	275,769	272,655	271,968	270,280	269,478	269,128
HARTLEY	353,547	468,925	418,255	289,161	227,468	165,579	98,299	63,785
HEMPHILL	21,935	55,176	52,338	52,217	52,409	52,305	52,340	52,358
HUTCHINSON	64,870	103,110	95,244	95,694	94,418	92,372	90,580	89,357
LIPSCOMB	39,006	55,112	267,540	266,710	267,370	266,591	266,556	266,546
MOORE	170,048	243,647	224,397	181,217	147,315	111,202	72,182	51,031
OCHILTREE	84,963	115,225	244,446	243,931	244,670	244,050	244,085	244,094
OLDHAM	13,775	40,879	44,721	40,203	33,513	26,206	18,617	16,165
POTTER	7,498	16,000	17,240	16,044	14,705	13,385	11,829	10,862
RANDALL	44,214	63,212	64,084	61,931	54,489	47,804	40,999	37,166
ROBERTS	79,284	359,716	431,798	455,129	428,388	390,246	342,747	311,054
SHERMAN	288,843	364,947	399,146	348,894	282,462	212,744	136,775	93,843
WHEELER	13,534	114,844	130,782	138,810	137,761	132,311	123,308	116,837
TOTAL	**1,881,597**	**3,161,039**	**3,562,997**	**3,240,078**	**2,938,951**	**2,606,500**	**2,236,421**	**2,027,338**

Documentation for GMA 1 meetings identified in Table 1.1 including meeting postings, agenda package, sign-in sheets and meeting supplements are provided in Appendix III- Meeting Documentation. The HPAS Report, HPAS Predictive Runs, and the final HPAS Technical Memorandum and supplemental GAM runs are provided in Appendix VI – GAM Models and Reports.

3.4 Ogallala Aquifer Factor Consideration

3.4.1 Aquifer uses or conditions

TWC Section 36.108(d)(1) requires district representatives to consider aquifer uses and conditions within the management area, including conditions that differ substantially from one geographic area to another.

District Representatives adopted different DFCs within GMA 1 based on varying aquifer uses and conditions including: physical landscape and land use, concentrated pumping centers, estimated groundwater use and predicted demands by county and by WUG; differing aquifer elevations, water level declines, saturated thicknesses, and depth to base of the aquifer differ substantially from one geographic area to another. GMA 1 District Representatives considered aquifer uses and conditions for the aquifers within the management area during meetings identified in Table 1.1.

GMA 1 District Representatives considered aquifer uses by water user groups (WUGs) collectively including: municipal, irrigated agriculture, livestock, manufacturing, steam electric, and mining. As part of their consideration, the representatives reviewed TWDB Water Use Survey Groundwater Pumpage Estimates (WUSGPE), GMA 1 District information, and water demand projections included in the 2012 State Water Plan and the 2016 PRWP incorporated by reference in the 2017 State Water Plan. The Ogallala Aquifer inclusive of the Rita Blanca Aquifer groundwater pumping in GMA 1 by year, by WUG and by county from 2005-2014 is shown in Table 3.2 and Table 3.3.

HPASGAM predictive runs based on the adopted DFCs show more water available for WUG current use or projected future WUG demands than has been historically developed except in Dallam, Hartley, Moore and Sherman counties. In these counties, Ogallala Aquifer water level declines will approximate modeled pumping projections for that management zone. Aquifer declines together with conservation measures are projected to cause reduced groundwater use in high agricultural irrigation water demand areas.

During their meetings, GMA 1 District Representatives received presentations from their respective staffs regarding aquifer uses and conditions including: physical landscape, satellite imagery modified to show estimated groundwater use by county; estimated groundwater use by county and by WUG; cross-sections and hydrologic maps showing differing aquifer elevations, water level declines, saturated thicknesses, and depth to base of the aquifer. GMA 1 District Representatives considered water uses and conditions provided in the 2011 PRWP and the 2016 PRWP, as well as other TWDB data sources, and GMA 1 District information.

Pumping locations in the management area may not necessarily be the same as the location of use because groundwater can be pumped from a well or well field and transported by pipeline to another geographic location within or outside the management area. GMA 1 District Representatives reviewed and considered aquifer uses as described in the regional planning process and considered both the places of use and points of withdrawal. According to the TWDB WUSGPE, irrigation use represents between 90 and 93 percent of the total aquifer pumping in GMA 1 during the ten-year period from 2005 to 2014. Municipal groundwater water use represents the second largest amount of aquifer pumping (between 4 and 5 percent annually) during the same ten-year period.

In 2011, groundwater use peaked because of a regional and statewide drought, further development of agriculture water use, and an ongoing regional trend of switching from surface water sources to groundwater from the Ogallala Aquifer. The Canadian River Municipal Water Authority's (CRMWA) development of groundwater resources to offset declining surface water availability is an example of this trend. CRMWA historically has provided water from Lake Meredith on the Canadian River to its member cities in the Texas Panhandle in GMA 1 and the Texas High Plains in GMA 2 as far south as Lamesa, Texas. Beginning in late 2001, CRMWA began supplementing water from Lake Meredith by blending groundwater from well fields in Roberts County to meet its water supply obligations to its member cities. Those member cities also supplement CRMWA supplies locally with groundwater from their own wells. In 2011, approximately 88 percent of the water used by the CRMWA member cities was groundwater. The remaining 12 percent was surface water. For a period from 2012 to 2014 CRMWA relied solely on groundwater due to low lake levels and water quality issues at Lake Meredith, but has since made small diversions from Lake Meredith. Table 3.4 shows CRMWA's surface water and groundwater use from 2000 to 2012.

Data from the 2017 State Water Plan, predicts that historical and projected total water use, including both surface water and groundwater in GMA 1 will decline over the next fifty years. When comparing, the historic water use for 2010 from the 2017 State Water Plan, and the TWDB WUSGPE, the Ogallala Aquifer accounts for over 95 percent of the total water used in GMA 1. Table 3.5 shows total water use from the 2017 State Water Plan. The highlighted records in Table 3.5 represent over ten percent of the GMA 1 total water use or water demand by decade in those counties.

Table 3.2 GMA 1 Ogallala Aquifer inclusive of the Rita Blanca Aquifer pumping in acre-feet by year and by WUG from 2005-2014 (TWDB).

Year	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2005	82,601	32,331	123	994	2,019,669	36,213	2,171,931
2006	90,063	32,182	265	867	1,550,789	49,876	1,724,042
2007	66,650	31,147	259	1,301	1,612,341	39,195	1,750,893
2008	76,762	31,762	82	3,870	1,752,098	39,547	1,904,121
2009	80,600	34,913	73	3,236	1,771,583	32,814	1,923,219
2010	83,435	27,910	0	346	1,518,338	22,231	1,652,260
2011	120,708	17,468	0	1,509	2,356,947	26,086	2,522,718
2012	115,988	15,718	0	447	2,270,686	33,159	2,435,998
2013	110,960	14,980	123	958	2,050,532	29,957	2,207,510
2014	110,994	15,979	112	780	1,961,391	31,481	2,120,737

<u>Table 3.3</u> Ogallala Aquifer inclusive of the Rita Blanca Aquifer pumping in acre-feet by year and by county from 2005-2014 (TWDB).

County	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ARMSTRONG	8,694	7,776	6,554	7,863	6,762	5,085	9,210	10,261	8,283	5,937
CARSON	73,689	67,466	87,586	90,756	78,323	89,009	129,007	144,731	122,745	109,603
DALLAM	414,763	357,489	377,411	417,880	427,708	368,397	498,199	504,289	399,965	389,843
DONLEY	31,250	26,640	39,013	32,757	29,761	26,089	39,564	42,271	30,784	35,270
GRAY	40,131	34,692	39,265	40,563	40,291	25,741	41,252	42,348	43,084	43,572
HANSFORD	220,398	141,599	111,641	147,188	156,835	132,327	238,169	223,736	203,302	216,207
HARTLEY	386,271	317,459	331,408	373,417	387,424	345,901	490,174	463,733	458,527	414,497
HEMPHILL	8,510	9,635	7,583	10,726	5,444	6,048	11,949	10,676	8,061	4,695
HUTCHINSON	100,165	104,309	80,232	83,340	80,658	61,458	91,110	85,465	79,913	79,038
LIPSCOMB	28,778	29,454	33,853	32,579	31,392	32,968	53,029	56,927	42,938	45,034
MOORE	304,813	195,218	259,721	199,971	212,529	172,943	281,426	250,097	237,354	220,898
OCHILTREE	92,936	71,943	55,556	79,685	71,090	64,066	114,166	114,879	97,413	97,081
OLDHAM	6,619	7,258	6,142	8,286	7,317	4,417	6,663	6,250	6,290	5,172
POTTER	7,865	6,192	26,239	45,823	25,285	2,831	5,817	15,763	17,404	14,768
RANDALL	56,619	52,461	29,371	30,983	27,837	25,880	38,239	32,550	28,024	22,487
ROBERTS	14,233	15,144	17,039	8,829	34,747	38,528	61,520	59,757	60,995	61,620
SHERMAN	365,494	267,805	230,103	281,091	288,155	239,211	399,600	353,439	349,003	341,600
WHEELER	10,703	11,502	12,176	12,384	11,661	11,361	13,624	18,826	13,425	13,415
Total	2,171,931	1,724,042	1,750,893	1,904,121	1,923,219	1,652,260	2,522,718	2,435,998	2,207,510	2,120,737

<u>Table 3.4</u> Canadian River Water Municipal Authority surface water and groundwater use from 2000 to 2012 in acre-feet (modified from CRWMA, 2014).

Year	CRMWA Lake	CRMWA Wells	Total
2000	86,488		86,488
2001	78,842		78,842
2002	54,689	30,559	85,248
2003	57,899	33,728	91,627
2004	36,518	36,611	73,129
2005	47,215	35,501	82,715
2006	41,837	40,125	81,962
2007	33,430	37,676	71,106
2008	28,050	40,442	68,492
2009	35,540	36,242	71,782
2010	32,405	39,604	72,009
2011	8,287	61,039	69,326
2012		62,909	62,909

Table 3.5 Historical water use and projected water demands for GMA 1 in acre-feet/year (2017 State Water Plan). The highlighted records represent over ten percent of the GMA 1 total water use or demand by decade in each of those counties.

County	2010	2020	2030	2040	2050	2060	2070
Armstrong	5,243	5,286	5,077	4,792	4,381	3,971	3,563
Carson	62,756	58,106	55,294	51,273	45,880	40,508	35,140
Dallam	368,553	376,493	354,620	326,399	291,512	256,648	221,798
Donley	27,031	26,033	25,141	23,771	21,338	18,912	16,486
Gray	29,480	33,086	33,051	32,205	31,540	30,024	28,652
Hansford	133,757	140,089	132,184	121,356	108,403	95,471	82,824
Hartley	347,481	353,384	334,432	309,381	276,600	243,876	211,204
Hemphill	7,095	6,446	5,885	5,308	4,692	4,075	3,809
Hutchinson	74,882	71,534	70,823	69,150	66,497	64,678	63,046
Lipscomb	33,223	23,142	21,891	20,273	18,089	16,086	14,184
Moore	178,277	161,328	153,840	144,155	131,884	119,984	108,181
Ochiltree	64,351	65,358	61,562	57,102	51,612	46,367	41,271
Oldham	6,353	6,288	6,239	6,066	5,708	5,384	5,067
Potter	48,137	69,374	74,224	79,447	84,518	92,870	100,990
Randall	45,591	50,260	52,200	53,904	55,268	57,048	59,012
Roberts	8,090	8,102	7,295	6,408	5,413	4,672	4,083
Sherman	239,462	225,104	212,287	195,370	174,359	153,357	132,400
Wheeler	17,332	14,195	13,156	11,711	10,014	8,872	8,078
TOTAL	**1,697,094**	**1,693,608**	**1,619,201**	**1,518,071**	**1,387,708**	**1,262,803**	**1,139,788**

The 2017 State Water Plan interprets that the amount of water used for municipal purposes is closely tied to population centers. Based on the 2017 State Water Plan, the total municipal water use in GMA 1 was 74,810 acre-feet in 2010, which is approximately four percent of total water use in the management area. Potter and Randall counties, which contain the cities of Amarillo and Canyon, comprised 65 percent of the municipal water use in GMA 1, while collectively Armstrong, Donley, Hemphill, Roberts, and Sherman counties comprise approximately three percent. Though Roberts County has relatively little municipal use within the county, groundwater pumping from well fields to replace diminishing surface water supplies is a significant source of the water used for municipal purposes in Potter and Randall counties through the City of Amarillo as well as for the member cities of CRMWA both inside and outside of GMA 1. Historical municipal water use and projected municipal water demand from the 2017 State Water Plan is shown in Table 3.6.

The 2016 PRWP divides water use into three major categories; municipal, industrial, and agricultural. Industrial water use includes mining, manufacturing, and power generation activities. In 2010, agricultural water use accounted for 92 percent of total water use and includes both irrigation and livestock watering. Irrigated crop use accounts for 90 percent of the total water use, while livestock production accounts for 2 percent of the total and is forecast to nearly double during the planning period (2020-2070). Table 3.7 shows historical irrigation water use and projected irrigation water demand and Table 3.8 shows historical livestock water use and projected livestock water demand for GMA 1.

GMA 1 industrial water use including mining, manufacturing, and power generation, accounted for approximately 64,300 acre-feet or 4 percent of the total water use in 2010 (Table 3.9).

Table 3.6 Historical municipal water use and projected municipal water demand for GMA 1 in acre-feet/year (2016 PRWP). The highlighted records represent over ten percent of the GMA 1 total water use or water demand by decade in each of those counties.

County	2010	2020	2030	2040	2050	2060	2070
Armstrong	349	447	438	432	429	428	428
Carson	1,361	1,279	1,286	1,284	1,274	1,272	1,272
Dallam	1,695	2,183	2,418	2,674	2,938	3,200	3,454
Donley	638	623	606	591	584	583	583
Gray	4,692	4,609	4,965	5,430	6,130	6,691	7,286
Hansford	1,090	1,120	1,164	1,208	1,251	1,304	1,357
Hartley	1,147	1,509	1,561	1,582	1,600	1,624	1,644
Hemphill	731	944	1,023	1,089	1,167	1,240	1,309
Hutchinson	5,600	5,148	5,221	5,193	5,180	5,173	5,171
Lipscomb	637	941	995	1,023	1,071	1,107	1,138
Moore	3,640	5,356	5,974	6,656	7,385	8,182	9,004
Ochiltree	2,261	3,075	3,252	3,456	3,696	3,969	4,268
Oldham	655	647	677	669	667	666	666
Potter	24,701	29,425	32,036	34,932	37,997	41,541	45,316
Randall	23,587	29,017	31,741	34,567	37,655	41,134	44,791
Roberts	168	273	276	272	271	271	271
Sherman	630	654	692	707	728	744	758
Wheeler	1,228	1,147	1,164	1,183	1,220	1,265	1,315
Total	**74,810**	**88,397**	**95,489**	**102,948**	**111,243**	**120,394**	**130,031**

Table 3.7 Historical irrigation water use and projected irrigation water demand for GMA 1 in acre-feet/year (2016 PRWP). The highlighted records represent over ten percent of the GMA 1 total water use or water demand by decade in each of those counties.

