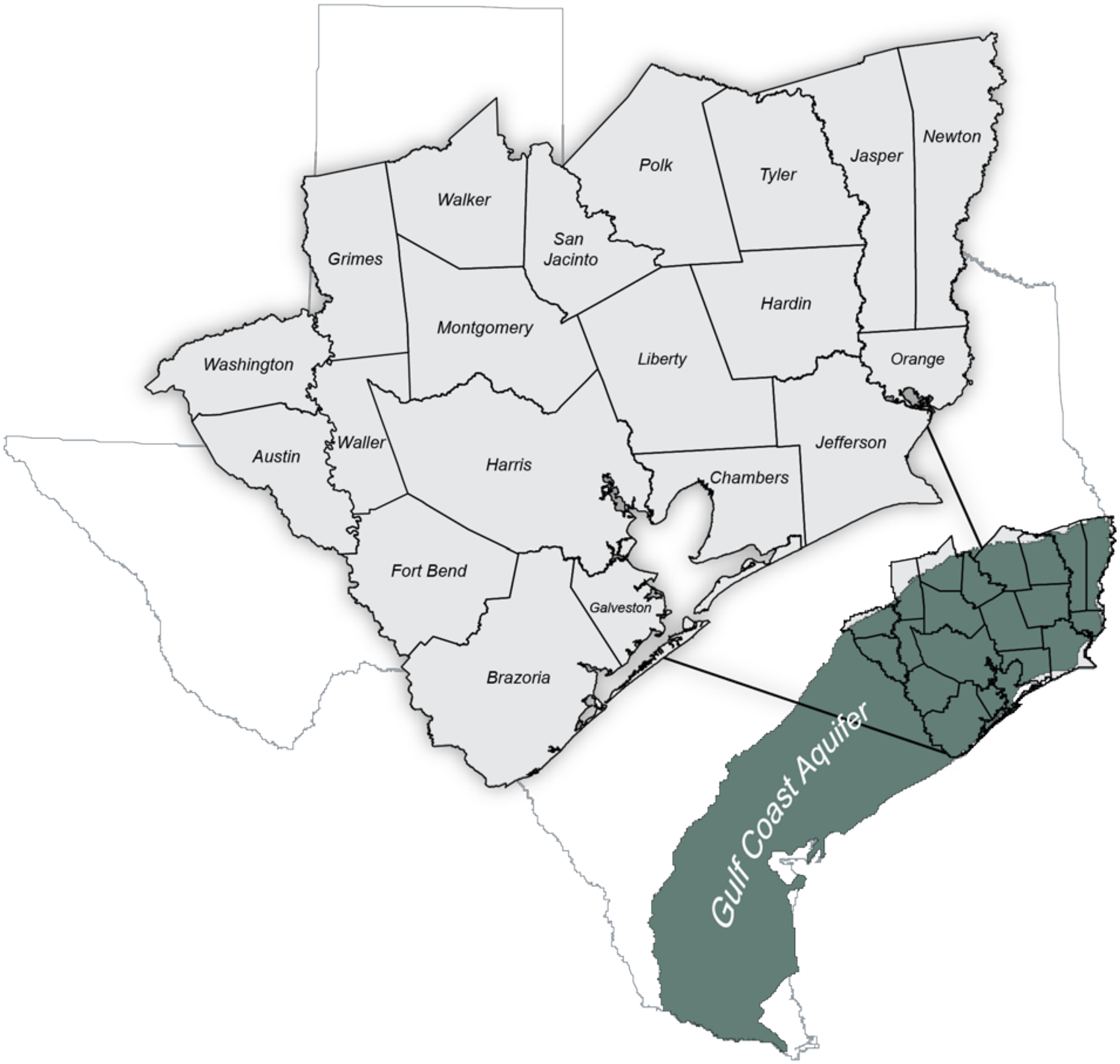

DESIRED FUTURE CONDITIONS EXPLANATORY REPORT

Prepared by the Groundwater Conservation Districts in Groundwater Management Area 14

Submitted to the Texas Water Development Board Mach 4, 2022

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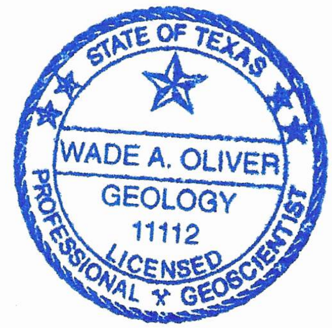
PROFESSIONAL GEOSCIENTIST SEAL

The hydrogeologic components (Sections 4.1, 4.3, 4.4, 4.5, 4.9 and Appendix R) of this explanatory report were prepared or overseen by the following Licensed Professional Geoscientist:



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EXECUTIVE SUMMARY

Groundwater Conservation District Representatives ("District Representatives") in Groundwater Management Area 14 ("GMA 14") developed this Explanatory Report as part of the requirements included in Texas Water Code Section 36.108 for developing desired future conditions ("DFCs"). A DFC is defined as "the desired, quantified condition of groundwater resources (such as water levels, spring flows, or volume) within a management area at one or more specified future times as defined by participating groundwater conservation districts within a groundwater management area as part of the joint planning process." (31 Texas Administrative Code Section 356.10(9)).

This GMA 14 Explanatory Report contains two main elements required in Tex. Water Code Section 36.108 for the joint planning process: the statement of desired future conditions adopted by the District Representatives for the Gulf Coast Aquifer in GMA 14 during a regularly scheduled meeting on January 5, 2022, and documentation of all data, analyses, and supporting materials including policy and technical issues considered by the District Representatives during the current round of joint planning.

The Texas Water Development Board ("TWDB") has made available an "Explanatory Report Checklist," which is used to determine administrative completeness with respect to the requirements of statute and administrative rules. To facilitate this review by TWDB, a populated Explanatory Report Checklist is included in Appendix A. Each of the required considerations included in Texas Water Code Section 36.108(d)(1-9) are listed below and discussed in detail in this Explanatory Report:

1. Aquifer Uses and Conditions
2. Water Supply Needs and Water Management Strategies
3. Hydrologic Conditions
4. Environmental Impacts
5. Subsidence
6. Socioeconomic Impacts
7. Private Property Rights
8. Feasibility of Achieving the DFCs
9. Other Relevant Information

Texas Water Development Board ("TWDB") designated the counties in Texas containing the northern portion of the Gulf Coast Aquifer System as GMA 14 (Figure 1-1). The Gulf Coast Aquifer System is made up of the Chicot Aquifer, Evangeline Aquifer, Burkeville Confining Unit, and Jasper Aquifer. The counties in GMA 14 are listed below along with the type of entity responsible for groundwater management in each county, if applicable:

Groundwater Management Entity Type	Groundwater Management Entity Name	County
Groundwater Conservation District "GMA 14 District Representatives"	Bluebonnet GCD	Austin
		Grimes
		Walker
		Waller
	Brazoria County GCD	Brazoria
	Lone Star GCD	Montgomery
	Lower Trinity GCD	Polk
		San Jacinto
	Southeast Texas GCD	Hardin
		Jasper
		Newton
		Tyler
Subsidence District	Fort Bend Subsidence District	Fort Bend
	Harris-Galveston Subsidence District	Galveston
		Harris
Counties without a Groundwater Management Entity (such as a GCD or Subsidence District)		Chambers
		Jefferson
		Liberty
		Orange
		Washington

GMA 14 District Representatives last adopted DFCs in 2016 and, as specified in Texas Water Code Section 36.108, are required to review and propose for adoption DFCs every 5 years. The DFCs adopted in 2016 for Lone Star GCD were the subject of multiple petitions declaring ultimately that Lone Star GCD's DFCs "no longer reasonable." After Lone Star GCD's 2016 DFCs were found to be no longer reasonable, the District Representatives convened and Lone Star GCD requested that its DFCs be revised immediately. The majority of District Representatives declined to revise Lone Star GCD's DFCs as an amendment to the second round of joint planning. Instead, District Representatives voted to revise Lone Star GCD's DFCs during the third round of joint planning when all DFCs were being developed. The District Representatives made a concerted effort during the current round of joint planning to develop, propose and adopt DFCs that address the issues identified in the petitions from 2016.