County	2010	2020	2030	2040	2050	2060	2070
Armstrong	4,396	4,194	3,990	3,708	3,296	2,884	2,472
Carson	60,069	55,702	52,838	48,776	43,356	37,937	32,517
Dallam	363,839	369,864	347,524	318,795	283,373	247,952	212,530
Donley	25,523	24,080	23,203	21,847	19,419	16,992	14,564
Gray	22,721	21,291	20,104	18,539	16,479	14,419	12,359
Hansford	128,632	134,902	126,481	115,759	102,897	90,035	77,173
Hartley	340,554	345,365	325,882	300,290	266,924	233,559	200,193
Hemphill	4,549	1,907	1,814	1,685	1,498	1,311	1,124
Hutchinson	40,372	40,008	37,671	34,635	30,786	26,938	23,090
Lipscomb	31,415	20,009	19,014	17,650	15,689	13,728	11,767
Moore	162,595	143,028	134,395	123,290	109,591	95,892	82,193
Ochiltree	60,484	57,243	53,825	49,414	43,923	38,433	32,942
Oldham	4,186	3,937	3,768	3,524	3,133	2,741	2,350
Potter	1,191	3,427	3,292	3,091	2,748	2,404	2,061
Randall	18,419	18,000	17,156	15,976	14,201	12,426	10,650
Roberts	7,362	5,958	5,609	5,155	4,582	4,009	3,437
Sherman	236,631	220,966	207,757	190,687	169,499	148,312	127,125
Wheeler	13,913	8,203	7,983	7,433	6,607	5,781	4,955
Total	**1,526,851**	**1,478,084**	**1,392,306**	**1,280,254**	**1,138,001**	**995,753**	**853,502**

<u>Table 3.8</u> Historical livestock water use and projected livestock water demand for GMA 1 in acre-feet/year (2016 PRWP). The highlighted records represent over ten percent of the GMA 1 total water use or water demand by decade in each of those counties.

County	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Armstrong	498	645	649	652	656	659	663
Carson	702	692	696	700	704	709	713
Dallam	3,013	4,437	4,669	4,920	5,191	5,485	5,803
Donley	870	1,330	1,332	1,333	1,335	1,337	1,339
Gray	1,579	1,352	1,378	1,407	1,438	1,473	1,511
Hansford	3,759	3,432	3,574	3,724	3,881	4,046	4,219
Hartley	5,778	6,498	6,977	7,498	8,066	8,684	9,359
Hemphill	1,061	1,275	1,279	1,284	1,289	1,295	1,302
Hutchinson	490	847	873	903	935	971	1,010
Lipscomb	795	947	969	993	1,020	1,050	1,083
Moore	2,384	3,676	3,906	4,155	4,424	4,716	5,032
Ochiltree	1,444	4,216	3,632	3,729	3,832	3,942	4,058
Oldham	1,105	1,229	1,231	1,234	1,237	1,240	1,243
Potter	768	481	482	484	486	488	491
Randall	3,077	2,654	2,665	2,677	2,690	2,704	2,719
Roberts	321	369	369	370	371	372	373
Sherman	2,163	3,449	3,631	3,825	4,034	4,257	4,497
Wheeler	1,326	1,577	1,680	1,682	1,684	1,687	1,689
Total	**31,133**	**39,106**	**39,992**	**41,570**	**43,273**	**45,115**	**47,104**

Table 3.9 Historical industrial water use and projected industrial water demand for GMA 1 in acre-feet/year (2016 PRWP).

County	2010	2020	2030	2040	2050	2060	2070
Armstrong	0	0	0	0	0	0	0
Carson	624	433	474	513	546	590	638
Dallam	6	9	9	10	10	11	11
Donley	0	0	0	0	0	0	0
Gray	488	5,834	6,604	6,829	7,493	7,441	7,496
Hansford	276	635	965	665	374	86	75
Hartley	2	12	12	11	10	9	8
Hemphill	754	2,320	1,769	1,250	738	229	74
Hutchinson	28,420	25,531	27,058	28,419	29,596	31,596	33,775
Lipscomb	376	1,245	913	607	309	201	196
Moore	9,658	9,268	9,565	10,054	10,484	11,194	11,952
Ochiltree	162	824	853	503	161	23	3
Oldham	407	475	563	639	671	737	808
Potter	21,477	36,041	38,414	40,940	43,287	48,437	53,122
Randall	508	589	638	684	722	784	852
Roberts	239	1,502	1,041	611	189	20	2
Sherman	38	35	207	151	98	44	20
Wheeler	865	3,268	2,329	1,413	503	139	119
Total	**64,300**	**88,021**	**91,414**	**93,299**	**95,191**	**101,541**	**109,151**

2017 State Water Plan projections indicate that total water use in GMA 1 will decline over 50 years, primarily due to an expected reduction in agricultural irrigation water requirements. Irrigation water demand is expected to decrease over time (primarily in Dallam, Hartley, Moore and Sherman counties) because of reduced irrigation well yield, implementation of conservation practices, implementation of new crop types, and the use of more efficient irrigation technology.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

3.4.2 Water supply needs and water management strategies included in the State Water Plan.

TWC Section 36.108(d)(2) requires that District Representatives consider the water supply needs and water management strategies included in the state water plan. GMA 1 Districts considered data from the 2012 State Water Plan and information from the 2017 State Water Plan. Information from both regional and state plans are provided in the supporting documentation; however, for the purposes of simplicity, the 2017 State Water Plan is referenced in discussing the water supply needs and water management strategies for GMA 1.

GMA 1 District Representatives considered water supply needs and water management strategies within GMA 1 during meetings identified in Table 1.1.

3.4.2.1 Water Supply Needs

A water supply need occurs when currently developed supplies are not sufficient to meet projected demands. The 2017 State Water Plan identified thirty-three WUGs (accounting for basin and county designations) with identified needs during the planning period (2020-2070). Of these, there are twenty-five cities and other WUGs in fourteen counties that are projected to experience water needs before 2070. The largest volumetric needs are attributed to high irrigation demand in Dallam, Hartley and Moore counties and an increase in municipal demand and comparably limited groundwater resources in Potter, and Randall counties. Water supply needs are shown for the county that has demand, which may differ from the county of the supply source.

In GMA 1, the total needs for all WUGs are projected to be 161,822 acre feet per year in 2020, increasing to 233,847 acre feet per year in 2040 and 245,751 acre-feet per year by 2070. In assessing water supply needs, the 2017 State Water Plan allocates water to WUGs considering geographical availabilities, infrastructure constraints, legal limits and contractual limits, as appropriate. With these considerations, the projected developed supplies total 1.57 million acre-feet per year in 2020, which is about 40 percent of the total water available. This indicates that there is sufficient water available in 2020 to users in GMA 1 that have not been developed (2017 State Water Plan). However, for some WUGs, the available water cannot be economically produced for the intended purpose to meet WUG need. This is the case for irrigation users that rely on locally developed supplies and cannot economically use water that is located many miles away. Municipal WUGs can develop and transport water to meet their needs from outside the county. GMA 1 water surplus/needs by county is detailed in Table 3.10. A summary of when the individual WUG needs begin by county and demand type is presented in Table 3.11.

Table 3.10 GMA 1 Water surplus/needs by county in acre-feet (2017 State Water Plan).

County	2020	2030	2040	2050	2060	2070
Armstrong	116	67	22	-18	-55	-93
Carson	946	369	191	101	-28	-176
Dallam	-79,909	-92,468	-95,342	-88,952	-79,729	-70,514
Donley	186	194	201	203	204	204
Gray	1,356	-816	-1,546	-1,384	-2,280	-3,214
Hansford	177	109	-16	-388	-651	-896
Hartley	-77,545	-93,712	-99,092	-93,227	-84,020	-74,803
Hemphill	64	65	67	64	61	58
Hutchinson	137	-1,402	-2,850	-4,329	-5,632	-6,930
Lipscomb	94	91	-6	-240	-365	-483
Moore	-2,600	-4,352	-6,003	-8,931	-15,697	-20,759
Ochiltree	-454	-938	-1,414	-1,856	-2,322	-2,771
Oldham	828	796	801	800	798	795
Potter	-4,895	-11,184	-18,316	-25,217	-31,490	-38,529
Randall	-3,118	-7,716	-12,976	-18,328	-23,677	-28,921
Roberts	451	448	451	369	302	234
Sherman	813	785	773	615	416	219
Wheeler	1,531	1,315	1,208	1,079	951	828
Total	**-161,822**	**-208,349**	**-233,847**	**-239,639**	**-243,214**	**-245,751**

Table 3.11 Summary of when the individual WUG needs located in each county begin and demand type (2017 State Water Plan).

County	Irrigation	Municipal	Manufacturing	Mining	Steam Electric Power	Livestock
Armstrong	-	2050	-	-	-	-
Carson	-	2020	-	-	-	-
Dallam	2020	2020	-	-	-	
Donley	-	-	-	-	-	-
Gray	-	2030	-	-	-	-
Hansford		2040	-	-	-	-
Hartley	2020	2020	-	-	-	
Hemphill	-	-	-	-	-	-
Hutchinson		2020	2030	-	-	-
Lipscomb	-	2040	2040	-	-	-
Moore	2060	2020	2020			-
Ochiltree	-	2020	-	-	-	-
Oldham	-		-	-	-	-
Potter	-	2020	2020	-	-	-
Randall	-	2020	2020	-	-	-
Roberts	-	-	-	-	-	-
Sherman		-	-	-	-	
Wheeler	-	2070	-	-	-	-

3.4.2.2 Water management strategies included in the State Water Plan.

The 2017 State Water Plan provides key findings and recommendations regarding addressing water supply needs with water management strategies. These findings are as follows:

- Significant reductions in surface water supplies have resulted in additional water needs in the PWPA. This is especially true for CRMWA member cities. With the development of additional groundwater in Roberts County, CRMWA can better manage their sources conjunctively to continue to utilize Lake Meredith.
- Ogallala groundwater supplies were allocated to irrigation and municipal water users such that the regional water planning goal was met both spatially and temporally. This results in immediate needs for some users that have geographical constraints for using groundwater. The actual distribution of water supplies over time may differ from these assumptions.
- Large irrigation needs are concentrated in Dallam and Hartley counties. Most of these needs are due to the spatial constraints for supply for irrigated agriculture. The recommended strategies are conservation.
- Four wholesale water providers are projected to have needs over the planning period. The recommended strategies for each provider are to develop additional groundwater.
- Conservation is a critical strategy to the region, as it can be used to reduce water needs as well as preserve limited water sources for future generations.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III - Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

3.4.3 Hydrological conditions

GMA 1 District Representatives considered hydrological conditions; including for each aquifer in the management area the total estimated recoverable storage (TERS) as provided by the TWDB Executive Administrator, as well as the average annual recharge, inflows, and discharge during meetings identified in Table 1.1. During those meetings, GMA 1 District Representatives reviewed numerous reports and model runs including:

- Previous TWDB GAM runs,
- TWDB estimates of TERS,
- Groundwater recharge reports,
- Aquifers of Texas TWDB Report 380, and
- Multiple TERS presentations during their meetings.

Documentation for GMA 1 meetings including meeting postings, agenda package, minutes, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

3.4.3.1 Total estimated recoverable storage (provided by TWDB)

The TWDB defines total estimated recoverable storage (TERS) as the estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume. In other words, the TWDB assumes that between 25 and 75 percent of groundwater held within an aquifer can be removed by pumping. TERS does not account for a variety of important conditions and aquifer characteristics that limit groundwater production such as well withdrawal rate, well density, hydraulic conductivity, withdrawal costs, aquifer petrology, permeability, and potential water quality degradation, etc. The TERS calculation represents the approximate percentage of total storage volume in the water-producing zones of an aquifer; however, not all the water in those zones are “practicably recoverable”. The basis of the TERS calculation does not require an amount that could be recovered during any planning period. Recovery of all water from TERS would take longer than the fifty-year planning horizon and at a cost impractical for regional uses. Therefore, TERS accounts for water that cannot be practicably produced for beneficial use at any level in the GMA 1. Unlike TERS which simply measures volume, the highest practicable level of groundwater production is defined as a rate by measuring a volume produced through time. Table 3.12 through Table 3.15 identify Ogallala Aquifer and Rita Blanca TERS by county & district in GMA 1 from TWDB GAM Task Report 15-006 (Kohlrenken, 2015).

As required by statute, the TWDB executive administrator provided the GMA 1 Districts with an updated TERS Report after the TWDB accepted the HPASGAM from INTERA Inc., in 2015. GMA 1 District Representatives evaluated TERS provided by the TWDB and found that though TERS provides a total amount of groundwater that can possibly be produced given the discussion above, only a portion of groundwater in storage can be feasibly withdrawn to address the current uses and future anticipated groundwater demands. GMA 1 District Representatives selected DFCs that allow for substantial storage to remain for future demands after the fifty-year planning period while ensuring that water is available to meet for most WUG water demands outlined in the 2017 State Water Plan.

Table 3.12. Ogallala Aquifer TERS by county for GMA 1 (TWDB GAM Task Report 15-006)

County	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Armstrong	4,600,000	1,150,000	3,450,000
Carson	15,000,000	3,750,000	11,250,000
Dallam	15,000,000	3,750,000	11,250,000
Donley	4,400,000	1,100,000	3,300,000
Gray	14,000,000	3,500,000	10,500,000
Hansford	24,000,000	6,000,000	18,000,000
Hartley	17,000,000	4,250,000	12,750,000
Hemphill	15,000,000	3,750,000	11,250,000
Hutchinson	11,000,000	2,750,000	8,250,000
Lipscomb	18,000,000	4,500,000	13,500,000
Moore	10,000,000	2,500,000	7,500,000
Ochiltree	21,000,000	5,250,000	15,750,000
Oldham	2,000,000	500,000	1,500,000
Potter	1,900,000	475,000	1,425,000
Randall	4,800,000	1,200,000	3,600,000
Roberts	30,000,000	7,500,000	22,500,000
Sherman	18,000,000	4,500,000	13,500,000
Wheeler	7,000,000	1,750,000	5,250,000
Total	**232,700,000**	**58,175,000**	**174,525,000**

Table 3.13 Ogallala Aquifer TERS by GCD in GMA 1 (TWDB Task Report 15-006).

Groundwater Conservation District	Total Storage (acre-feet)	25% of Total Storage (acre-feet)	75% of Total Storage (acre-feet)
Hemphill County UWCD[5]	15,000,000	3,750,000	11,250,000
High Plains UWCD No.1	3,100,000	775,000	2,325,000
North Plains GCD	130,000,000	32,500,000	97,500,000
Panhandle GCD	77,000,000	19,250,000	57,750,000
No District	9,600,000	2,400,000	7,200,000
Total	**234,700,000**	**58,675,000**	**176,025,000**

Table 3.14. Rita Blanca Aquifer TERS by county for GMA 1 (TWDB Task Report 15-006).

County	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Dallam	9,800,000	2,450,000	7,350,000
Hartley	1,300,000	325,000	975,000
Total	**11,100,000**	**2,775,000**	**8,325,000**

Table 3.15. Rita Blanca Aquifer TERS by GCD in GMA 1 (TWDB Task Report 15-006).

Groundwater Conservation District	Total Storage (acre-feet)	25% of Total Storage (acre-feet)	75% of Total Storage (acre-feet)
North Plains GCD	11,000,000	2,750,000	8,250,000
No District	5,500	1,375	4,125
Total	**11,005,500**	**2,751,375**	**8,254,125**

3.4.3.2 Average annual recharge, Inflows, and Discharge

In groundwater models, a water budget reflects the relationship between input and output of water through a given area modeled. Water budgets for the Ogallala Aquifer and Rita Blanca Aquifer were developed as part executing the HPASGAM. The HPASGAM has calculates a water budget for steady state conditions (before pumping) in the 1930s and for transient conditions (after pumping began) in 1980 and 2012. The HPASGAM calculates a water budget for recharge, evapotranspiration, discharge to springs, draws, and escarpments, flows associated with rivers and reservoirs, aquifer storage, lateral flow, and cross-formational flow. HPASGAM calculations for the steady-state model and the 2012 transient model are shown in Table 3.16 and Table 3.17. Before pumping began in GMA 1, water generally flowed into and out of the Ogallala Aquifer and the Rita Blanca Aquifer without affecting aquifer storage. The HPASGAM calculates recharge for the Ogallala was 324,889 acre-feet per year before pumping began. In GMA 1, the Ogallala Aquifer discharges water as evapotranspiration, springs, rivers, draws, escarpments, lateral and cross-formational flow.