During the process of developing DFCs, District Representatives extensively reviewed and evaluated DFC options, public feedback, and the factors above to ensure that the adopted DFCs "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" (Texas Water Code Section 36.108(d-2)). As part of the process, the District Representatives quantified the potential endpoints of this balance, determining the amount of pumping in each county consistent with no additional drawdown (representing conservation) and depletion of half of the available predevelopment drawdown (one way to approximate highest practicable pumping).

At the April 9, 2021 GMA 14 joint planning meeting, the District Representatives proposed for adoption the following DFCs for the Gulf Coast Aquifer within the bounds of Austin, Brazoria, Chambers, Grimes, Hardin, Jasper, Jefferson, Liberty, Montgomery, Newton, Orange, Polk, San Jacinto, Tyler, Walker, Waller, and Washington counties:

> *In each county in GMA 14, no less than 70 percent median available drawdown remaining in 2080 and no more than an average of 1.0 additional foot of subsidence between 2009 and 2080.*

This single DFC statement applicable to each county was developed in part to ensure a more uniform management standard across the aquifer while still accounting for the significant hydrogeologic variability in GMA 14. The statement uses multiple metrics – median available drawdown and average additional subsidence – to capture that the limiting factor for groundwater availability in some areas of GMA 14 is different than in others. As discussed below, the "and" in the DFC statement was changed to an "or."

The proposed DFCs were mailed to the individual GCDs on April 20, 2021. All Districts subsequently posted the public notices for individual GCD public hearings on the proposed DFCs as required by Texas Government Code Chapter 551 and by Texas Water Code Section 36.108(e). Copies of the public notices given for all required public hearings are contained in Appendix B.

After receiving comments during the public comment period, the District Representatives met on October 5, 2021 to consider public comments and potential revisions to the proposed DFCs. The public comments as compiled and summarized by the District Representatives are shown in Appendix C. At the October 5, 2021 GMA 14 meeting, the District Representatives approved in form the "*RESOLUTION FOR THE APPROVAL OF DESIRED FUTURE CONDITIONS FOR AQUIFERS IN GROUNDWATER MANAGEMENT AREA 14*," which included the following DFCs for the Gulf Coast Aquifer within the bounds of GMA 14:

In each county in GMA 14, no less than 70 percent median available drawdown remaining in 2080 or no more than an average of 1.0 additional foot of subsidence between 2009 and 2080.

This Explanatory Report documents that the District Representatives in GMA 14 have considered all of the elements required by Texas Water Code Section 36.108(d-3) in establishing the 2021 DFCs by: 1) identifying each desired future condition; 2) providing the policy and technical justifications for each desired future condition; 3) documenting that the factors under Texas Water Code Section 36.108(d) were considered by the Districts along with how the adopted desired future conditions impact each factor; 4) listing other desired future condition options considered, if any, and the reasons why those options were not adopted; and 5) discussing reasons why recommendations made by any advisory committee and relevant public comments received by the districts were or were not incorporated into the Desired Future Conditions. This Explanatory Report documents each of these elements, the process for developing the DFCs, and confirms that the adopted DFCs are reasonable.

1. INTRODUCTION

1.1 JOINT GROUNDWATER PLANNING IN GMA 14

In Texas, the legislature has declared groundwater conservation districts ("GCDs") as the preferred method of groundwater management (Texas Water Code Section 36.0015). Local GCDs manage, preserve, and protect the groundwater resources within their jurisdiction pursuant to their statutory powers and duties as set forth in Chapter 36 of the Texas Water Code and their respective enabling legislation. In 2005, the Texas Legislature passed legislation that created a joint planning process by which GCDs located within a groundwater management area must conduct joint planning to develop Desired Future Conditions ("DFCs"). These DFCs describe how the GCDs in the management area want the groundwater resources of the region to look in the future. They must also 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 (Texas Water Code Section 36.108(d-2)). GCDs develop their management plans with goals and objectives consistent with achieving the adopted desired future conditions of the relevant aquifers as adopted during the joint planning process (Texas Water Code Section 36.1085).

A groundwater management area ("GMA") is a geographic area designated and delineated by the Texas Water Development Board ("TWDB") under Chapter 35 of the Texas Water Code as an area suitable for management of groundwater resources. TWDB designated sixteen (16) GMAs, which together cover the entire State of Texas. TWDB designated the area encompassing all of Austin, Brazoria, Chambers, Fort Bend, Galveston, Grimes, Hardin, Harris, Jasper, Jefferson, Liberty, Montgomery, Newton, Orange, Polk, San Jacinto, Tyler, Walker, Waller and Washington counties as Groundwater Management Area 14 ("GMA 14"), shown in Figure 1-1. GMA 14 is located along the Upper Texas Gulf Coast, and groundwater management efforts for GMA 14 are primarily focused on the Gulf Coast Aquifer System.

The Bluebonnet Groundwater Conservation District (Austin, Grimes, Walker and Waller counties), Brazoria County Groundwater Conservation District (Brazoria County), Lone Star Groundwater Conservation District (Montgomery County), Lower Trinity Groundwater Conservation District (Polk and San Jacinto counties), and Southeast Texas Groundwater Conservation District (Hardin, Jasper, Newton and Tyler counties) are GCDs located wholly within the boundaries of GMA 14 (Figure 1-1). As required by Chapter 36 of the Texas Water Code and further described herein, these GCDs have engaged in joint planning and, in that regard, have adopted DFCs for the relevant groundwater resources underlying GMA 14.

The Fort Bend Subsidence District (Fort Bend County) and Harris-Galveston Subsidence District (Harris and Galveston counties) are also located within GMA 14 and have authority to regulate groundwater withdrawals. However, these districts were created by the Texas Legislature specifically to end or prevent subsidence and are not bound by DFCs adopted in joint planning as are the five GCDs in GMA 14 as dictated by Chapter 36. However, in the interest of sharing the responsibility of planning for shared groundwater resources, the GCDs, the subsidence districts, and Chamber and Washington counties entered into an Interlocal Agreement for Governmental Functions and Services Related to Joint Planning in GMA 14 ("Interlocal Agreement") that allows them to share costs and expenses associated with joint planning activities and the preparation of desired future conditions. The term "Participants" as used herein collectively refers to the parties of the Interlocal Agreement.