The Rita Blanca Aquifer within GMA 1 does not recharge or receive potential inflow from rivers because it is not exposed at the surface or intersect rivers in the area to receive water. The lack of exposure at the surface also prevents the aquifer from discharging water through evapotranspiration, springs, rivers, draws, and escarpments. The aquifer received lateral flow from outside of GMA 1 and discharged the water to other aquifers, probably to the Ogallala Aquifer or Dockum Aquifer.

Table 3.16 HPAS Water budget for the Ogallala Aquifer by county for the steady-state model (HPAS Report).

County	Recharge	ET	Springs	Rivers	Draws	Escarpm ents	Lateral	Cross-Formati onal
Armstrong	9,499	-28	-227	-4,313	0	-2,822	127	-2,235
Carson	12,471	-583	0	4,018	0	-206	-15,986	287
Dallam	24,489	-2,416	0	11,778	-389	0	-33,912	451
Donley	17,217	-2,417	-1,567	-15,735	-129	-7,035	9,666	0
Gray	26,145	-1,094	0	-4,840	0	-6,305	-13,907	0
Hansford	11,525	-4,540	0	-13,446	-133	0	6,594	0
Hartley	29,125	-7,346	-69	-14,320	0	-1,825	-4,325	-1,240
Hemphill	33,925	-24,895	-196	-21,966	-112	-3,600	16,844	0
Hutchinson	6,962	-5,977	-426	-18,842	-3,728	-12,165	34,176	0
Lipscomb	29,600	-8,292	0	-3,849	0	0	-17,459	0
Moore	17,353	-1,054	0	-3,600	-1,056	-3,809	-7,535	-298
Ochiltree	12,379	-487	0	1,938	0	0	-13,830	0
Oldham	18,225	-867	-262	-9,361	-1,183	-8,967	6,244	-3,830
Potter	7,110	-577	-199	-184	-263	-2,874	-1,311	-1,703
Randall	10,140	-1,784	-346	-10,779	-1,070	-1,524	8,607	-3,243
Roberts	13,084	-29,422	-4	-18,220	-3,014	-2,785	40,361	0
Sherman	17,547	-406	0	5,975	0	0	-23,170	54
Wheeler	28,093	-4,020	-1,194	-9,592	-2,223	-12,521	1,458	0
Total	324,889	-96,205	-4,490	-125,338	-13,300	-66,438	-7,358	-11,757

Table 3.17 HPAS Water budget for the Rita Blanca Aquifer by county for the steady-state model (HPAS Report).

County	Recharge	ET	Springs	Rivers	Draws	Escarp-ments	Lateral	Cross-Form-ational
Dallam	0	0	0	0	0	0	500	-500
Hartley	0	0	0	0	0	0	65	-65

As pumping develops in the management area, it begins to affect the total water budget by taking water out of aquifer storage as well as changing inflows and outflows. The HPAS 2012 transient model estimated that wells pumped 2,497,882 acre-feet per year reducing Ogallala Aquifer storage by 2,313,189 acre-feet per year. In addition to taking water from storage, increased pumping significantly increased lateral flow from outside GMA 1, decreased discharge to springs, rivers, draws, and escarpments as well as decreased discharge to other aquifers as cross formational flow. Table 3.18 shows the water budget as expressed in the HPAS 2012 transient model for the Ogallala Aquifer. The HPASGAM calculates that wells withdrew 6,202 acre-feet per year from the Rita Blanca Aquifer, with 2,146 acre-feet coming from aquifer storage, 944 acre-feet. from lateral flow and 3,110 acre-feet. from cross-formational flow from either the Ogallala or Dockum aquifers. Table 3.19 shows the water budget as expressed in the HPAS 2012 transient model for the Rita Blanca Aquifer.

The adopted Ogallala Aquifer (including the Rita Blanca Aquifer) DFCs will increase the effect shown from well pumping on aquifer storage. Increased pumping significantly increases lateral flow, decreases discharges to springs, rivers, draws, escarpments and cross formational flow shown in the HPAS 2012 transient model if or when groundwater pumping approaches the HPAS modeled groundwater pumping developed from DFCs. Table 3.20 shows the effect of the adopted DFCs on aquifer conditions from predicted groundwater pumping.

Table 3.18 HPAS Water budget for the Ogallala Aquifer by county for the 2012 transient model (modified from HPAS Report).

County	Recharge	ET	Springs	Rivers	Draws	Escarp-ments	Reser-voirs	Wells	Storage	Lateral	Cross-Form-ational
Armstrong	9,535	0	-39	-1,227	0	-2,339	0	-8,805	11,286	-6,262	-2,150
Carson	12,471	-367	0	5,470	0	-143	0	-129,816	124,865	-12,826	347
Dallam	24,600	-61	0	19,836	0	0	0	-429,574	379,136	7,428	-1,365
Donley	17,361	-1,688	-1,286	-11,948	-35	-6,715	0	-39,308	26,676	16,943	0
Gray	26,409	-764	0	-2,979	0	-6,240	0	-41,569	40,077	-14,934	0
Hansford	11,531	-483	0	10,052	0	0	419	-242,130	217,629	2,981	0
Hartley	29,186	-3,213	-2	-5,377	0	-1,636	42	-488,903	486,978	-17,996	920
Hemphill	34,367	-24,400	-198	-20,587	-101	-3,673	0	-21,951	21,931	14,614	0
Hutchinson	7,082	-2,367	-185	-4,744	-798	-6,860	0	-85,118	82,617	10,373	0
Lipscomb	29,621	-5,733	0	1,567	0	0	0	-56,294	47,145	-16,307	0
Moore	17,436	0	0	5,266	-164	-1,730	0	-282,841	256,336	7,024	-1,326
Ochiltree	12,379	-170	0	3,738	0	0	126	-113,704	100,672	-3,040	0
Oldham	18,476	-758	-258	-8,550	-1,015	-7,868	0	-14,397	11,621	6,315	-3,567
Potter	7,090	0	-64	597	-267	-1,655	0	-8,573	12,040	-7,587	-1,580
Randall	10,169	-559	-104	-45	-231	-991	0	-44,304	30,515	7,810	-2,258
Roberts	13,328	-26,681	0	-13,211	-2,354	-2,103	0	-79,392	84,930	25,483	0
Sherman	17,550	0	0	9,682	0	0	0	-397,598	370,112	246	9
Wheeler	28,976	-3,969	-1,184	-8,133	-2,274	-12,809	0	-13,605	8,623	4,376	0
Total	327,567	-71,213	-3320	-20,593	-7,239	-54,762	587	-2,497,882	2,313,189	24,641	-10970

Table 3.19 Water budget for the Rita Blanca Aquifer by county for year 2012 of the transient model (modified from HPAS Report).

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Dallam	0	0	0	0	0	0	0	-6,202	2,054	945	3,203
Hartley	0	0	0	0	0	0	0	0	92	1	-93

Table 3.20 Water budget for the Ogallala Aquifer by county and GCD based on the effects of predicted groundwater pumping from the adopted DFCs (INTERA Inc., 2016).

	STORAGE	RECHARGE	WELLS	ET	SPRINGS	DRAWS	ESCARPMENT	RIVERS	RESERVOIRS	GHB	LATERAL	X-FORMATIONAL
Hemphill County UWCD												
2015	21,058	34,479	-21,951	-24,327	-198	0	-3,673	-20,308	0	0	15,021	0
2020	66,957	34,479	-52,462	-20,757	-116	0	-2,181	-14,189	0	0	-11,657	0
2030	70,553	34,479	-52,452	-15,388	-88	0	-1,762	-3,617	0	0	-31,681	0
2040	68,537	34,479	-52,478	-11,596	-79	0	-1,619	3,930	0	0	-41,154	0
2050	65,585	34,479	-52,500	-8,832	-73	0	-1,549	8,647	0	0	-45,757	0
2060	62,140	34,479	-52,518	-6,728	-68	0	-1,491	11,827	0	0	-47,640	0
2070	58,599	34,479	-52,531	-5,093	-63	0	-1,431	13,940	0	0	-47,899	0
North Plains GCD												
2015	1,281,622	137,188	-1,468,704	-8,260	0	0	0	55,741	587	0	2,569	-732
2020	1,975,499	137,188	-2,247,149	-2,164	0	0	0	72,236	587	0	64,976	-1,173
2030	1,601,560	137,188	-1,931,113	-396	0	0	0	87,248	587	0	107,039	-2,113
2040	1,360,745	137,188	-1,710,271	-69	0	0	0	90,241	587	0	124,959	-3,381
2050	1,133,555	137,188	-1,490,113	-21	0	0	0	90,884	587	0	132,969	-5,049
2060	929,028	137,188	-1,285,559	-4	0	0	0	91,154	587	0	134,969	-7,361
2070	770,231	137,188	-1,119,827	-2	0	0	0	91,240	587	0	132,774	-12,190
Panhandle GCD												
2015	306,759	113,937	-318,687	-33,056	-2,521	0	-32,160	-29,873	0	0	3,154	-2,715
2020	965,045	113,937	-1,100,905	-14,705	-1,265	0	-15,102	10,386	0	0	46,399	-2,553
2030	902,071	113,937	-1,116,796	-2,891	-630	0	-8,590	45,698	0	0	69,748	-2,419
2040	811,895	113,937	-1,048,903	-961	-378	0	-6,461	57,481	0	0	75,749	-2,352
2050	720,945	113,937	-963,742	-588	-289	0	-5,361	63,554	0	0	73,878	-2,335
2060	630,274	113,937	-872,158	-404	-239	0	-4,801	67,057	0	0	68,693	-2,359
2070	546,180	113,937	-783,041	-286	-209	0	-4,493	69,201	0	0	61,123	-2,413
High Plains UWCD No.1 (GMA 1)												
2015	18,618	7,175	-27,418	0	-36	-61	-430	2,203	0	0	1,345	-1,396
2020	32,263	7,175	-40,622	0	-31	-32	-386	2,424	0	0	622	-1,412
2030	31,673	7,175	-39,287	0	-20	0	-315	2,645	0	0	-403	-1,466
2040	26,493	7,175	-33,591	0	-12	0	-258	2,773	0	0	-1,050	-1,528
2050	22,038	7,175	-29,300	0	-6	0	-221	2,832	0	0	-919	-1,598
2060	18,241	7,175	-25,868	0	-2	0	-188	2,873	0	0	-567	-1,665
2070	15,233	7,175	-23,239	0	0	0	-159	2,904	0	0	-191	-1,724

3.4.4 Environmental impacts

GMA 1 District Representatives considered environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water. GMA 1 District Representatives reviewed the 2012 State Water Plan the 2017 State Water Plan; the HPASGAM Report and presentations during their meetings.

Based on HPASGAM water balance calculations, annual recharge to the Ogallala Aquifer remained between 324,889 acre-feet and 327,567 acre-feet from before to after aquifer pumping developed (1930-2012). Annual Ogallala Aquifer discharge to springs, rivers, and draws declined from 209,566 acre-feet to 85,914 acre-feet from before to after aquifer pumping developed. These reductions to discharge adversely affect stream flow in the management area. Hemphill UWCD illustrated the relationship between aquifer pumping and surface water impacts shown in Figure 3.4 through Figure 3.7.

Figure 3.4 2008-2009 groundwater level elevation impact on surface water in Hemphill County (from Hemphill UWCD 3-D Visualization Model).

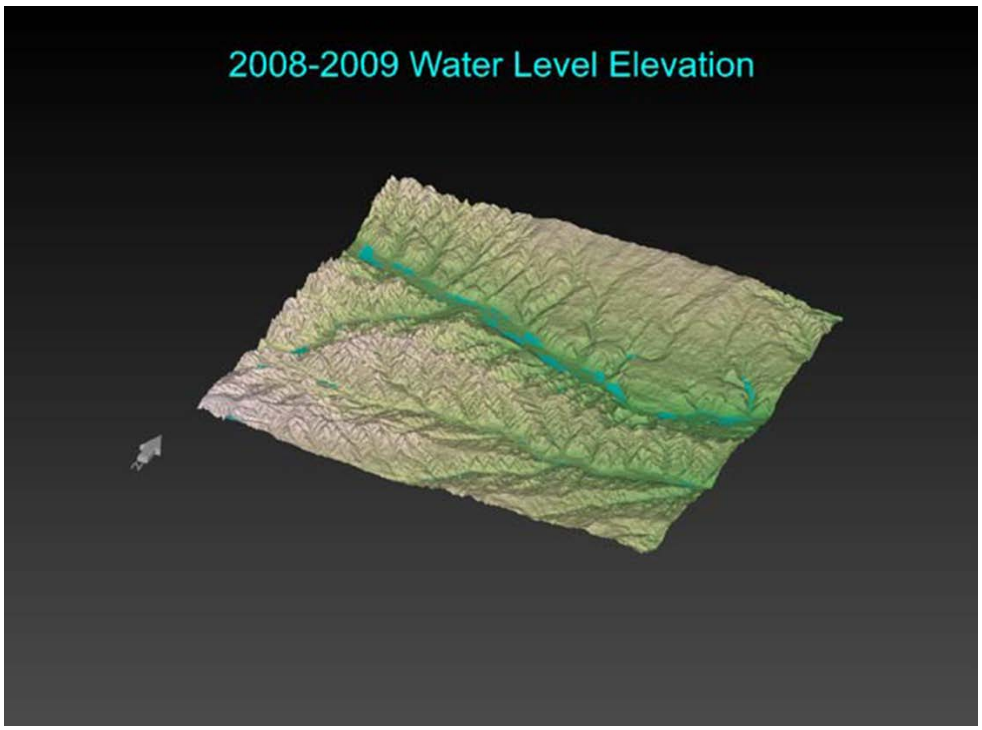


Figure 3.5 Impact to natural discharge with 80 percent remaining in storage (from Hemphill UWCD 3-D Visualization Model).

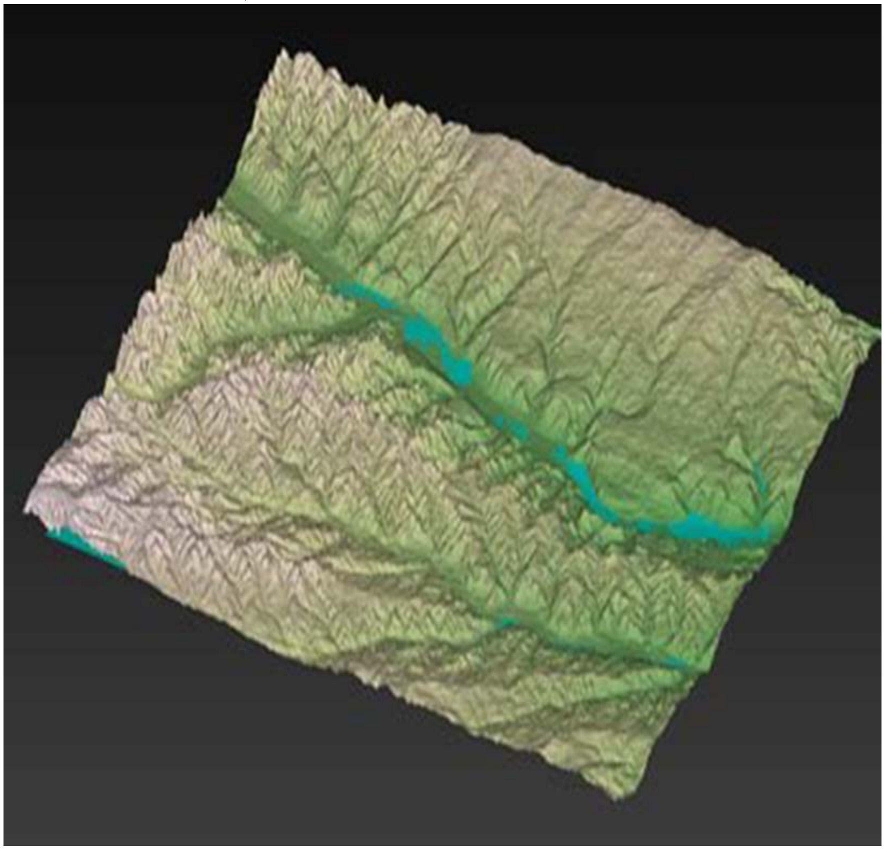


Figure 3.6 Impact to natural discharge with 70 percent remaining in storage (from Hemphill UWCD 3-D Visualization Model).