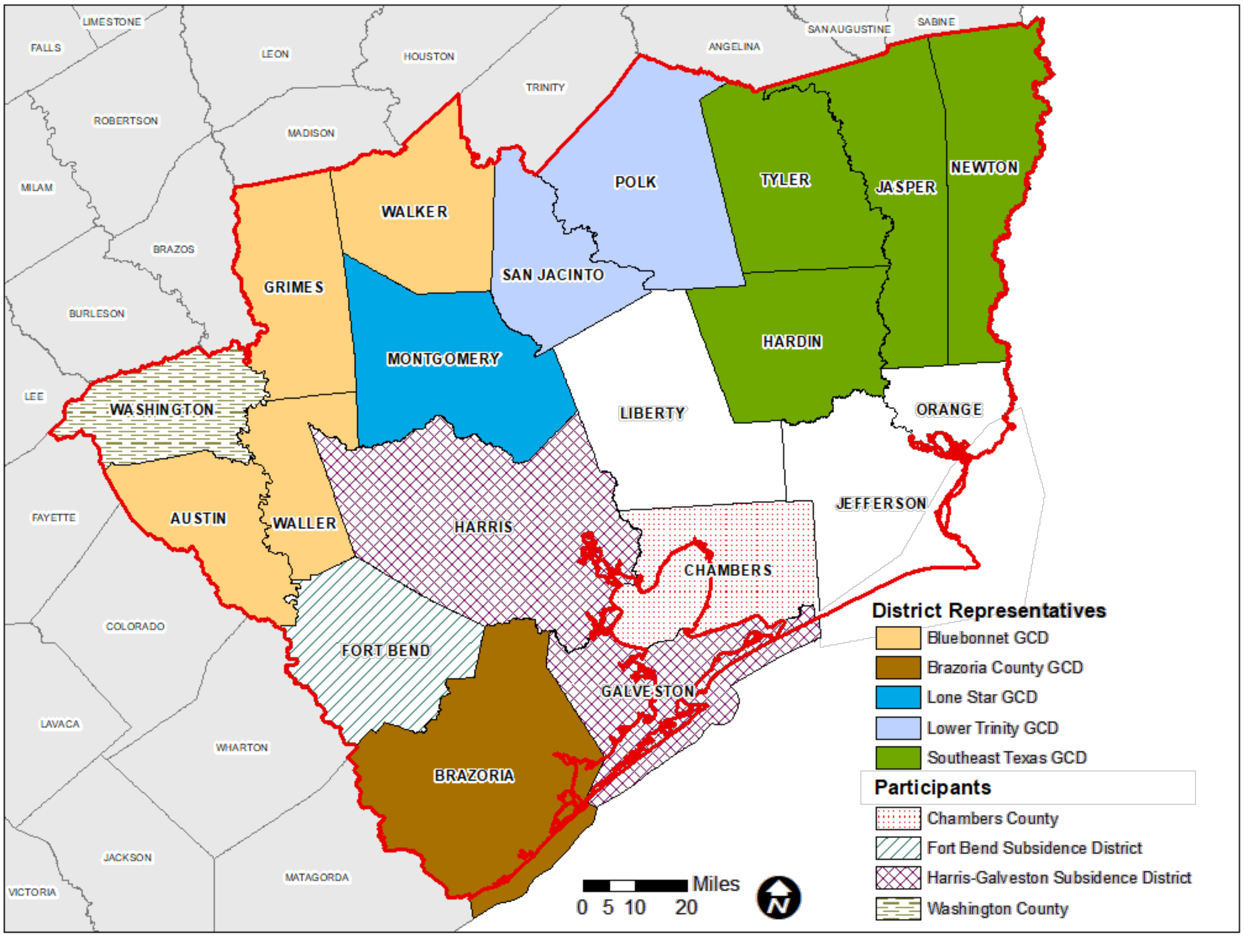

FIGURE 1-1. DISTRICT REPRESENTATIVES AND PARTICIPANTS IN IN GROUNDWATER MANAGEMENT AREA 14. NOTE THAT ONLY THE FIVE DISTRICT REPRESENTATIVES OF THE GROUNDWATER CONSERVATION DISTRICTS ARE VOTING MEMBERS IN JOINT PLANNING.

1.2 Fundamentals of the Joint Planning Process

The joint planning process for coordination of groundwater management activities by GCDs was first amended by the Texas Legislature to include the requirement to establish DFCs with the passage of House Bill ("HB") 1763 in 2005. HB 1763 amended Chapter 36 of the Texas Water Code to require representatives of GCDs located within a GMA to meet and adopt DFCs for the aquifers underlying the GMA no later than September 1, 2010, and every five years thereafter. After the first round of DFCs were adopted by the initial 2010 deadline, the joint planning process was significantly expanded prior to the second round of DFCs with the passage of Senate Bill ("SB") 660 in 2011. In order to better align the joint planning process with Texas' regional water planning process, the Texas Legislature passed HB 2215 in 2017, which set the deadline for proposing DFCs for adoption during the current (third) round of joint planning as May 1, 2021, and the deadline for finally adopting DFCs as January 5, 2022.

Texas Water Code Section 36.108 provides the current requirements applicable to this third round of joint planning and DFC development. As set forth in the statute, representatives from each GCD within each GMA are required to meet at least annually to conduct joint planning; consider each other's groundwater management plans and, accomplishments in the GMA; and, proposals to adopt new or amend existing DFCs. At least every five years, the GCD representatives must meet to consider groundwater availability models and other data and information for the GMA and propose for adoption DFCs for the relevant aquifers within the GMA (Texas Water Code Section 36.108).

The primary tools for analyzing groundwater conditions and for groundwater management are numerical groundwater availability models. These models are used to assess the effects of past, current, and future pumping and droughts on groundwater availability. In correspondence dated February 18, 2014, TWDB formally approved the updated Houston Area Groundwater Model ("HAGM") as the official Groundwater Availability Model ("GAM") for the northern segment of the Gulf Coast Aquifer System. The 2016 DFCs and the DFCs documented in this report were both developed using the HAGM.

In developing proposed DFCs, the GCDs must consider nine statutory factors: (1) aquifer uses and 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) hydrogeological conditions; (4) other environmental impacts; (5) the impact on subsidence; (6) socioeconomic impacts reasonably expected to occur; (7) the impact on the interests and rights in private property; (8) the feasibility of achieving the DFC; and (9) any other relevant information (Texas Water Code Section 36.108(d)(1-9)). After consideration of these factors, the representatives of the GCDs in the GMA ("District Representatives") must approve proposed DFCs by a two-thirds vote.

Once approved by the District Representatives during joint planning, the proposed DFCs are sent to the individual GCDs within the GMA and a public comment period of at least 90 days begins. During the public comment period, each GCD is required to hold a public hearing on the proposed DFCs. After the public hearing and comment period, each GCD is required to compile for consideration at the next joint planning meeting a summary of the relevant comments received, suggested revisions to the proposed DFCs, and the basis for the suggested revisions. The District Representatives are required to reconvene to review the summary reports prepared by each GCD, consider proposed changes to the DFCs, and finally adopt DFCs by a resolution adopted by two-thirds vote of all the District Representatives in the GMA. Upon final adoption, the District Representatives are required to, among other things, prepare and submit an Explanatory Report to TWDB and each GCD in the GMA (Texas Water Code Section 36.108(d-3)).

The joint planning process, described in Chapter 36 of the Texas Water Code and followed by the District Representatives in GMA 14, is a public and transparent process where all planning decisions are made in open, publicly noticed meetings. GMA 14 began this third round of joint planning in 2019. Over the course of several years, the District Representatives in GMA 14 held many joint planning meetings, and in a coordinated effort to manage the groundwater resources, adopted DFCs for GMA 14. A timeline of the GMA 14 joint planning process and significant events, including but not limited to consideration of model run results, consideration of information applicable to each of the statutory factors, proposal of DFCs for adoption, the public comment period, and final adoption of DFCs is provided in Section 3.