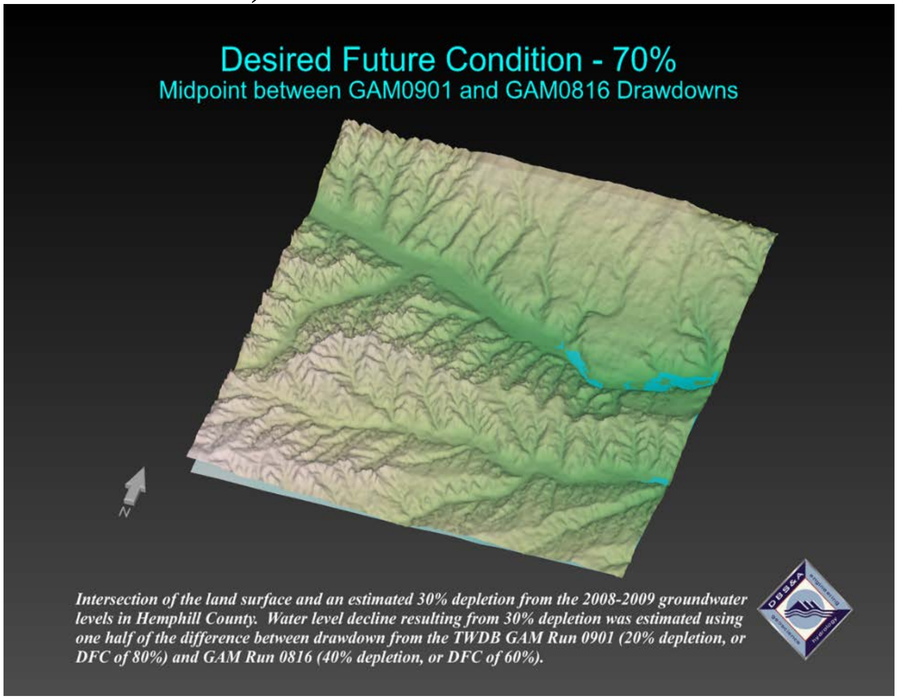
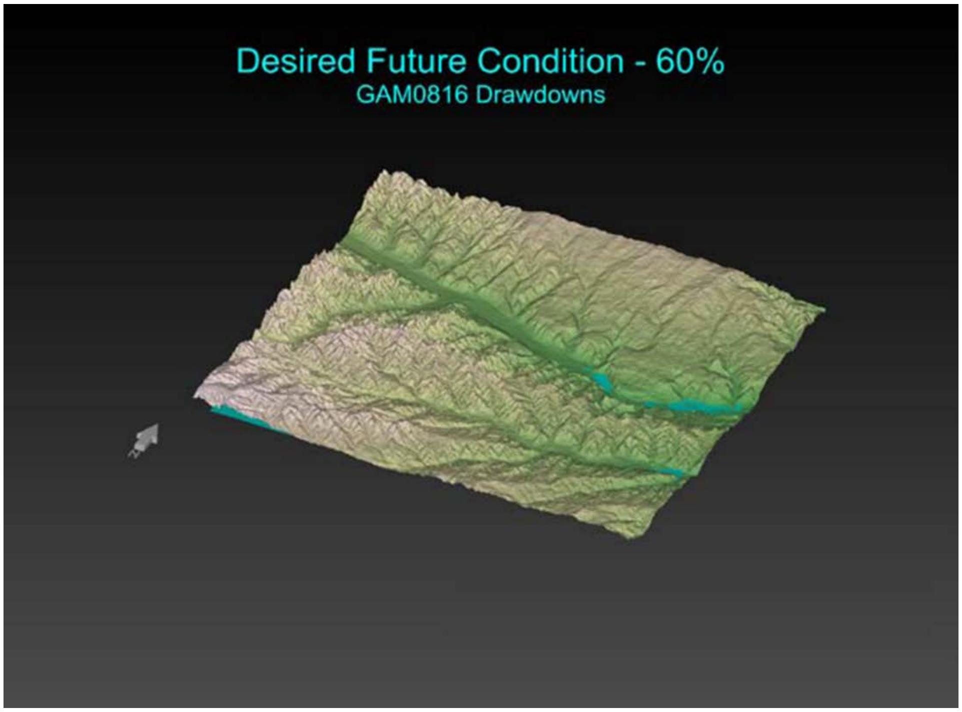


Figure 3.7 Impact to natural discharge with 60 percent remaining in storage (from Hemphill UWCD 3-D Visualization Model).



The 2011 PRWP articulates that reservoir development, groundwater development, and invasion by brush have altered natural stream flow patterns in the area. Spring flows in the area have generally declined over the past several decades. Much of the impact to springs is due to groundwater development, the spread of high water use plant species such as mesquite and salt cedar, or the loss of native grasses and other plant cover. High water use plant species have reduced reliable flows for many tributary streams. Reservoir development also changes natural hydrology by diminishing flood flows and capturing low flows. The DFCs considered by the GMA 1 will not change these issues.

GMA 1 Districts anticipate that groundwater pumping in the Ogallala Aquifer will continue to diminish the groundwater discharge to springs, rivers, draws and escarpments.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

3.4.5 Subsidence impacts

GMA 1 District Representatives considered impacts of the adopted DFCs on land subsidence based primarily on the 2017 State Water Plan and individual district records, GMA 1 District Representatives determined groundwater withdrawals from the Ogallala Aquifer create no significant impacts on subsidence in the management area and therefore the adopted DFCs should not impact subsidence.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

3.4.6 Socioeconomic impacts

GMA 1 District Representatives considered socioeconomic impact studies prepared by the TWDB for regional water planning purposes, along with multiple other studies that target areas in GMA 1 based on the DFCs options during joint planning meetings identified in Table 1.1.

GMA 1 District Representatives have identified that the adopted DFCs will not have any socio-economic impacts identified in the 2017 State Water Plan and associated with currently projected regional pumping demands. In addition to the socioeconomic information provided in the 2017 State Water Plan, the GMA 1 Districts reviewed other information that included:

- Economic Impacts of Selected Water Conservation Policies in the Ogallala Aquifer Report (Amosson et.al, 2014);
- Economic Impacts of Groundwater Management Standards in the Panhandle Groundwater Conservation District of Texas (Weinheimer, 2012);
- Evaluation of Changing Land Use and Potential Water Conservation Strategies: North Plains Groundwater Conservation District (Amosson et.al, 2014);
- Farm Level Financial Impacts of Water Policy on the Southern Ogallala Aquifer (Weinheimer, 2008);
- Multi-year water allocation: an economic approach towards future planning and management of declining groundwater resources in the Texas Panhandle (Tewari et.al, 2014);
- Socioeconomic Impacts of Projected Water Shortages for the Panhandle (Region A) Regional Water Planning Area Prepared in Support of the 2011 Panhandle Regional Water Plan (Norvell et.al, 2010);
- Water Conservation Policy Alternatives for the Ogallala Aquifer in Texas (Johnson, et.al, 2007); and
- Letter of Opinion Concerning Texas Panhandle Land Values: Hemphill UWCD (Scott Land Company LLC, Clift Land Brokers and the USFMRA Land Trends, 2016)

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and copies of the above reference documentation is found in the reference folder under Appendix IV – Factor Analysis.

3.4.7 Private property impacts

GMA 1 District Representatives considered the impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in groundwater during joint planning meeting described in Table 1.1. In 2015, GMA 1 District Representatives considered a presentation by Keith Good, attorney with Lemon, Shearer, Phillips and Good, P.C., regarding possible DFC impacts on private property rights. Mr. Good's presentation is as follows:

The consideration of impacts on private property rights is not new in groundwater management in Texas. a new concept for the GMAs. However, in 2010, if a petition was filed, the TWDB under its rules, considered the impact on private property rights as one of the Factors to determine if the adopted DFC was reasonable. In EAA vs. Day, the Texas Supreme Court sent a variety of signals regarding regulation by GCDs including:

- "Unquestionably, the State is empowered to regulate groundwater production."
- "Regulation is essential to groundwater conservation and use."
- The rule of ownership must be considered with the law of capture and is subject to police regulation.
- Each landowner "owns separately, distinctly, and exclusively all the water under his land."
- "Landowners do have a constitutionally compensable interest in groundwater."
- "Groundwater rights are property rights subject to constitutional protection; whatever difficulties may lie in determining adequate compensation for a taking."
- Any meaningful Rules adopted by a District to achieve a DFC may have a potential impact on property rights.
- "Considerations" analyze how property rights could be impacted.
- Impacts are not equated as "takings" in this process.
- Impacts may be viewed as both restricting and benefitting property rights.

Mr. Good condensed the interest groups with property interests and rights related to the production and conservation of groundwater in GMA 1 including:

- Interests and rights that are benefitted or enhanced by the present use of groundwater;
- Interests and rights that are benefitted or enhanced using groundwater soon;
- Interests and rights that are benefitted or enhanced by the ability to use groundwater over the long-term; and
- Interests and rights that are benefitted or enhanced by leaving a significant amount of groundwater in place.

By statute and under EAA vs. Day, all landowners have constitutionally protected property rights in groundwater beneath their property. A GMA must consider the rights of all owners of private property including all owners of groundwater within the GMA. All identified interests have the potential to be "impacted" by groundwater regulation (or the absence of regulation). Existing GCD rules that implement DFCs adopted by GMA-1 in 2010 impact or affect private property rights by setting well spacing requirements and production limits. Spacing Requirements impact where landowners may drill wells. Spacing requirements may also positively impact the property interests of neighboring landowners by reducing the potential for interference between wells.

Production limitations currently exist in the GMA-1 districts. Such rules are designed to prolong the groundwater supply and reduce the drainage of groundwater owned by neighboring landowners.

Some of the potential impacts on property rights of DFCs favoring "highest practicable production" are as follows:

- Lenient production restrictions that allow existing users to produce more groundwater with less acreage;
- Endangers water supply and needs of future users; and
- Escalated production will increase drainage of groundwater from neighboring landowners.

Potential impacts on property rights of DFCs favoring conservation, preservation, protection and recharging:

- Increased production limits may force existing users to reduce groundwater production or acquire additional groundwater rights;
- May extend groundwater supply and levels to meet future needs;
- May extend the productive life of the aquifer; and
- May minimize interference between groundwater right owners.

A GMA is expressly allowed to adopt DFCs for the "establishment of DFCs that provide for the reasonable long-term management of groundwater resources. GMA 1 must consider the impact of GMA-1 DFCs on private property rights in groundwater as recognized under TWC Section 36.002. Owners are entitled to drill for and produce groundwater (subject to regulation by groundwater conservation districts). Owners are not entitled to capture any amount of groundwater they choose. Section 36.002 does not grant a GCD the authority to deprive or divest an owner of the rights described by Section 36.002. It is unlikely that GMA 1 DFCs will result in an owner being prohibited from drilling for and producing groundwater; and, it is unlikely that GMA 1 DFCs will result in an owner being deprived or divested of groundwater rights described in Section 36.002.

Different DFCs, rules, and policy decisions by the Districts within GMA 1 may impact private property rights differently. Each District's management plan and rules and the implementation thereof, may have more potential to "impact" private property rights in groundwater than DFCs.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis**.**

3.4.8 Achievement feasibility

GMA 1 District Representatives considered the feasibility of achieving the adopted DFCs. During the last round of joint planning, the TWDB was required by statute to determine if DFCs were "reasonable". The TWDB determination was based primarily on whether achieving the adopted DFCs was possible. GMA 1 District Representatives used the HPASGAM, other groundwater models, estimated groundwater production compared to the modeled pumping levels, GMA 2 Technical Memorandum, DFC, INTERA modeled pumping levels, and the TERS provided by the TWDB and various presentations to analyze feasibility of the adopted DFCs. The most recent GAM predictive run (Task Run 15-006) from the TWDB indicates that the adopted DFCs are physically possible even within the constraints of recoverable storage. The available information shows that the adopted DFCs are achievable and therefore, feasible based on TWDB precedence.

GMA 1 District Representatives adopted DFCs that can be individually and as a group feasibly achieved based on the predictive runs from the HPASGAM.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis**.**

3.4.9 Other information

TWC Section 36.108(d)(9) requires the districts to consider any other information relevant to the specific DFCs. GMA 1 did not discuss other information relevant to the specific DFCs that was not already considered under the other eight factors.

To this point, all material information related to the adoption of an adopted DFC has been tied to one or more of the previously discussed Factors. These presentations were considered in relationship to multiple Factors discussed above. As such, no additional information has been designated as “other” at this time by the voting membership of the GMA 1.

Documentation for GMA 1 joint planning meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

3.5 Discussion of other DFCs considered

GMA 1 District Representatives originally considered Ogallala Aquifer DFCs adopted in 2009, during the first round of Joint Planning. The original DFCs were expressed as percent of storage remaining in fifty years. In the current round of joint planning, the GMA 1 Districts elected to continue with percent of storage remaining in all areas within GMA-1 except for Randall County and within the High Plains UWCD in Armstrong and in Potter counties. High Plains District’s jurisdiction primarily lies within GMA-2 and has only 4.6 percent (345,722 Acres) of its jurisdiction is within GMA 1. The High Plains UWCD requested that GMA-1 adopt DFCs using feet of drawdown instead of percent storage in the district’s jurisdictional areas. By establishing DFCs based on feet of aquifer drawdown, High Plains UWCD can consistently apply the Ogallala Aquifer DFC in GMA-1 to the DFCs set for the rest of its district in GMA 2.

Hemphill UWCD evaluated different potential DFCs ranging from 60 percent through 70 percent to 80 percent of the Ogallala Aquifer remaining in storage in 50 years. Hemphill UWCD’s 3-D Visualization Model shows that leaving 80 percent of the Ogallala Aquifer in storage is a good balance of addressing stream flow while providing for groundwater withdrawals. As shown in figure 3.5 of this report, even at 80 percent of the aquifer remaining, part of the Canadian River becomes a losing stream, and subsequent figures show continuing decline of stream flow as pumping is increased. The 80 percent DFC provides the desired balance between production and conservation within the Hemphill UWCD.

3.6 Discussion of other recommendations

GMA 1 District Representatives provided the public opportunity to comment on the DFC Joint Planning Process or recommend other DFCs at all sixteen joint planning meetings. Each District also held respective public hearings to discuss the Proposed DFCs with the public in their local service areas.

3.6.1 Advisory committees

GMA 1 Districts did not establish advisory committees for this round of planning and therefore no comment from such committees were filed.

3.6.2 Public comments

On April 20, 2016, the GMA 1 Districts unanimously voted to adopt Proposed DFCs for the major aquifers in the Joint Planning Area.