This Explanatory Report provides an official record demonstrating compliance with all statutory requirements applicable to the joint planning process and the adoption of DFCs. As part of this Explanatory Report, documentation of all meetings conducted by the Participants in GMA 14, including duly posted GMA 14 meeting agendas, and approved GMA 14 meeting minutes is included in Appendix D. This documentation establishes that through appointed District Representatives, the GCDs in GMA 14 participated in joint planning over the course of several years to develop DFCs as required by statute. As described in the agendas and meeting minutes, the District Representatives considered statutory criteria required prior to proposing DFCs for adoption and properly adopted DFCs in accordance with procedural requirements.

Also, included in this Explanatory Report are the five individual GCD Summary Reports prepared and presented at the October 5, 2021 GMA 14 joint planning meeting, which includes copies of all comments received by each GCD (Appendix C). These Summary Reports contain documentation of all public comments received by the individual GCDs during the public comment period on the proposed DFCs, along with any recommendations for changes to the proposed DFCs offered by the individual GCDs that were considered by the Participants. On January 5, 2022, the District Representatives adopted DFCs for the groundwater resources in GMA 14 as further described in this Explanatory Report.

1.3 Aquifers Within GMA 14

As defined by TWDB, the major aquifers in GMA 14 are shown in Figure 1-2. The Gulf Coast Aquifer System, which includes the Chicot Aquifer, Evangeline Aquifer, Burkeville Confining Unit, Jasper Aquifer and portions of the Catahoula Formation (where applicable) is the primary groundwater resource in each county in GMA 14. TWDB Report 380 (George, Mace, & Petrossian, 2011) provides a good summary of the main characteristics of the Gulf Coast Aquifer:

"The Gulf Coast Aquifer is a major aquifer paralleling the Gulf of Mexico coastline from the Louisiana border to the border of Mexico. It consists of several aquifers, including the Jasper, Evangeline, and Chicot aquifers, which are composed of discontinuous sand, silt, clay, and gravel beds. The maximum total sand thickness of the Gulf Coast Aquifer ranges from 700 feet in the south to 1,300 feet in the north. Freshwater saturated thickness averages about 1,000 feet. Water quality varies with depth and locality: it is generally good in the central and northeastern parts of the aquifer, where the water contains less than 500 milligrams per liter of total dissolved solids, but declines to the south, where it typically contains 1,000 to more than 10,000 milligrams per liter of total dissolved solids and where the productivity of the aquifer decreases. High levels of radionuclides, thought mainly to be naturally occurring, are found in some wells in Harris County in the outcrop and in South Texas. The aquifer is used for municipal, industrial, and irrigation purposes. In Harris, Galveston, Fort Bend, Jasper, and Wharton counties, water level declines of as much as 350 feet have led to land subsidence."

A small portion of the Carrizo-Wilcox Aquifer, which is a major source of groundwater in areas to the north and west of GMA 14, is present within GMA 14 in the northern areas of Grimes, Walker, and Washington counties.

The minor aquifers in GMA 14 as defined by TWDB are shown in Figure 1-3. These include the Brazos River Alluvium Aquifer, Queen City Aquifer, Sparta Aquifer, and Yegua-Jackson Aquifer. As shown in Figure 1-3, the Brazos River Alluvium Aquifer is adjacent to the Brazos River and runs through the western portion of GMA 14 into Fort Bend County. The remaining minor aquifers are present in the northern portions of GMA 14, primarily in those areas outside the extent of the Gulf Coast Aquifer system.

TWDB rules allow for portions of major and minor aquifers to be classified as non-relevant for joint planning purposes if their aquifer characteristics, groundwater demands, and current groundwater uses do not warrant adoption of a desired future condition. After review, District Representatives in GMA 14 have classified all portions of the following aquifers located within GMA 14 as non-relevant aquifers for joint planning: (1) Carrizo-Wilcox Aquifer,

(2) Queen City Aquifer, (3) Sparta Aquifer, (4) Yegua-Jackson Aquifer, and (5) Brazos River Alluvium Aquifer. A summary of each non-relevant aquifer, which includes a description of aquifer characteristics, groundwater demands, groundwater uses, and total estimated recoverable storage, is provided in Appendix E.

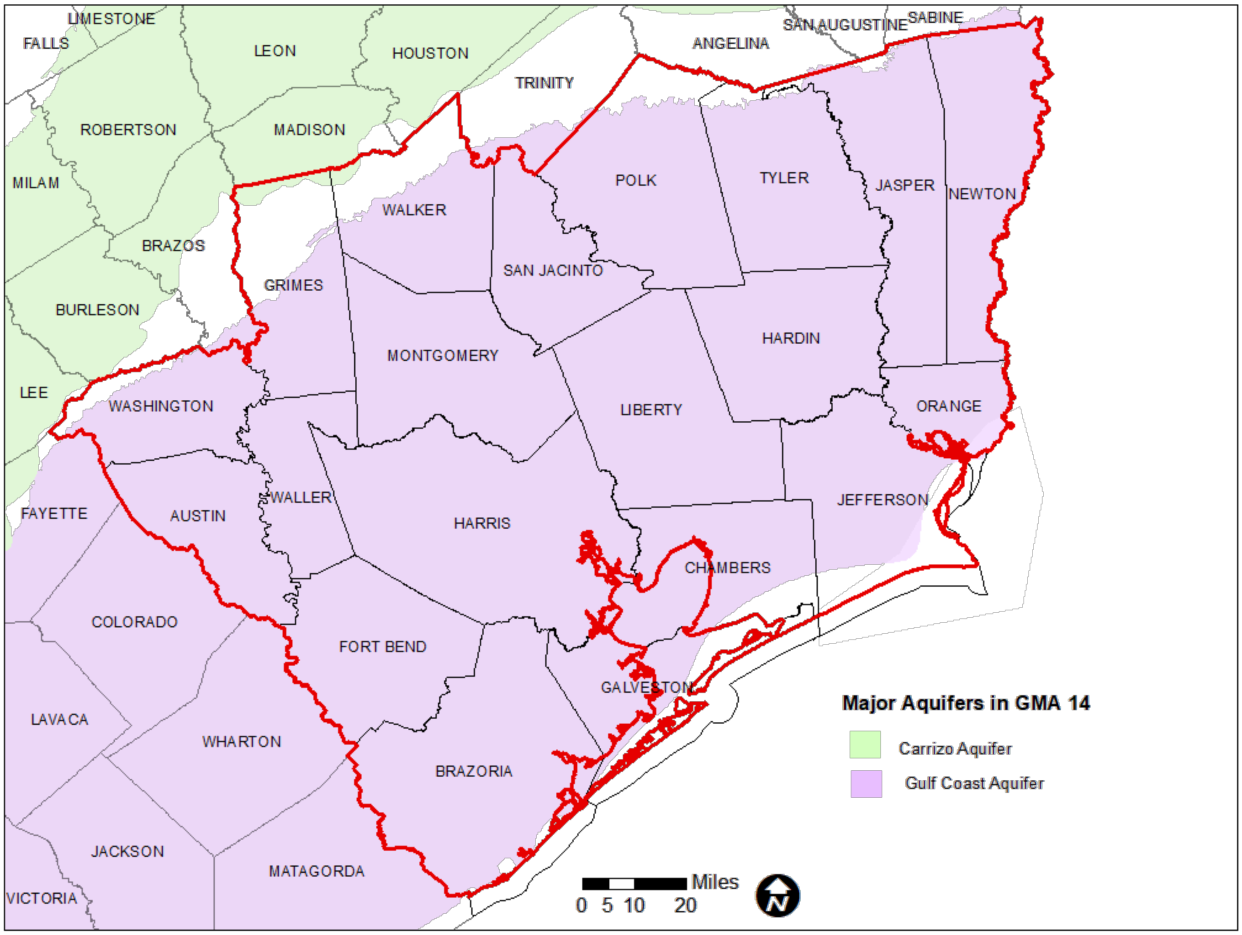

FIGURE 1-2. MAJOR AQUIFERS IN GMA 14

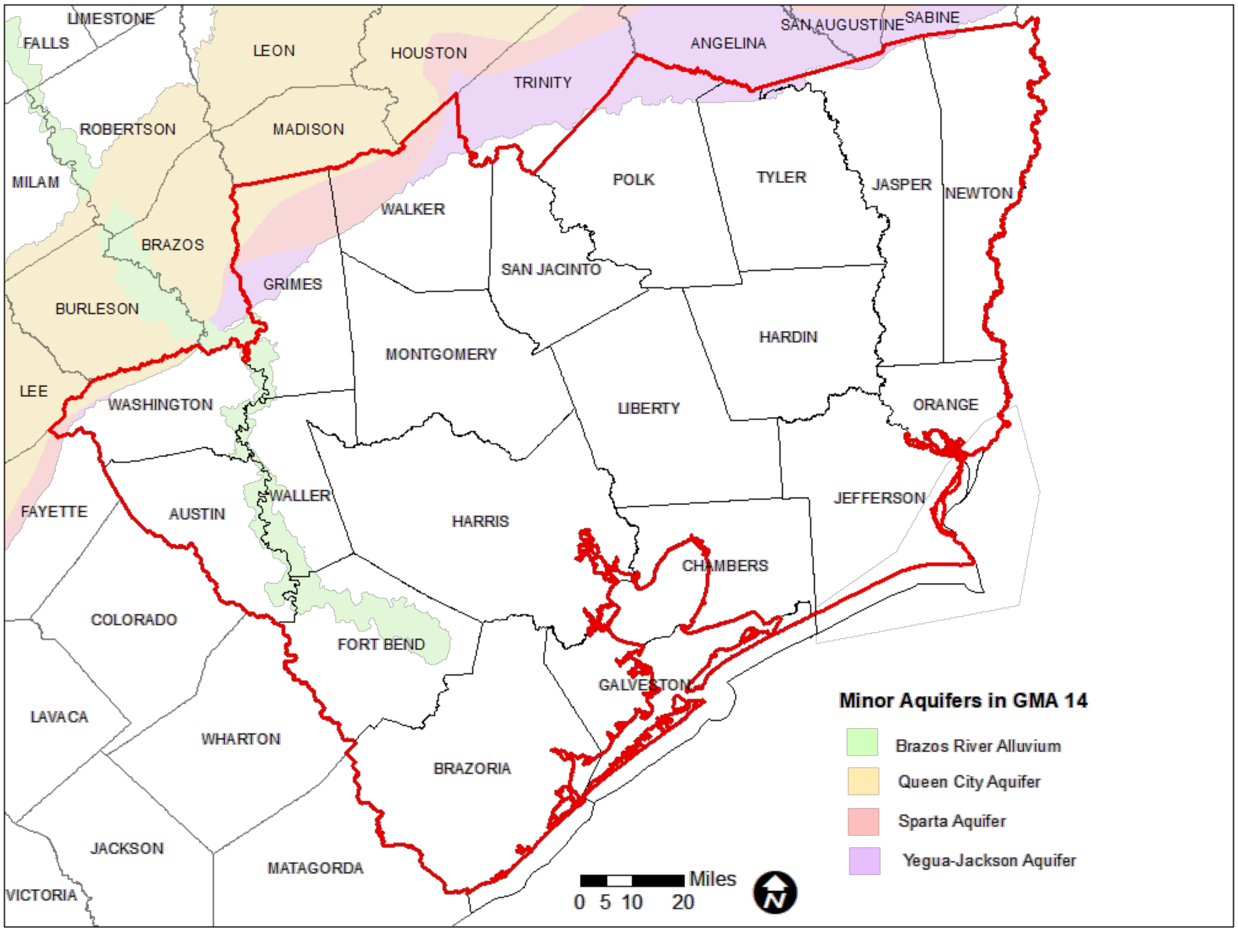

FIGURE 1-3. MINOR AQUIFERS IN GMA 14

2. GMA 14 Desired Future Conditions

2.1 DFC Metrics and Balancing Test

During the current round of joint planning, the GMA 14 District Representatives followed an intentional process for developing DFCs that are reasonable and address issues identified with DFCs previously adopted in GMA 14.

Criticism of Previous DFC Metrics

Chapter 36 of the Texas Water Code defines a Desired Future Condition as “a quantitative description, adopted in accordance with Section 36.108, of the desired condition of the groundwater resources in a management area at one or more specified future times.” Though DFCs must be quantitative, there is no additional guidance given as to what characteristic of the aquifer should be quantified. This characteristic is known as the DFC “metric”. In the 2016 round of joint planning in GMA 14, the DFCs were articulated using metrics of average drawdown in each unit of the Gulf Coast Aquifer in each county, average drawdown in each unit of the Gulf Coast Aquifer across GMA 14, and maximum subsidence in select counties. The 2016 DFCs were developed using the Houston Area Groundwater Model (“HAGM”) (Kasmarek, 2012). The result of this selection of metrics is that there were 66 separate DFCs for GMA 14 during the 2016 round of joint planning. Using Austin County as an example, in addition to the four GMA 14-wide DFCs, five DFCs were applicable in the county including:

- From estimated year 2009 conditions, the average drawdown of the Chicot Aquifer should not exceed approximately 39 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Evangeline Aquifer should not exceed approximately 23 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Burkeville confining unit should not exceed approximately 23 feet after 61 years.
- From estimated year 2009 conditions, the average drawdown of the Jasper Aquifer should not exceed approximately 76 feet after 61 years.
- From estimated year 1890 conditions, the maximum subsidence in Austin County should not exceed approximately 2.83 feet by the year 2070.

These DFCs were subject to numerous comments and the DFCs adopted for Lone Star GCD in 2016 were the subject of multiple petitions challenging their reasonableness. Issues raised in the comments and petitions included criticisms that they 1) were reverse engineered, 2) did not adequately balance the development of the aquifer with conservation, and 3) had management standards that seemed to change arbitrarily at county boundaries instead of treating the aquifer as a “common reservoir.”

Addressing Reverse Engineering with Median Percent Available Drawdown Remaining

The GMA 14 District Representatives sought to address these criticisms during the current round of joint planning through changes to the DFC development process and by selecting more appropriate metrics. One metric considered and ultimately used was median percent "available drawdown" remaining in wells. Though the term available drawdown has varied definitions within hydrogeology, the meaning used in developing the DFCs in this round of planning is shown in Figure 2-1 where available drawdown represents the height of the water column in a well between the water level in the well (as defined by the associated aquifer in the HAGM) and the bottom of the well (as defined by the well depth from land surface). Unlike other definitions of available drawdown, this definition does not consider the depth to the aquifer top or the setting of the pump. The median available drawdown was evaluated rather than the mean because the median -- the middle well in a list of all wells within a county sorted by percent medial drawdown remaining -- is not influenced by outliers.