A 90-day public comment period extended from May 13, 2016 to August 15, 2016 was utilized. During the public comment period and after posting notice as required by TWC Section 36.063, each district held at least one public hearing on proposed DFCs relevant to that district. During the public comment period, the districts made available in its office a copy of the proposed DFCs and any supporting materials. All documents considered in the joint planning process were organized and posted for the convenience of the public and GMA 1 membership. Individual districts held public hearings during the statutorily required ninety (90) day public input phase prior to the final consideration of DFCs on the Panhandle Regional Planning Commission's website as follows:
http://www.panhandlewater.org/GMA_Proposed_Documents.html

After the public hearings, the GMA 1 Districts compiled information for consideration at the October 5, 2016 and November 2, 2016 Joint Planning meetings a summary of relevant comments received, any suggested revisions to the proposed DFCs, and the basis for the revisions. These comments were also considered during the November 2, 2016 meeting at which DFCs were adopted.

Through the public input process, GMA 1 Districts received one public comment to High Plains UWCD against any proposed so-called "Desired Future Condition" greater than zero.

GMA 1 District Representatives recognized that the public comment was ambiguous. To technically consider the comment's feasibility, the GMA 1 Districts relied on TWDB TERS report information provided for the Joint Planning Process (TWDB 2015). According to the information included in the report that TERS for the all aquifers within GMA 1 ranges between 25 percent and 75 percent, GMA 1 District Representatives interpreted the report that at least some water in storage is not recoverable. Therefore, achieving a DFC of zero storage is technically not feasible. Likewise, a DFC of zero drawdown is not feasible because of current and projected future WUG groundwater pumping.

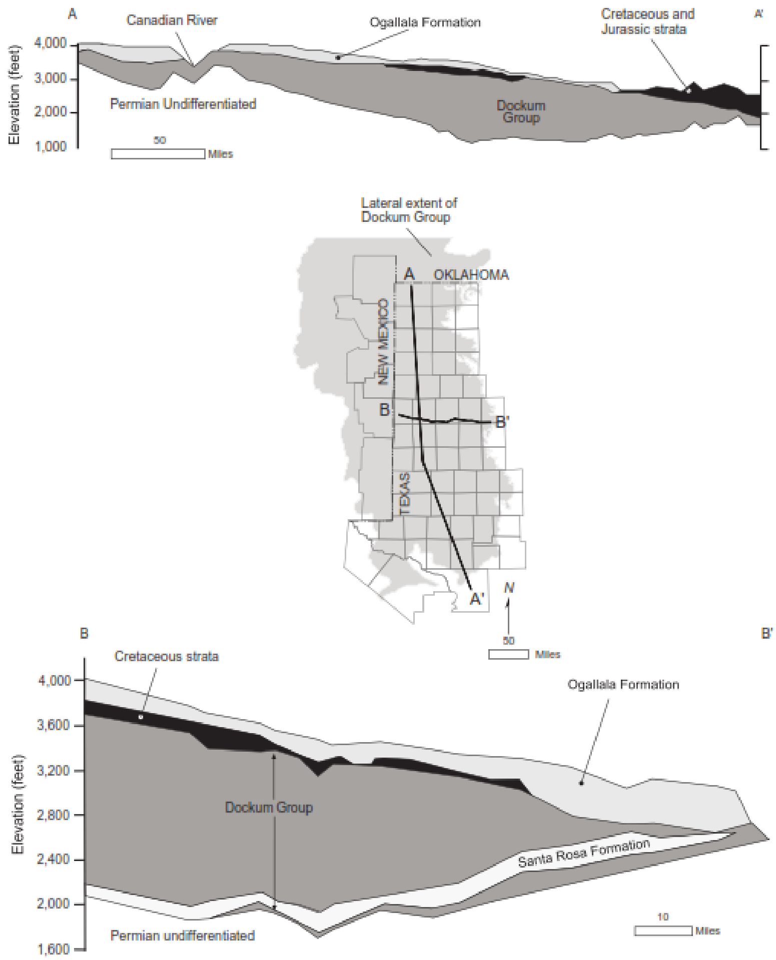
4 DOCKUM AQUIFER DESCRIPTION AND DESIRED FUTURE CONDITIONS

4.1 Dockum Aquifer Description

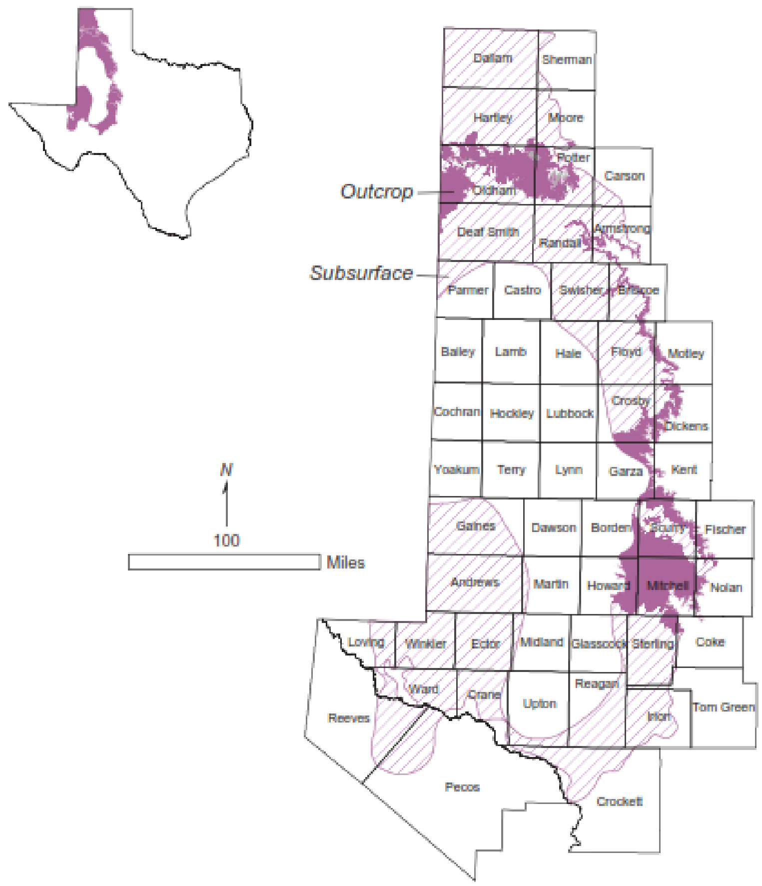
The TWDB defines the Dockum Aquifer as the water bearing units of the Triassic aged Dockum Group. The Dockum Group extends through parts multiple TWDB Regional Water Planning Areas and parts of four Groundwater Management Areas. TWDB Report 359 (Bradley and Kalaswad, 2003) estimated that the Dockum Group's total aerial extent is approximately 42,000 square miles in Texas. Figure 4.1 shows geologic cross sections of the Dockum Group, modified from Bradley and Kalaswad, 2003). Though regionally extensive, the TWDB classifies the Dockum Aquifer as a minor aquifer because of its generally poor water quality and limited production. In GMA 1, is located on the north-northwest end of the Dockum basin. Based on water quality data from North Plains GCD, the Lower Dockum Aquifer appears to be of higher water quality in Dallam, Hartley and Moore counties than further south in the Dockum basin. Figure 4.2 shows the aerial extent of the Dockum Aquifer in Texas (George et.al. 2011).

The Dockum Aquifer is in nine counties primarily in the western portion of GMA 1. The TWDB HPASGAM segregates the aquifer into the Upper Dockum and the Lower Dockum. The Lower Dockum is present in the management area and includes Tecovas Formation, a variegated, sometimes sandy mudstone with interbedded fine to medium grained sandstone; and the Santa Rosa Formation, a red to reddish-brown sandstone and conglomerate. Groundwater located in the Santa Rosa sandstone and conglomerate provides the highest yields water resource in the aquifer with lesser amounts of water yielding from the Tecovas sands. Locally, all water bearing sands within the Dockum Aquifer are referred to as "Santa Rosa".

Figure 4.1 Geologic cross sections of the Dockum Group along (A-A') and across (B-B') (modified from Bradley and Kalaswad, 2003)



<u>Figure 4.2</u> Dockum Aquifer the aerial extent in Texas (George et.al. 2011)



4.2 Dockum Aquifer Desired Future Conditions

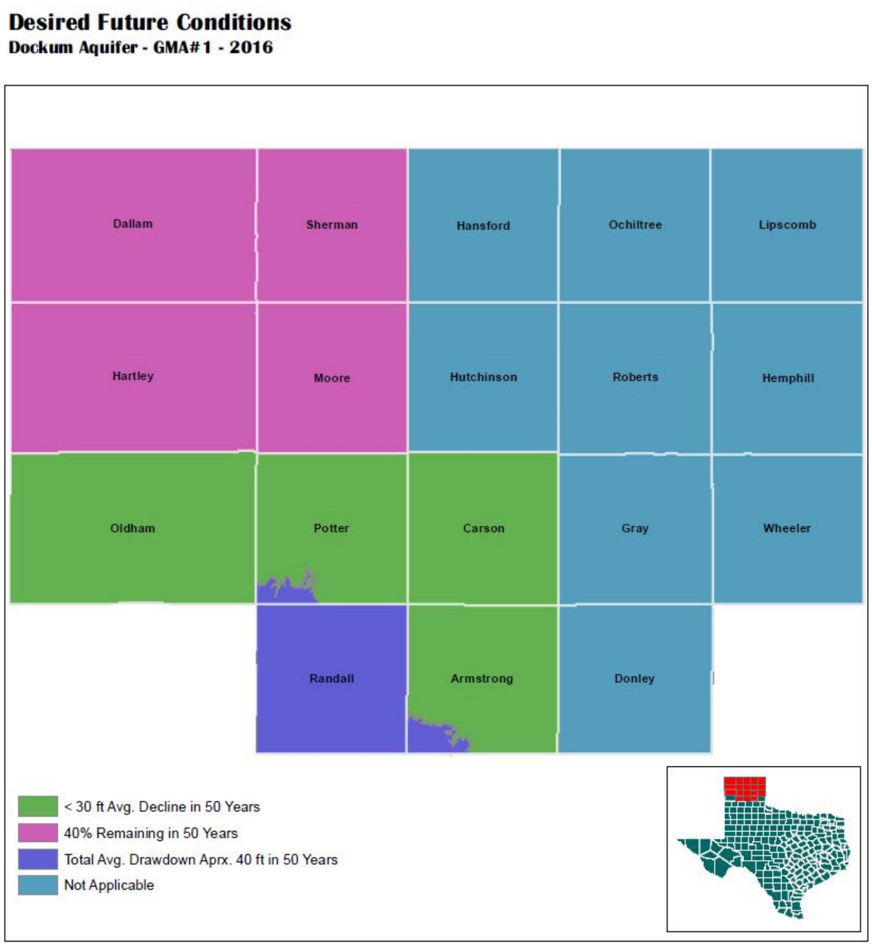
GMA 1 District Representatives unanimously adopted DFCs for the Dockum Aquifer by resolution (Resolution 2016-2) on November 2, 2016.

The Dockum Aquifer DFCs adopted by Groundwater Management Area 1 are as follows:

- At least 40 percent of the available drawdown remaining for the period 2012 -2062 in 50 years for Dallam, Hartley, Moore, and Sherman counties
- No more than 30 feet average decline in water levels in for the period 2012 -2062 in 50 years in Carson and Oldham counties and in Armstrong and Potter counties within the Panhandle GCD ; and
- The total average drawdown is approximately 40 feet in 50 years for the period 2012 -2062, in Randall County, and in Armstrong and Potter counties within the High Plains UWCD.

Resolution 2016-2 is provided in Appendix I – DFC Documents. Documentation for this meeting including meeting postings, agenda package, sign-in sheet and meeting supplements, including the draft resolution are provided in Appendix III- Meeting Documentation.

Figure 4.3 GMA 1 Dockum Aquifer DFC Map (provided by PRPC, 2016)



4.3 Policy and Technical Justification

TWC Section 36.108(d-2) requires that DFCs proposed as part of joint planning in the management area must provide a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the management area. GMA 1 District Representatives established different DFCs throughout the management area based on a combination of policy and technical considerations that provide continued economic development of the area while providing for the reasonable long-term management of groundwater resources consistent with the management goals under TWC Section 36.1071(a).

4.3.1 Policy justification

The Dockum Aquifer is in the nine western counties in GMA 1 and is currently designated as a minor regional water supply that will more than likely be tapped more to offset diminishing Ogallala Aquifer supplies in the future. The development of different Dockum Aquifer DFCs in GMA 1 strike a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste.

The estimated modeled pumping levels from the adopted Dockum DFCs exceed the current groundwater pumping and will be used to meet future needs over the next fifty years while leaving substantial water in the ground for the future in GMA 1.

4.3.2 Technical justification

The Dockum Aquifer DFCs allow for future growth while promoting conservation. GMA 1 District Representatives reviewed numerous information sources when considering DFC options and before adopting final DFCs. To evaluate the DFC options and the adopted DFCs, INTERA Inc. used the TWDB HPASGAM (Deeds and Jigmond, 2015). The

In December 2015, TWDB accepted as the official GAM for the region the HPASGAM along with the HPAS Report (Final Report for the High Plains Aquifer System Groundwater Availability Model); and HPAS Numerical Model Report. The final predictive model run based on the adopted DFCs and Technical Memorandum were prepared by INTERA Inc. at the request of GMA 1 GCDs. The Technical Memorandum, provided in Appendix VI, provides a summary of the adopted DFC simulations. The purpose of this memorandum is to provide the model input files to the TWDB so that the Executive Administrator can evaluate the feasibility of the adopted DFCs and to confirm predictive run results to estimate modeled available groundwater (MAG).

Because 2012 was the last year of the transient model, 2012 was used as the reference year for comparison to a future aquifer condition. For comparison to a condition 50 years in the future, hydraulic heads at the end of the stress period corresponding to 2062 were compared to the initial calculated hydraulic heads (from the end of 2012). For the predictive simulation, the last simulated year was 2070, so the run was comprised of a total of 58 annual stress periods. To perform the HPASGAM predictive run for the adopted DFCs, INTERA assumed 2015 pumping rates are identical to the last year of the calibrated model (2012) except in North Plains GCD where annual pumping rates were provided by North Plains GCD staff. HPASGAM predictive run input file shows that to achieve the adopted DFCs in GMA 1, the Dockum Aquifer predicted modeled available groundwater will decline from 232,458 acre-feet/year in 2016 to 229,891acre-feet/year by 2062 (the 50-year planning period) and 220,461 acre-feet/year in 2070. When compared to the 2017 State Water Plan, the Dockum Aquifer predicted modeled available groundwater can be used to supplement the water supply to meet projected water demand in GMA 1. Though the modeled pumping levels show that even with the Dockum Aquifer's supplemental capability, localized and county-wide areas will experience water needs that cannot be met by the Dockum Aquifer and the Ogallala Aquifer together. Those areas will need to implement water management strategies such as transporting water from other areas, conservation or developing additional water resources from other aquifers. Table 4.1 is a compilation of modeled pumping levels based on the adopted DFCs. The 2015 rates are estimated production rates identical to the last year of the calibrated model (2012). The 2016 rate is first year of the HPAS GAM run to show modeled pumping levels, which provides 68 percent more water available aquifer wide than was estimated annually withdrawn in 2012 through 2015.

Table 4.1 Dockum Aquifer modeled pumping levels based on the adopted DFCs in acre-feet/year (modified from the Technical Memorandum).