Median percent available drawdown remaining in wells is a useful metric for characterizing different areas of the Gulf Coast Aquifer in GMA 14 because it is relevant regardless of whether the aquifer is thin or thick, shallow or deep. The percent of available drawdown metric allows for reasonable comparison between wells that may have less than 50 feet of available drawdown and deeper areas that may have more than 1000 feet of available drawdown.

Another reason the above definition of available drawdown was used is that well location and depth are two of the most widely available characteristics for wells in GMA 14 and in Texas more broadly. Data from each of the water wells available from the TWDB Groundwater and Submitted Drillers Reports with available depth information was assigned to an aquifer layer (Chicot, Evangeline, Burkeville, or Jasper). Since well screen information is not as widely available as well depth, the aquifer assignments were made using the aquifer present at the deeper of 80 percent of the total well depth or 50 feet shallower than the total well depth. Figure 2-2 shows the distribution of wells by aquifer used for the analysis. It is important to note that changes in the model base elevation of aquifers may change the aquifer designation of wells and may have an impact on these simulated results.

With aquifer assignment, depth, and modeled water level information available for each of the wells in Figure 2-2, the District Representatives first considered the median change in available drawdown between pre-development and 2009 (the historical period of the model). This is shown in Table 2-1. As shown in Table 2-1, counties that have historically not used much groundwater have a high percentage of median available drawdown remaining.

Counties that have historically produced higher quantities of groundwater (i.e., Fort Bend and Harris Counties) have the lower percentage of median available drawdown remaining. Table 2-1 also shows the modeled pumping for 2009 from the HAGM and the modeled maximum subsidence in each county between pre-development and 2009.

The use of median available drawdown remaining allowed for the development of model runs using the HAGM that targeted a specific percent of available drawdown remaining in each county as opposed to running the model based primarily on a prescribed volume of pumping. By setting a target metric beforehand and iteratively running the model to determine the pumping consistent with that condition, the District Representatives sought to address the critique that the DFCs during the 2016 round of joint planning were “reverse engineered.”

Addressing the Balancing Test Quantitatively

In addition to developing DFCs that were not “reverse engineered,” the District Representatives in GMA 14 sought to ensure that the DFCs appropriately balanced both conservation and development of groundwater. Texas Water Code Section 36.108(d-2) states, in part, that adopted DFCs “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.” This requirement for development of DFCs is referred to here as the “balancing test.”

The two ends of the balancing test described in Texas Water Code Section 36.108(d-2) represent the competing priorities and interests that must be considered when developing DFCs. It highlights that there are benefits and harms associated both with developing groundwater and with not developing groundwater. Texas Water Code Section 36.108(d-2) does not define the two ends of the balancing test in a manner that is readily quantified. The District Representatives, however, sought to develop a quantitative description of the Gulf Coast Aquifer System in each county that reasonably represents each end of the balancing test to ensure that the proposed and adopted DFCs developed were well within this range.

To estimate the highest practicable level of groundwater production, the District Representatives considered a median depletion of 50 percent of the pre-development available drawdown in wells in each county. This analysis does not consider many factors including environmental impacts, subsidence, the costs to produce water, and water demands. Pumping was adjusted in the model to the extent possible to match the target median available drawdown depletion in each county simultaneously beginning in 2010 and running through 2070. Note that pumping in the Harris-Galveston Subsidence District and Fort Bend Subsidence District was not changed during this process and held constant at the level of their current (2013) regulatory plans.

Lone Star GCD's concern with this approach is that it did not allow for any variation in pumping in Harris, Galveston, or Fort Bend counties because the pumping estimates in those counties were fixed in every scenario (and iterative simulation) based on the adopted 2013 regulatory plans in HGSD and FBSD. The assumption of "fixed pumping" for the three counties does have an impact on surrounding counties and GMA 14. The approach and assumptions only allow for evaluation of changes to pumping in other counties. Lone Star GCD expressed concerns regarding impacts that Harris County pumping has on Montgomery County particularly in southern Montgomery County where stakeholders have expressed concerns on water level declines and subsidence.

The results of the analysis of using a median depletion of 50 percent of the pre-development available drawdown as an example of the highest practicable level of groundwater production are shown in Table 2-2. For GMA 14, the modeled pumping in 2070 that achieves a median 50 percent depletion of pre-development available drawdown in each county is approximately 2.5 million acre-feet per year. This compares to the pumping in GMA 14 for 2009 from Table 2-1 of approximately 720,000 acre-feet per year. For context, the modeled recharge to GMA 14 is approximately 510,000 acre-feet per year.

A similar approach was used to evaluate the other end of the balancing test: the "conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the management area." Using the percent median available drawdown remaining metric, the District Representatives reviewed and considered a median of zero drawdown between 2009 and 2070 (that is, 100 percent of available drawdown remaining) as representative of conservation to an extent that is unlikely to be feasible or realistic to implement. The results of this analysis are shown in Table 2-3. As shown in Table 2-3, the total pumping consistent with this scenario in GMA 14 is approximately 550,000 acre-feet per year. Note that much of this pumping is from Harris and Fort Bend counties, which were not adjusted in the analysis as mentioned above. This "fixed pumping" assumption in Harris, Galveston, and Fort Bend counties decreases the pumping volumes allowed in surrounding counties in order to maintain production in these three counties.

It is also important to note the limitation of the HAGM in these simulations. The limitation of the general head boundary conditions that are implemented in the HAGM are discussed in more detail in Chapter 4 and Appendix K, but for purposes of this discussion on DFCs it is important to note that the results of the two endpoint simulations described above are impacted by the general head boundary conditions in the HAGM.

Following the effort to quantify the endpoints of the balancing test described above, the final information related to the balancing test was reviewed during the August 15, 2019 meeting of the GMA 14 District Representatives and is shown in Table 2-4. This table represents six model scenarios showing percent of median available drawdown remaining between 2009 and 2070. The 100 percent scenario is the same scenario used to represent the conservation end of the balancing test described above. The other scenarios shown follow the same methodology, but with targets of 90 percent, 80 percent, 70 percent, 60 percent, and 50 percent of the 2009 median available drawdown remaining in each county in 2070. Note that the 50 percent scenario in Table 2-4 differs from the 50 percent scenario in Table 2-2 in that it uses a base year of 2009 instead of pre-development.

Addressing the Common Reservoir through More Uniform Management Standards

Percent available drawdown is an important metric because excessive drawdown may lead to undesirable outcomes such as a need to lower pumps and/or deepen wells, potential issues with water quality, reduced groundwater production efficiency, and/or an influence on economic growth based on water availability. However, the percent of remaining available drawdown in wells is not necessarily the limiting factor on groundwater availability throughout GMA 14. In some areas, especially close to the coast, subsidence can be a key factor for determining groundwater availability (discussed in more detail in Section 4.5).

Though GMA 14 District Representatives sought to create more uniform DFCs for the common reservoir of the Gulf Coast Aquifer System, groundwater availability can be limited by different factors in different areas of the aquifer. To attempt to address this, GMA 14 District Representatives developed a multi-metric approach whereby goal-oriented (i.e., not reverse-engineered) model runs were developed using both percent available drawdown remaining and subsidence in each county simultaneously. A uniform goal was set for each metric across each county in the GMA and pumping was adjusted in each county in GMA 14 until the first limiting metric was reached. Based on modeling and aquifer conditions, each GCD will adopt the applicable limiting factor or factors for the counties within their jurisdiction.