COUNTY	2015	2016	2020	2030	2040	2050	2062	2070
ARMSTRONG	171	5,824	7,246	9,023	9,614	9,704	9,493	9,270
CARSON	29	53	68	108	140	169	203	225
DALLAM	2,755	14,234	14,231	14,188	14,224	14,184	14,183	14,183
HARTLEY	2,019	55,683	55,399	55,035	55,077	54,862	54,836	54,847
MOORE	1,604	5,302	5,233	5,106	5,033	4,925	4,758	4,639
POTTER	1,348	32,050	38,930	39,112	37,037	34,504	31,557	29,665
OLDHAM	1,128	111,290	129,354	128,828	120,848	111,196	99,735	92,701
RANDALL	2,603	7,895	11,202	14,016	14,902	15,113	15,034	14,844
SHERMAN	484	127	127	127	127	127	92	87
TOTAL	12,141	232,458	261,790	265,543	257,002	244,784	229,891	220,461

Documentation for GMA 1 meetings identified in Table 1.1 including meeting postings, agenda package, sign-in sheets and meeting supplements are provided in Appendix III- Meeting Documentation. The HPAS Report, HPAS Predictive Runs, and the final HPAS Technical Memorandum and supplemental GAM runs are provided in Appendix VI – GAM Models and Reports.

4.4 Dockum Aquifer Factor Consideration

4.4.1 Aquifer uses or conditions

During their meetings, GMA 1 District Representatives received presentations from their staffs regarding aquifer uses and conditions including: physical landscape, satellite imagery modified to show estimated groundwater use by county; estimated groundwater use by county and WUG; cross-sections and hydrologic maps showing differing aquifer elevations, water level declines, saturated thicknesses, and depth to base. GMA 1 District Representatives considered water uses and conditions provided in the 2012 State Water Plan and in the 2017 State Water Plan, as well as other TWDB data sources, and GMA 1 District information. GMA 1 District Representatives considered aquifer uses and conditions for the aquifers within the management area during the DFC joint planning meetings identified in Table 1.1.

GMA 1 District Representatives considered aquifer uses by water user groups (WUGs) collectively including: municipal, irrigated agriculture, livestock, manufacturing, steam electric, and mining. Historically, the Dockum Aquifer supplied minor amounts of water for irrigation, municipal and domestic water use, and livestock watering compared to the Ogallala Aquifer. Dockum Aquifer pumping in GMA 1 by year, by WUG and by county from 2005-2014 is shown in Table 4.2 and Table 4.3. Table 4.4 shows GMA 1 Dockum Aquifer average pumping in acre-feet by WUG and by county from 2005-2014.

HPASGAM predictive runs based on the adopted Dockum Aquifer DFCs show additional water available to supplement WUG current use or projected future WUG demands than has been currently developed. Ogallala Aquifer declines may cause increased groundwater use from the Dockum Aquifer.

Table 4.2 GMA 1 Dockum Aquifer pumping in acre-feet by year and by WUG from 2005-2014 (TWDB WUSGPE, updated October 9, 2016).

Year	Municipal	Manufacturing	Mining	Steam Electric Power	Irrigation	Livestock	Total
2005	876	0	0	0	3,220	1,458	5,554
2006	1,803	0	0	0	2,257	2,450	6,510
2007	1,434	0	0	0	2,751	1,666	5,851
2008	1,613	0	0	0	2,343	1,379	5,335
2009	1,800	0	0	0	2,293	1,330	5,423
2010	4,074	0	0	0	1,770	1,330	7,174
2011	3,228	0	0	0	2,837	1,581	7,646
2012	2,602	0	0	0	2,579	1,606	6,787
2013	2,469	0	0	0	2,440	1,467	6,376
2014	2,361	0	0	0	2,115	1,554	6,030

Table 4.3 GMA 1 Dockum Aquifer pumping in acre-feet by year and by county from 2005-2014 (TWDB WUSGPE, updated October 9, 2016).

County	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ARMSTRONG	146	163	109	122	114	92	127	131	93	76
CARSON	0	8	6	7	12	17	19	18	11	7
HARTLEY	621	1,054	692	831	791	694	948	1,003	982	1,042
MOORE	2,008	1,261	1,733	1,297	1,362	1,129	1,853	1,627	1,544	1,441
OLDHAM	1,223	1,497	1,163	814	758	794	1,056	959	961	874
POTTER	626	1,138	1,020	1,022	1,111	1,131	1,011	1,046	1,020	783
RANDALL	930	1,389	1,128	1,242	1,275	3,317	2,632	2,003	1,765	1,807
Total	5,554	6,510	5,851	5,335	5,423	7,174	7,646	6,787	6,376	6,030

Table 4.4 GMA 1 Dockum Aquifer average pumping in acre-feet by WUG and by county from 2005-2014 (TWDB WUSGPE, updated October 9, 2016).

County	Municipal	Manufac turing	Mining	Steam Electric Power	Irrigation	Livestock	Total
ARMSTRONG	11	0	0	0	47	59	117
CARSON	12	0	0	0	0	0	12
HARTLEY	70	0	0	0	0	796	866
MOORE	6	0	0	0	1520	0	1526
OLDHAM	325	0	0	0	315	370	1010
POTTER	872	0	0	0	111	8	991
RANDALL	932	0	0	0	468	349	1749

4.4.2 Water supply needs and water management strategies included in the State Water Plan.

TWC Section 36.108(d)(2) requires that District Representatives consider the water supply needs and water management strategies included in the state water plan. GMA 1 Districts considered data from the 2012 State Water Plan and from the 2017 State Water Plan. Information from both regional and state plans are provided in the supporting documentation; however, for the purposes of simplicity, the 2017 State Water Plan is referenced in discussing the water supply needs and water management strategies for GMA 1.

The GMA 1 anticipates that the Dockum Aquifer will be used to supplement the water to address regional water supply needs and water management strategies included in the 2017 State Water Plan. GMA 1 District Representatives used the same information for consideration of water supply needs and water management strategies as for consideration of this Factor in adopting Ogallala Aquifer DFCs. For a more thorough discussion of GMA 1 consideration of this Factor please refer to Section 3.4.2 Water Supply Needs and Water Management Strategies in this explanatory report.

GMA 1 District Representatives considered water supply needs and water management strategies within GMA 1 during the DFC joint planning meetings identified in Table 1.1.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III - Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

4.4.3 Hydrological conditions

GMA 1 District Representatives considered hydrological conditions; and, including for each aquifer in the management area, TERS as provided by the TWDB Executive Administrator, as well as the average annual recharge, inflows, and discharge during meetings identified in Table 1.1. During those meetings, GMA 1 District Representatives reviewed numerous reports and model runs including:

- Previous TWDB GAM runs,
- TWDB estimates of TERS,

- Groundwater recharge reports,
- Aquifers of Texas TWDB Report 380, and
- Multiple TERS presentations during their meetings.

Documentation for GMA 1 meetings including meeting postings, agenda package, minutes, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

4.4.3.1 Total estimated recoverable storage (provided by TWDB)

The TWDB defines total estimated recoverable storage (TERS) as the estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume. In other words, the TWDB assumes that between 25 and 75 percent of groundwater held within an aquifer can be removed by pumping. TERS does not account for a variety of important conditions and aquifer characteristics that limit groundwater production such as well withdrawal rate, well density, hydraulic conductivity, withdrawal costs, aquifer petrology, permeability, and potential water quality degradation, etc. The TERS calculation represents the approximate percentage of total storage volume in the water-producing zones of an aquifer; however, not all the water in those zones are “practicably recoverable”. The basis of the TERS calculation does not require an amount that could be recovered during any planning period. Recovery of all water from TERS would take longer than the fifty-year planning horizon and at a cost impractical for regional uses. Therefore, TERS accounts for water that cannot be practicably produced for beneficial use at any level in the GMA 1. Unlike TERS which simply measures volume, the highest practicable level of groundwater production is defined as a rate by measuring a volume produced through time.

Table 4.5 and Table 4.6 identify Dockum Aquifer TERS by county and District in the GMA 1 TERS by county & district in GMA 1 from TWDB GAM Task Report 15-006 (Kohlrenken, 2015).

As required by statute, the TWDB executive administrator provided the GMA 1 Districts with an updated TERS Report after the TWDB accepted the HPASGAM from INTERA Inc., in 2015. GMA 1 District Representatives evaluated TERS provided by the TWDB and found that though TERS provides a total amount of groundwater that can possibly be produced given the discussion above, only a portion of groundwater in storage can be feasibly withdrawn to address the current uses and future anticipated groundwater demands. GMA 1 District Representatives selected DFCs that allow for substantial storage to remain for future demands after the fifty-year planning period while ensuring that water is available to meet for most WUG water demands outlined in the 2017 State Water Plan.

Table 4.5 Dockum Aquifer TERS by county in GMA 1 (TWDB GAM Report 15-006.)

County	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Armstrong	7,000,000	1,750,000	5,250,000
Carson	1,900,000	475,000	1,425,000
Dallam	80,000,000	20,000,000	60,000,000
Hartley	96,000,000	24,000,000	72,000,000
Moore	7,400,000	1,850,000	5,550,000
Oldham	43,000,000	10,750,000	32,250,000
Potter	10,000,000	2,500,000	7,500,000
Randall	46,000,000	11,500,000	34,500,000
Sherman	540,000	135,000	405,000
Total	**291,840,000**	**72,960,000**	**218,880,000**

Table 4.6 Dockum Aquifer TERS by GCD in GMA 1 (TWDB GAM Report 15-006.)

Groundwater Conservation District	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
High Plains UWCD[2] No.1	28,000,000	7,000,000	21,000,000
North Plains GCD	170,000,000	42,500,000	127,500,000
Panhandle GCD	15,000,000	3,750,000	11,250,000
No District	77,000,000	19,250,000	57,750,000
Total	**290,000,000**	**72,500,000**	**217,500,000**

4.4.3.2 Average annual recharge, Inflows and Discharge

GMA 1 District Representatives considered the aquifer's annual recharge, inflows, and discharge. A water budget for the Dockum Aquifer was developed as part of constructing the HPASGAM. The model divides the Dockum Aquifer into the upper Dockum and the lower Dockum hydrostratigraphic units and has calculated a water budget for the steady state conditions (before pumping) in the 1930s and for transient conditions (after pumping began) in 1980 and 2012 for each of these units. The HPASGAM water budget calculates recharge, evapotranspiration, springs, rivers, draws, escarpments, reservoirs, aquifer storage, lateral flow, and cross-formational flow. HPASGAM calculations for the steady-state model and the 2012 transient model are shown from Table 4.7 through Table 4.10. Before pumping began in GMA 1, the water flowed into and out of the Dockum Aquifer without affecting aquifer storage. The upper Dockum constitutes a very minor influence in the total well withdraws in the Dockum Aquifer. However, the model shows that water in storage in the upper Dockum is being lost to cross-formational flow. The upper Dockum does not interact with regards to recharge, evapotranspiration, springs, rivers, draws and escarpments. In GMA 1, the lower Dockum receives recharge in areas where its strata are exposed at the surface. The aquifer discharges water as evapotranspiration, springs, rivers, draws, escarpments, lateral and cross-formational flow. The model calculates recharge based on HPASGAM water budget calculations. Annual recharge to the lower Dockum remained between 8,572 acre-feet during the aquifer's steady state (generally before pumping) and 8,706 acre-feet during the aquifer's transient state (after pumping developed) from 1930 to 2012. The aquifer provides significant discharge to springs, rivers and draws.

Table 4.7 Water budget for the upper Dockum by county for the steady-state model (modified from HPAS Report).

County	Recharge	ET	Springs	Rivers	Draws	Escarp-ments	Lateral	Cross-Form-ational
Dallam	0	0	0	0	0	0	3	-3
Hartley	0	0	0	0	0	0	4	-4
Moore	0	0	0	0	0	0	0	0
Oldham	0	0	0	0	0	0	-1	1
Potter	0	0	0	0	0	0	0	0
Randall	0	0	0	0	0	0	0	0
Sherman	0	0	0	0	0	0	0	0

Table 4.8 Water budget for the lower Dockum by county for the steady-state model (modified from HPAS Report).

County	Recharge	ET	Springs	Rivers	Draws	Escarp-ments	Lateral	Cross-Form-ational
Armstrong	226	0	-295	-509	-2,276	0	619	2,235
Carson	0	0	0	0	0	0	287	-287
Dallam	0	0	0	0	0	0	-51	51
Hartley	205	-314	0	969	0	0	-2,170	1,310
Hutchinson	0	0	0	0	0	0	0	0
Moore	64	0	0	-65	0	0	-298	298
Oldham	5,786	-3,674	-120	-10,130	0	0	4,310	3,828
Potter	2,211	-1,106	-22	-3,561	-395	0	1,171	1,703
Randall	80	0	0	-2,557	-748	0	-18	3,243
Sherman	0	0	0	0	0	0	53	-53
Total	**8572**	**-5094**	**-437**	**-15,853**	**-3419**	**0**	**3903**	**12,328**

Table 4.9 Water budget for the upper Dockum by county for year 2012 of the transient model (modified from HPAS Report).

County	Recharge	ET	Springs	Rivers	Draws	Escarp ments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Dallam	0	0	0	0	0	0	0	-23	1,131	5	-1,113
Hartley	0	0	0	0	0	0	0	-2	706	4	-708
Moore	0	0	0	0	0	0	0	0	14	0	-14
Oldham	0	0	0	0	0	0	0	-1	7	-2	-4
Potter	0	0	0	0	0	0	0	0	0	0	0
Randall	0	0	0	0	0	0	0	-22	240	-1	-218
Sherman	0	0	0	0	0	0	0	0	0	0	0

Table 4.10 Water budget for the lower Dockum by county for year 2012 of the transient model (modified from HPAS Report).

County	Recharge	ET	Springs	Rivers	Draws	Escarp ments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Armstrong	228	0	-295	-509	-2,261	0	0	-173	274	586	2,150
Carson	0	0	0	0	0	0	0	-138	310	174	-347
Dallam	0	0	0	0	0	0	0	-2,757	3,466	22	-731
Hartley	205	-313	0	985	0	0	0	-2,022	3,826	-2,566	-115
Hutchinson	0	0	0	0	0	0	0	0	0	0	0
Moore	64	0	0	-55	0	0	0	-1,605	222	34	1,340
Oldham	5,906	-3,719	-120	-9,813	0	0	0	-1,129	1,112	4,192	3,571
Potter	2,217	-1,078	-22	-3,392	-395	0	0	-1,472	1,443	1,120	1,580
Randall	86	0	0	-2,328	-747	0	0	-2,634	2,811	336	2,476
Sherman	0	0	0	0	0	0	0	-485	252	241	-8
Total	8,706	-5,110	-437	-15,112	-3403	0	0	-12,415	13,716	4,139	9,916

Based on HPAS GAM water budget calculations, annual Dockum Aquifer discharge to springs, rivers, and draws ranged between 19,709 acre-feet and 18,952 acre-feet from before to after aquifer pumping developed.

4.4.4 Environmental impacts

GMA 1 District Representatives considered environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water. GMA 1 District Representatives reviewed the 2012 State Water Plan the 2017 State Water Plan; the HPASGAM Report and presentations during their meetings.

Based on HPASGAM water balance calculations, annual discharge from the Dockum Aquifer to springs, rivers and draws remained approximately 20,000 acre-feet from before to after aquifer pumping developed (1930-2012).

As groundwater production from the Dockum Aquifer increases with additional well withdrawals, GMA 1 District Representatives anticipate the amounts of water discharge to maintain spring and river flows should decrease.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III - Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

4.4.5 Subsidence impacts

GMA 1 District Representatives considered impacts of the adopted DFCs on land subsidence based primarily on the 2017 State Water Plan and individual district records, GMA 1 District Representatives determined groundwater withdrawals from the Ogallala Aquifer create no significant impacts on subsidence in the management area and therefore the adopted DFCs should not impact subsidence.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

4.4.6 Socioeconomic impacts

GMA 1 District Representatives considered socioeconomic impact studies prepared by the TWDB for regional water planning purposes, along with multiple other studies that target areas in GMA 1 based on the DFCs options during joint planning meetings identified in Table 1.1.

GMA 1 considered the same information to address this Factor as they considered under Section 3.4.6 of this report. GMA 1 District Representatives have determined that the adopted DFCs will not have any socio-economic impact that exceed the socio-economic impacts identified in the 2016 PRWP associated with currently projected regional pumping demands.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

4.4.7 Private property impacts

GMA 1 District Representatives considered the impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in groundwater during joint planning meeting described in Table 1.1.

A full discussion of GMA 1 consideration of this Factor is provided under Section 3.4.7 Private Property Impacts of this explanatory report. Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis.

4.4.8 Achievement feasibility

GMA 1 District Representatives considered the feasibility of achieving the adopted DFCs. During the last round of joint planning, the TWDB was required by statute to determine if DFCs were “reasonable”. The TWDB determination was based primarily on whether achieving the adopted DFCs was possible. GMA 1 District Representatives used the HPASGAM, other groundwater models, estimated groundwater production compared to the modeled pumping levels, GMA 2 Technical Memorandum, DFC, INTERA modeled pumping levels, and the TERS provided by the TWDB and various presentations to analyze feasibility of the adopted DFCs. The most recent GAM predictive run (Task Run 15-006) from the TWDB indicates that the adopted DFCs are physically possible even within the constraints of recoverable storage. The available information shows that the adopted DFCs are achievable and therefore, feasible based on TWDB precedence.

GMA 1 District Representatives adopted DFCs that can be individually and as a group feasibly achieved based on the predictive runs from the HPASGAM.

Documentation for GMA 1 meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV – Factor Analysis**.**

4.4.9 Other information

TWC Section 36.108(d)(9) requires the districts to consider any other information relevant to the specific DFCs. GMA 1 did not discuss other information relevant to the specific DFCs that was not already considered under the other eight factors.

To this point, all material information related to the adoption of an adopted DFC has been tied to one or more of the previously discussed Factors. These presentations were considered in relationship to multiple Factors discussed above. As such, no additional information has been designated as “other” at this time by the voting membership of the GMA 1.

Documentation for GMA 1 joint planning meetings including meeting postings, agenda package, sign-in sheets and meeting supplements for this Factor are provided in Appendix III- Meeting Documentation and additional supporting documentation is found in the reference folder under Appendix IV **–** Factor Analysis.

4.5 Discussion of other DFCs considered

GMA 1 District Representatives originally considered Dockum Aquifer DFCs adopted in 2010, during the first round of joint planning. The original DFCs were expressed as feet of drawdown occurring in fifty years. In the current round of joint planning, GMA 1 District Representatives elected to continue with feet of drawdown occurring within GMA 1 except Dallam, Hartley, Moore and Sherman counties where the North Plains GCD requested that the DFC be expressed as 40 percent of the available drawdown remaining for the period to establish consistency with the Ogallala DFC.

4.6 Discussion of other recommendations

GMA 1 District Representatives provided the public opportunity to comment on the DFC Joint Planning Process or recommend other DFCs at all sixteen joint planning meetings. Each District also held respective public hearings to discuss the Proposed DFCs with the public in their local service areas.

4.6.1 Advisory committees

GMA 1 District Representatives did not establish advisory committees for this round of planning and therefore no comment from such committees were filed.

4.6.2 Public comments

On April 20, 2016, GMA 1 District Representatives unanimously voted to adopt Proposed DFCs for the major aquifers in the Joint Planning Area.

A 90-day public comment period extended from May 13, 2016 to August 15, 2016. During the public comment period and after posting notice as required by TWC Section 36.063, each district held at least one public hearing on proposed relevant to that district. During the public comment period, the districts made available in their offices a copy of the proposed DFCs and any supporting materials. All documents considered in the joint planning process were organized and posted for the convenience of the public and GMA 1 membership. Individual districts move forward with public hearings during the statutorily required ninety (90) day public input phase prior to the final consideration of DFCs on the Panhandle Regional Planning Commission's website as follows: http://www.panhandlewater.org/GMA_Proposed_Documents.html .

After the public hearings, the districts compiled for consideration at the October 5, 2016 and November 2, 2016 Joint Planning meetings a summary of relevant comments received, any suggested revisions to the proposed DFCs, and the basis for the revisions.

During this public input process, the districts received one public comment to High Plains UWCD against any proposed so-called "Desired Future Condition" greater than zero.

GMA 1 District Representatives recognized that the public comment was ambiguous. To technically consider the comment's feasibility, GMA 1 District Representatives relied on TWDB TERS report information provided for the Joint Planning Process (TWDB 2015). The information in the report indicates that TERS for the all aquifers within GMA 1 ranges between 25 percent and 75 percent. GMA 1 District Representatives interpret this report that at least some water in storage is not recoverable. Therefore, achieving a DFC of zero storage is technically not feasible. Likewise, a DFC of zero drawdown is not feasible because of current and projected future WUG groundwater pumping.

5 NON-RELEVANT AQUIFERS

GMA 1 District Representatives considered the relevance of the Blaine Aquifer in the overall scheme of joint planning to adopt DFCs for GMA 1. The Blaine Aquifer is in portions of the Panhandle District in Wheeler County and is managed. However, only 25 wells are currently permitted in the aquifer and only twelve wells are considered to have publishable data. The Panhandle GCD requested that GMA 1 District Representatives classified the Blaine Aquifer in GMA 1 as non-relevant. That request was unanimously approved by the GMA 1 District Representatives. GMA 1 Districts adopted the following information has been extracted from a technical memorandum prepared by Bill Mullican for Panhandle GCD as a reason justification for the non-relevant determination.

Panhandle GCD provided the technical memorandum as justification for and a request to classify the Blaine Aquifer in Wheeler County as "non-relevant" for the purposes of joint-planning as detailed in TAC Section 356.31. Specifically, TAC Section 356.31 states:

(a) GCDs in a groundwater management area may, as part of the process for adopting and submitting DFCs, propose classification of a portion or portions of a relevant aquifer as non-relevant if the districts determine that aquifer characteristics, groundwater demands, and current groundwater uses do not warrant adoption of a desired future condition. In such a case, no desired future condition is required. The districts must submit the following documentation to the agency related to the portion of the relevant aquifer proposed to be classified as non-relevant:

(1) A description, location, and/or map of the aquifer or portion of the aquifer;
(2) A summary of aquifer characteristics, groundwater demands, and current groundwater uses, including the total estimated recoverable storage as provided by the executive administrator, that support the conclusion that DFCs in adjacent or hydraulically connected relevant aquifer(s) will not be affected; and
(3) An explanation of why the aquifer or portion of the aquifer is non-relevant for joint planning purposes.

Panhandle GCD is currently participating in the joint-planning process as a member of GMA 1. As part of this effort, Panhandle GCD reviewed the major and minor aquifers located within the Panhandle GCD boundaries for assembling information on any aquifers that GMA 1 District Representatives may determine to be non-relevant during the joint-planning process as described above in TAC Section 356.31. In the Panhandle GCD, the TWDB has formally designated one major aquifer (the Ogallala Aquifer) and two minor aquifers (the Dockum and Blaine aquifers). It was the Panhandle GCD's recommendation that both the Ogallala and Dockum aquifers are relevant for joint-planning and that desired future condition statements will need to be adopted for both aquifers. However, due to the very localized nature, limited yield, and poor water quality, it is Panhandle GCD's recommendation that the Blaine Aquifer in Wheeler County be designated as non-relevant for the purposes of joint planning in GMA 1, as allowed by TAC Section 356.31.

The Blaine Aquifer, both within Panhandle GCD and in GMA 1, is isolated to the south-southeastern portion of Wheeler County (see Figure 5.1). A more detailed map of the Blaine Aquifer (subcrop only), along with the locations of registered/permitted Blaine Aquifer wells is illustrated in Figure 5.2.

Figure 5.1. Map of minor aquifers designated by the TWDB in GMA 1

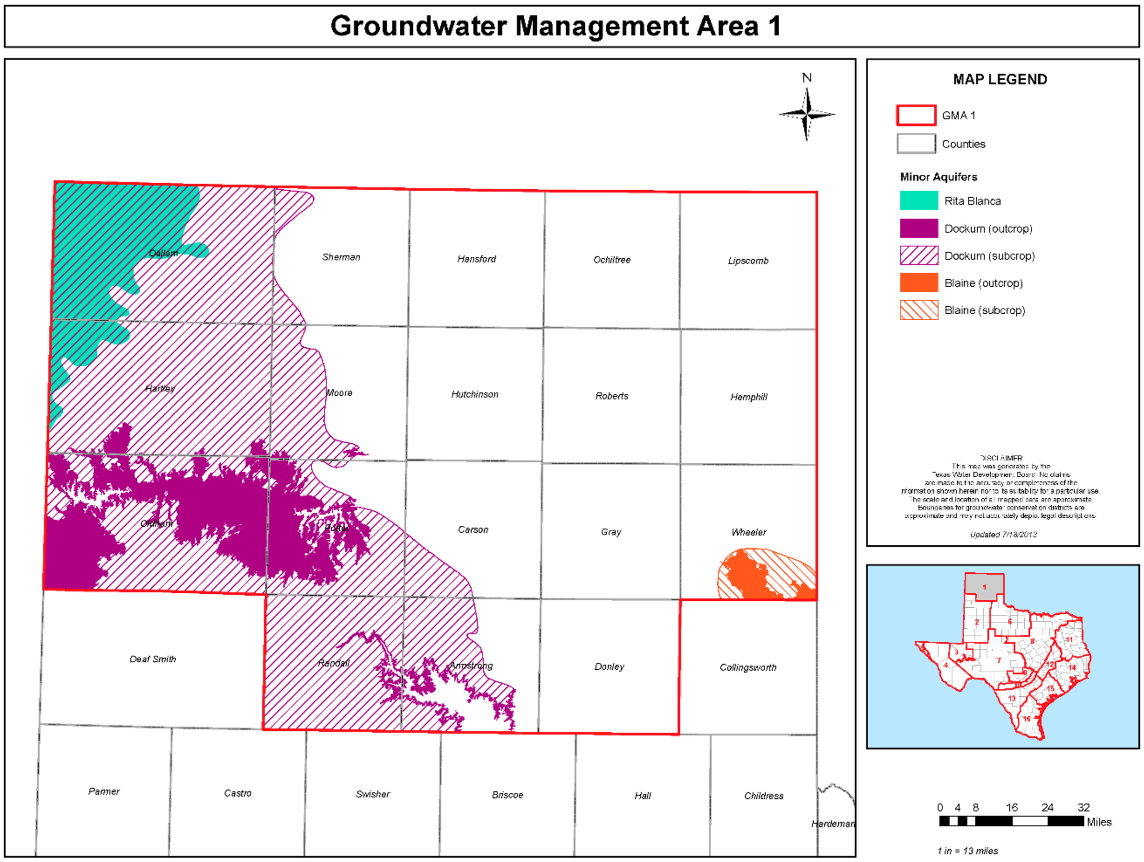


Figure 5.2. Map of the Blaine Aquifer in Wheeler County including locations of registered/permitted Blaine Aquifer wells.

Due primarily to poor water quality, there has been only limited scientific research published on the Blaine Aquifer. A few of the more notable publications on the Blaine Aquifer are George and others, (2011), Hopkins and Muller (2011) and Maderak (1973). Another good reference is the 2007 Texas Water Plan. The Blaine Aquifer, one of 21 minor aquifers designated in Texas, is part of the Permian Blaine Formation, which is made up of cycles of marine and non-marine sediments deposited in a broad, shallow sea (George and others, 2011). Groundwater in this aquifer is generally present in solution channels and caverns within strata composed of anhydrite and gypsum. The interaction of groundwater flowing through these calcium-sodium-magnesium-sulfate dominated sediments provides an explanation for the poor water quality of the Blaine Aquifer. According to TWDB (2007), the average saturated thickness for the Blaine Aquifer regionally is 137 feet. The Blaine Aquifer is approximately 20 to 35 miles wide and located along the eastern edge of the Texas Panhandle from Wheeler County in the north to Nolan County in the south. The aquifer occurs in portions of 16 counties. According to Hopkins and Muller (2011) water quality for the Blaine Aquifer in Wheeler County ranges from 1,000 – 3,000 total dissolved solids.

While the Blaine Aquifer is an important water resource to the south of the District, in Wheeler County and GMA 1 it has limited use. In the Panhandle GCD well database, there are currently twenty five wells in the District with an aquifer code of either Blaine Aquifer or Dog Creek/Blaine Aquifer, and only 15 have been measured during the last five years. Of that 15, twelve are publishable due to data quality issues. Two of the longer-term hydrographs are illustrated in Figure 5.3 and Figure 5.4 below. These hydrographs illustrate that no consistent trend in water level declines is evident, albeit based on very limited data.

Figure 5.3 Hydrograph for Panhandle GCD Well 546603 in Wheeler County. The period of record for this well is from July 1955 – December 2001. The total water level change is a rise of 7.88 feet over the period of record (Mullican, 2014).

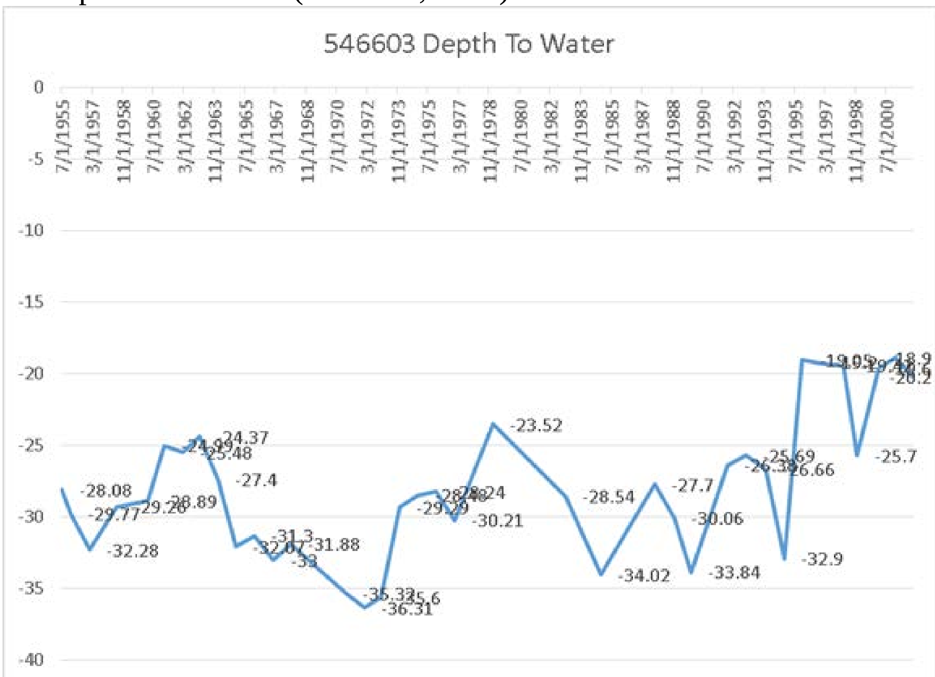
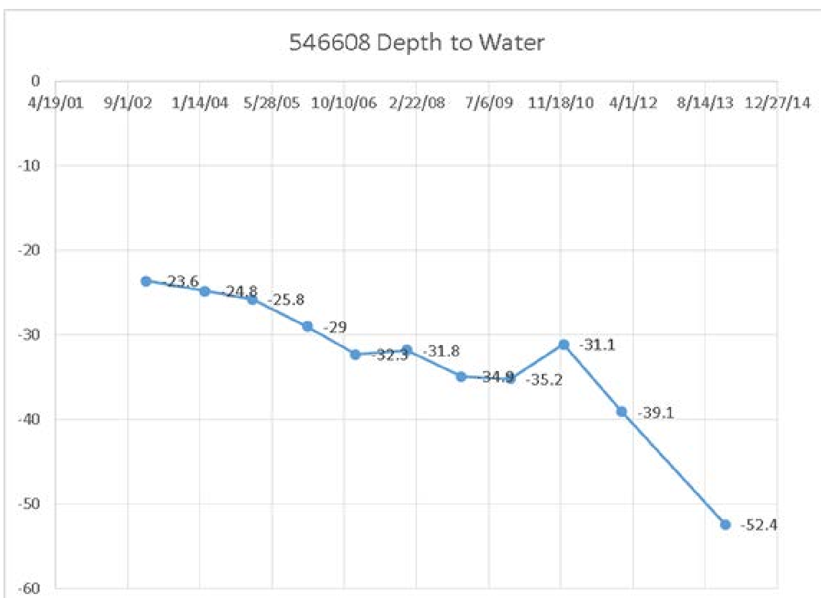


Figure 5.4 Hydrograph for Panhandle GCD Well 546608 in Wheeler County. The period of record for this well is from September 2002 – January 2014. The total water level change is a decline of 28.8 feet over the period of record (Mullican, 2014).