Following review of the above modeling results, the District Representatives requested additional runs with average additional subsidence thresholds up to 1.0 foot. This request was motivated by an issue identified in Brazoria County where implementation of a subsidence threshold of 0.5 feet would not have been feasible given existing aquifer uses and water demands. The relevance and appropriateness of the 1.0-foot metric for additional subsidence for Lone Star GCD was not discussed. Lone Star GCD also requested additional model runs using Run D from the district's Strategic Planning Study as the base pumping distribution in Montgomery County instead of the base pumping distribution from the 2016 round of joint planning.

Following the presentation of updated model run results addressing the above requests, the District Representatives in GMA 14 proposed moving forward with three scenarios for a more detailed review of the remaining factors in Texas Water Code Section 36.108(d)(1-9). These three scenarios were:

- In each county in GMA 14, no less than 70 percent median available drawdown remaining and no more than 1.0 feet average additional subsidence between 2009 and 2080.
- In each county in GMA 14, no less than 80 percent median available drawdown remaining and no more than 1.0 feet average additional subsidence between 2009 and 2080.
- In each county in GMA 14, no less than 70 percent median available drawdown remaining and no more than 1.0 feet average additional subsidence between 2009 and 2080 using the "Run D" well file as a base pumping distribution in Montgomery County.

Methods, results and limitations for each of these model runs are presented in more detail in Appendix R.

As described here, the process followed by the GMA 14 District Representatives was designed to address criticisms raised during the 2016 round of DFCs by developing improved metrics that are applicable across the aquifer, evaluating the balance of conservation and development of groundwater, and attempting to develop consistent management standards across the common reservoir. This process helped inform the development of proposed and final DFCs, as described in the next section.

2.2 Adopted DFCs

After consideration of the balancing test and the three scenarios described in Section 2.1, the policy and technical justifications presented in Section 3, and the information from each of the factors in Section 4, the GMA Representatives on April 9, 2021, unanimously voted to propose the following DFCs for adoption:

> The Member Districts of Groundwater Management Area 14 ("GMA 14") propose the following Desired Future Conditions ("DFCs") for the Gulf Coast Aquifer within Austin, Brazoria, Chambers, Grimes, Hardin, Jasper, Jefferson, Liberty, Montgomery, Newton, Orange, Polk, San Jacinto, Tyler, Walker, Waller, and Washington counties:

> *In each county in GMA 14, no less than 70 percent median available drawdown remaining in 2080 and no more than an average of 1.0 additional foot of subsidence between 2009 and 2080.*
>
> The model simulation consistent with the above proposed DFCs was developed by using the Houston Area Groundwater Model (HAGM) and adjusting the pumping distribution in each county starting with the distribution used in the 2016 round of joint planning in GMA 14.

These proposed DFCs were mailed to each GCD in GMA 14 on April 20, 2021 (Appendix F). Following the public comment period and review of the relevant comments received, the District Representatives in GMA 14 adopted the following desired future conditions as excerpted from GMA 14 Resolution 2021-10-5:

> *In each county in GMA 14, no less than 70 percent median available drawdown remaining in 2080 or no more than an average of 1.0 additional foot of subsidence between 2009 and 2080.*

The resolution in its entirety is presented in Appendix G. This resolution was adopted by GMA 14 District Representatives, after providing notice as required, on January 5, 2022. As clarified at the February 23, 2022 GMA 14 meeting, for the purpose of TWDB developing estimates of modeled available groundwater, the GMA 14 District Representatives consider a model run to be consistent with the DFCs if it matches the above conditions within a tolerance of 3 percent median available drawdown remaining and 0.2 feet of average additional subsidence.

After extensive review and consideration of public comments the GMA 14 District Representatives changed the “and” in the proposed DFC to an “or” in the adopted DFC. The significance of the “or” is evident in Table 2-5, which shows the model results detailed in Appendix R for the adopted multi-metric DFC. The results demonstrate there is a single metric of primary importance in most counties. As discussed in Section 2.1, modeled annual pumping in each county was increased to the point at which any additional pumping would either exceed: 1) the 70% median available drawdown threshold, 2) the average additional subsidence threshold of 1 foot, or 3) surpass an annual pumping rate that is not realistic because it significantly exceeds expected demand. In seven counties (e.g., Grimes, Jasper, Jefferson, Montgomery, Newton, Walker, and Waller) pumping was limited by the available drawdown metric, suggesting that in these counties managing to and monitoring available drawdown is sufficient to comply with adopted DFCs. The average subsidence metric limited annual pumping in Brazoria, Chambers, Liberty, and Orange counties, suggesting that managing to and monitoring subsidence is sufficient to comply with the adopted DFCs. In Austin, Hardin, Polk, San Jacinto, Tyler, and Washington counties annual pumping was not limited by the available drawdown or subsidence metric but was instead limited by the model limitation of 30,000 acre-feet per year above the maximum projected water demand in the State Water Plan. In Austin, Hardin, Polk, San Jacinto, Tyler, and Washington counties, groundwater pumping is unlikely to threaten non-compliance with the DFCs; however, monitoring both available drawdown and subsidence to the extent feasible in these counties may be useful.