An important consideration in the designation of an aquifer as non-relevant is aquifer use. The Blaine Aquifer in Wheeler County is used primarily for domestic and livestock purposes. The Blaine Aquifer is also used for some limited irrigation. Groundwater pumping in Wheeler

County from 2007 – 2012 for the Blaine Aquifer is reported below by water use sector in Table 5.1.

Table 5.1. Groundwater pumping estimates for the Blaine Aquifer in Wheeler County. Data obtained from the TWDB Water Use Survey for 2007 – 2012). Reported values in acre-feet per year.

Year	Municipal	Manufacturing	Mining	Power	Irrigation	Livestock	Total
2007	9	0	0	0	1,537	121	1,667
2008	11	0	0	0	1,514	116	1,641
2009	13	0	0	0	1,428	118	1,559
2010	16	0	0	0	1,391	98	1,505
2011	18	0	0	0	1,660	108	1,786
2012	17	0	0	0	2,407	0	2,424

Another consideration in the designation of an aquifer as non-relevant is projections for water demands in the future from the aquifer. Water demand projections for regional water planning are developed irrespective of source. Water demand projections for Wheeler County for the next 50-years are presented in Table 5.2.

Table 5.2. Total water demand projections for Wheeler County as adopted for the upcoming 2016 PRWP (TWDB Website

http://www.twdb.texas.gov/waterplanning/data/projections/2017/demandproj.asp)

Wheeler	2020	2030	2040	2050	2060	2070
Irrigation	8,203	7,983	7,433	6,607	5,781	4,955
Livestock	1,577	1,680	1,682	1,684	1,687	1,689
Manufacturing	0	0	0	0	0	0
Mining	3,268	2,329	1,413	503	139	119
Municipal	1,147	1,164	1,183	1,220	1,265	1,315
Steam-electric	0	0	0	0	0	0
Total	14,195	13,156	11,711	10,014	8,872	8,078

A new parameter of the joint-planning process in establishing DFCs in Total Estimated Recoverable Storage, or TERS, for each of the relevant aquifers. As required by TAC Section 356.31, TERS must also be considered for an aquifer to be designated as non-relevant for the purposes of joint-planning. By statute, TERS is provided by the Executive Administrator of the TWDB. Table 5.3 includes estimates of TERS for the Blaine Aquifer in Wheeler County (from Kohlrenken, 2013).

Table 5.3 – Total estimated recoverable storage for the Blaine Aquifer in Wheeler County.

County	Total Storage (acre feet)	25 percent of Total Storage (acre feet)	75 percent of Total Storage (acre feet)
Wheeler	6,700,000	1,675,000	5,025,000

In the initial round of joint planning in GMA 1 from 2005 – 2010, a desired future condition of 50/50 was adopted for the Blaine Aquifer in Wheeler County. Since that time, the process has been changed significantly, primarily through provisions included in Senate Bill 660 that was passed by the Texas Legislature in 2011. Under these new provisions, it is now necessary for any aquifer designated as a major or minor aquifer (as is the case with the Blaine Aquifer) to have statements of DFCs <u>unless the aquifer has been declared through the joint-planning process as non-relevant for the purposes of joint-planning</u>. Under the new procedures included in Texas Water Code §36.108, if an aquifer has an adopted desired future condition, then the responsible GCD must also include management goals, objectives, and performance standards for that aquifer. Then, the responsible GCD is required to develop and adopt rules as necessary to achieve the DFCs, management goals, objectives and standards for the aquifer.

Due to the very limited use of the Blaine Aquifer in Wheeler County, as described above, at this time we do not feel that sufficient justification exists to develop statements of DFCs, management goals, objectives, performance standards, and rules for the Blaine Aquifer in Wheeler County, therefore, we recommend that the Panhandle GCD Board of Directors request that the GMA 1 GCDs designate the Blaine Aquifer as non-relevant for the purposes of joint planning for the current cycle from 2011 – 2016.

The Technical Memorandum provided by Panhandle GCD and other documents further detailing that reasoning are included as meeting supplements to the August 20, 2014 meeting documents in Appendix III.

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7 APPENDICES.

I. Appendix I - DFC Documents

- A. Proposed DFCs
  1. 4-20-2016 Meeting Posting Documents
  2. Resolution 2016-01
  3. Draft Explanation of DFCs
  4. DFC Factor Presentation
- B. Adopted DFCs
  1. 11-02-2016 Meeting Posting Documents
  2. Resolution 2016-2
  3. Public Comment and District Summaries
     - a. Public Comment During GMA 1 Meetings
     - b. Districts Summaries
       1. Hemphill UWCD
       2. High Plains District
       3. North Plains District
       4. Panhandle GCD
  4. Groundwater Availability Model Report

II. Appendix II -Guidance Documents

- A. Explanatory Report Template
- B. Texas Water Code
  1. Chapter 35
  2. Chapter 36
- C. Texas Administrative Code Chapter 356
- D. TWDB DFC Documents

III. Appendix III - Meeting Documentation

- A. August 9, 2012
  1. Minutes
  2. Postings
  3. Agenda Package
  4. Sign-In Sheet
  5. Meeting Supplements
     - a. SB 660 82nd
     - b. GAM 12-005
     - c. Bylaws
- B. July 23, 2013
  1. Minutes
  2. Postings
  3. Agenda Package
  4. Sign-In Sheet
  5. Meeting Supplements

        a. SB 1282 - 83rd
        b. SB 660 - 82nd
        c. Mullican Workflow

C. November 7, 2013
    1. Minutes
    2. Postings
    3. Agenda Package
    4. Sign-In Sheet
    5. Meeting Supplements
        a. Bylaws
        b. Mullican Timeline

D. February 24, 2014
    1. Minutes
    2. Postings
    3. Agenda
    4. Sign-In Sheet
    5. Meeting Supplements
        a. Informal Manager's Discussion Notes
        b. District 9 Factor Review Template
        c. PRPC 9 Factor Summary for PWPG
        d. 11/11/09 - DFC Public Hearing Notes - Review Template
        e. 2011 Regional Water Plan
        f. Mullican Scope of Work
        g. The Role of Modeled Available Groundwater in Regional Water Planning

E. April 11, 2014
    1. Minutes
    2. Postings
    3. Agenda
    4. Sign-In Sheet
    5. Meeting Supplements
        a. Wade Oliver Estimated Recoverable Storage Presentation
        b. High Plains GAM Update (Intera)
        c. Mullican Timeline
        d. TWDB Explanatory Report for Submital of DFCs to the TWDB

F. May 30, 2014
    1. Minutes
    2. Postings
    3. Agenda Package
    4. Sign-In Sheet
    5. Meeting Supplements
        a. NPGCD Aquifer Uses and Conditions Presentation
        b. PGCD Water Supply Needs and Management Strategies

c. Hemphill County Presentation
d. PGCD Presentation on Water Supply and Strategies in 2012 State Plan
e. NPGCD Presentation - Estimated Recoverable Storage and Hydro Conditions

G. August 19, 2014
1. Minutes
2. Postings
3. Agenda Package
4. Sign-In Sheet
5. Meeting Supplements
   a. J.C. Adams Letter
   b. FNI - Regional Water Planning Presentation
   c. CRMWA Presentation
   d. Walthour Pumping (Factor 1) Presentation
   e. State Plan - Factor 2 Presentation
   f. Walthour - Summary of Factor 3
   g. NPGCD - Environmental Impacts Presentation
   h. Factor 5 - Subsidence Presentation
   i. NPGCD - Socio-Economic Presentation

H. November 6, 2014
1. Minutes
2. Postings
3. Agenda Package
4. Sign-In Sheet
5. Meeting Supplements
   a. City of Amarillo Presentation
   b. Ray Brady Presentation for Hemphill (3d Model)
   c. PGCD Presentation Conditions
   d. PGCD - Blaine Aquifer Presentation (Non-Relevant)

I. February 18, 2015
1. Minutes
2. Postings
3. Agenda Package
4. Sign-In Sheet
5. Meeting Supplements
   a. Keith Good Presentation on Property Rights
   b. Neil Deeds High Plains Aquifer GAM Presentation
   c. Blaine Aquifer Documentation

J. July 23, 2016
1. Minutes
2. Postings
3. Agenda Package
4. Sign-In Sheet

5. Meeting Supplements
    a. Wade Oliver MAG Presentation
    b. Monique Norman Presentation on Statutory Revisions
    c. Mullican Briefing Presentation

K. February 25, 2016
1. Minutes
2. Postings
3. Agenda Package
4. Sign-In Sheet
    a. Bill Hutchinson GMA 2 Memo
    b. HPAS Model
    c. GAM 15-006
    d. GMA 1 Exempt Use
    e. Major Aquifer Uses 2004-2013
    f. Minor Aquifer Uses 2004-2013
    g. Predictive Run 10-7-16
    h. Draft Summary Report

L. March 17, 2016
1. Minutes
2. Postings
3. Agenda Package
4. Sign-In Sheet
5. Meeting Supplements
    a. HPAS Tech Memo 16-01
    b. GAM Task Run 15-006
    c. NPGCD Historical vs. Modeled Pumping Graph
    d. NPGCD Spreadsheet Oct 15 Memo vs. New
    e. Transient vs. Steady Model
    f. 2016 Socio-Economic Plan
    g. Draft Summary Document

M. April 20, 2016
1. Minutes
2. Postings
3. Agenda Package
4. Sign-In Sheet
5. Meeting Supplements
    a. DFC Factors Presentation 4-20-2016
    b. 4-6-16 Predictive Run
    c. Draft Explanation of Proposed DFCs
    d. GMA 1 Exempt Use
    e. Executed Proposed DFCs

N. October 5, 2016
1. Minutes

    o. Randall
    p. Roberts
    q. Sherman
    r. Wheeler
3. County Water Use Survey
4. Hemphill County Documents
    a. Cross Section Map
    b. Static Water Level Change
    c. North Cross Section
    d. 2011-13 Drought Effects
    e. Mid-North Cross Section
    f. 5 Year Water Level Trend
    g. Middle Cross Section
    h. Long Term Water Level Trends
    i. Amarillo State-Line Cross Section
    j. South Cross Section
    k. 2013 DFC Status Report
    l. 2013 DFC Tracking Report
    m. Water Use Amounts
    n. Water Use Survey - Pumpage
    o. Cross Section Presentation
5. High Plains
    a. GMA 1 Usage Map
    b. Potter County Saturated Thickness
    c. Randall County Saturated Thickness
    d. Armstrong County Saturated Thickness
    e. GAM Task 11-010
    f. GMA 2 Technical Memo
6. North Plains
    a. DFC Presentation
    b. MAG and Production
    c. Production Compared to MAG
    d. Production Compared to MAG Prelim
    e. Production Compared to 2011 DFC
    f. Resources
7. Panhandle
    a. City of Amarillo Report
    b. CRMWA Historic Use
    c. CRMWA 2014 Use Report
    d. PGCD Hydrological Conditions Report
    e. 2013 Use Table
8. TWDB WUS - Pumpage Estimates
    a. 2004

- b. 2005
- c. 2006
- d. 2007
- e. 2008
- f. 2009
- g. 2010
- h. 2011
- i. 2012
- j. 2013

9. Miscellaneous
   - a. CRMWA - All Cities Historic Usage
   - b. 2015 Exempt Use
   - c. GMA 1 Minor Aquifer Total Pumping Report
   - d. GMA 1 Major Aquifer Pumping Report

B. Water Needs and Water Management Strategies
1. 2011 Panhandle Regional Water Plan
2. 2016 Regional Water Plan
3. 2012 Texas State Water Plan
4. 2017 Texas State Water Plan
5. 2016 Agricultural Water Demand Report
6. County Demand Table
7. Municipal Demand Table
8. Non-Municipal Demand Table
9. Water Supply Needs Table
10. Walthour 4-20-16 Factor Summary

C. Hydrological Conditions
1. Balancing Total Estimated Recoverable
2. Aquifers and Estimated Recoverable Storage Presentation
3. GAM 15-006 Total Estimated Recoverable Storage
4. Gam 10-019 MAG
5. 2011 Dockum MAG Letters (Merged)
6. 2011 Ogallala MAG Letters (Merged)
7. GAM Run 09-014
8. GAM Run 09-026
9. GAM Run 10-020
10. Groundwater Recharge in the Central High Plains
11. Estimated Recoverable Storage
12. Aquifers of Texas
13. GAM Run 13-025
14. DFC Factors Presentation 4-20-2016

D. Environmental
1. 2011 Panhandle Regional Water Plan
2. 2016 Panhandle Regional Water Plan

3. DFC Factors Presentation 4-20-2016

E. Subsidence
   1. 1994 Subsidence
   2. 2016 Regional Water Plan
   3. Hemphill Management Plan
   4. North Plains Management Plan
   5. Panhandle Management Plan
   6. High Plains Management Plan
   7. DFC Factors Presentation 4-20-2016

F. Socioeconomic Impacts
   1. 2011 Panhandle Regional Water Plan (Appendix I)
   2. 2016 Panhandle Regional Water Plan
   3. Economic Impacts of Selected Water Conservation (Ogallala)
   4. Farm Level Financial Impacts of Water Policy (Ogallala)
   5. Multi-Year Water Allocation: Economic Approach-Panhandle
   6. Evaluation of Changing Land Use
   7. Economic Impacts of Groundwater Management Standards
   8. GAM Run 09-014 Addendum
   9. Water Conservation Policy Alternatives
   10. DFC Factors Presentation 4-20-2016

G. Private Property Rights
   1. 2-15-15 GMA 1 Presentation
   2. DFC Factors Presentation 4-20-2016

H. Feasibility
   1. HPAS Water Balance
   2. Production Compared to MAG 03172016
   3. MAG 03172016
   4. Predictive Run 20151007
   5. GMA 2 Technical Memorandum 16-01
   6. DFC Factors Presentation 4-20-2016

I. Other Relevant Factors
   1. All Factor Incorporated into 8 Above
   2. DFC Factors Presentation 4-20-2016
   3. City of Amarillo Presentation
   4. CRMWA Presentation
   5. PWPG Report

V. Appendix V - District Management Plans

- A. High Plains District
  1. 2014
  2. 2016
- B. North Plains District
  1. 2014
  2. 2016
- C. Panhandle GCD
  1. 2014
  2. 2016
- D. Hemphill UWCD
  1. 2014
  2. 2016

VI. Appendix VI - GAM Models and Reports

A. HPAS 11-15

B. HPAS Predictive Runs

   1. 10-7-15

   2. 3-16-16

   3. 4-16-16

C. HPWD Letter

D. Hutchinson Tech Memo

E. Final GAM Report