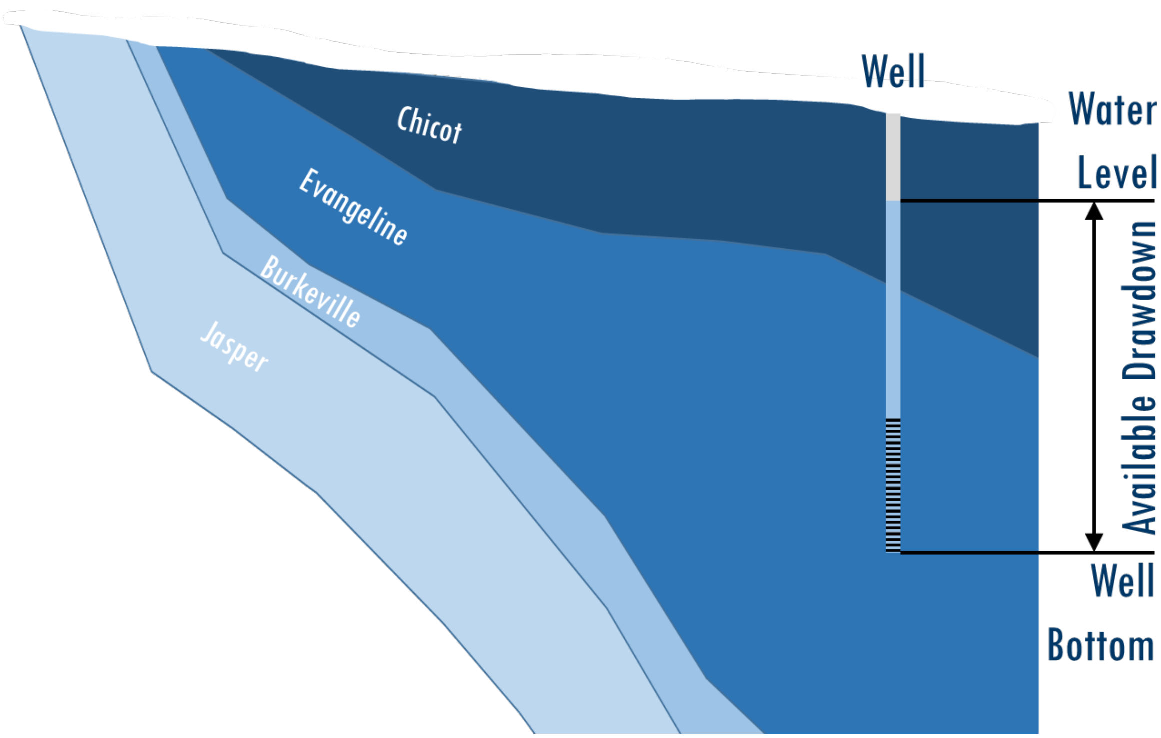

FIGURE 2-1. ILLUSTRATION OF THE CONCEPT OF AVAILABLE DRAWDOWN AS DEFINED FOR USE IN 2022 GMA 14 JOINT PLANNING

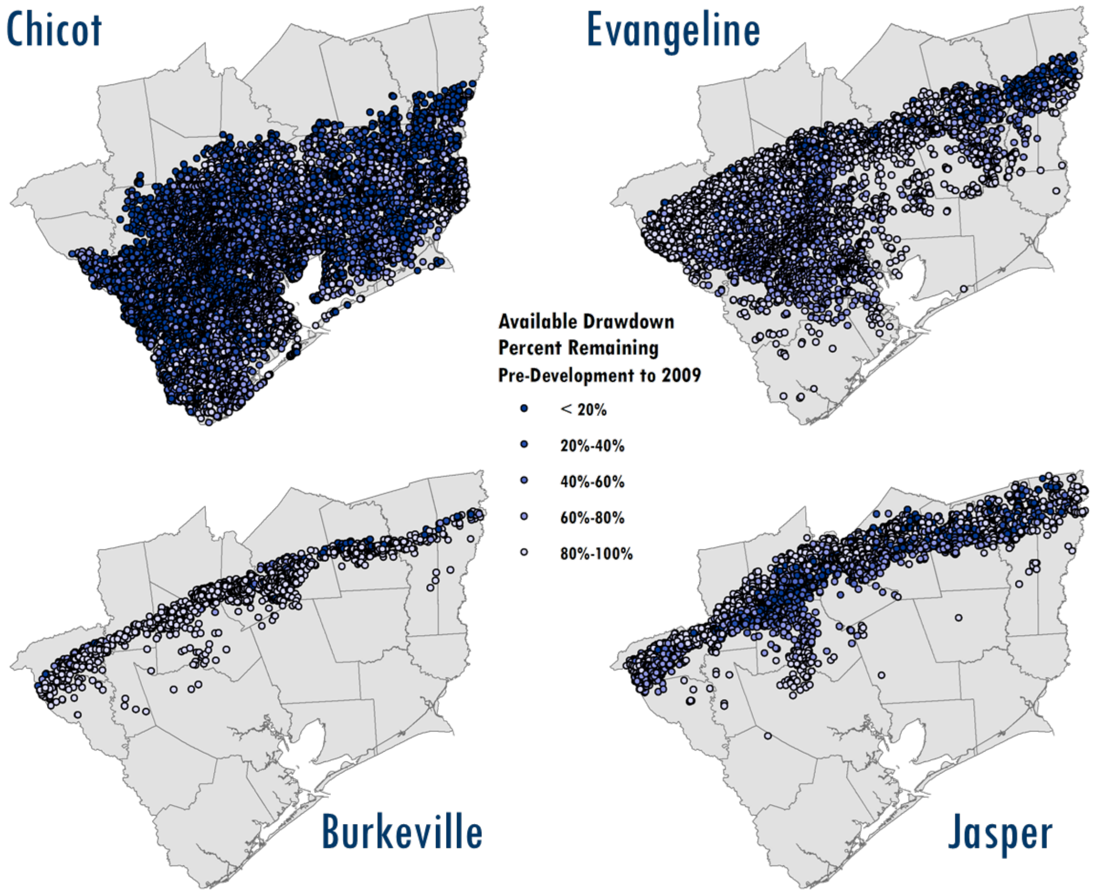

FIGURE 2-2. WELLS USED FOR CALCULATING MEDIAN PERCENT AVAILABLE DRAWDOWN REMAINING

TABLE 2-1. MEDIAN PERCENT OF PRE-DEVELOPMENT AVAILABLE DRAWDOWN REMAINING IN 2009 BY COUNTY IN GMA 14 COMPARED TO 2009 PUMPING AND MAXIMUM SUBSIDENCE IN EACH COUNTY.

County	2009 Modeled Pumping (acre-feet)	Available Drawdown Remaining (Pre-Development to 2009)	2009 Modeled Maximum Subsidence (feet)
Austin	10,002	96%	0.4
Brazoria	41,968	64%	5.9
Chambers	4,328	61%	4.4
Fort Bend	121,022	36%	5.6
Galveston	1,076	68%	6.8
Grimes	3,737	89%	0.1
Hardin	18,992	67%	1.9
Harris	300,652	40%	10.3
Jasper	53,751	60%	4.0
Jefferson	3,049	61%	0.3
Liberty	26,711	66%	3.4
Montgomery	74,100	61%	3.8
Newton	3,041	66%	0.5
Orange	17,192	77%	3.1
Polk	4,178	85%	0.0
San Jacinto	2,545	89%	0.1
Tyler	2,860	76%	0.2
Walker	5,564	85%	0.0
Waller	24,402	66%	2.4
Washington	1,917	92%	0.0
GMA 14	721,085	60%	10.3

TABLE 2-2. ESTIMATED HIGHEST PRACTICABLE LEVEL OF GROUNDWATER PRODUCTION AS DEFINED BY A MEDIAN 50 PERCENT DEPLETION OF PRE-DEVELOPMENT AVAILABLE DRAWDOWN IN EACH COUNTY.

County	2070 Modeled Pumping (acre-feet)	Available Drawdown Remaining (Pre-Development to 2070)	2070 Modeled Maximum Subsidence (feet)	2009 Modeled Recharge (acre-feet)
Austin	672,535	44%	28.0	23,219
Brazoria	129,433	50%	12.4	50,921
Chambers	26,000	52%	7.9	7,553
Fort Bend	168,869	4%	24.2	58,014
Galveston	9,180	60%	12.9	1,370
Grimes	146,227	50%	0.6	5,796
Hardin	59,881	51%	3.4	24,795
Harris	228,813	33%	14.5	131,187
Jasper	67,928	50%	4.6	24,539
Jefferson	1,120	46%	4.3	5,309
Liberty	97,012	50%	7.2	33,799
Montgomery	95,789	50%	6.6	35,994
Newton	60,924	50%	5.3	18,042
Orange	77,079	51%	13.7	11,504
Polk	148,488	50%	1.4	16,940
San Jacinto	152,620	50%	3.1	7,024
Tyler	87,287	50%	2.0	12,675
Walker	70,328	50%	0.4	6,159
Waller	57,458	49%	10.5	25,898
Washington	94,375	49%	0.5	8,449
GMA 14	2,451,346	42%	28.0	509,188

TABLE 2-3. ESTIMATED PUMPING ASSOCIATED WITH THE CONSERVATION, PRESERVATION, PROTECTION, RECHARGING, AND PREVENTION OF WASTE OF GROUNDWATER AND CONTROL OF SUBSIDENCE.

County	2070 Modeled Pumping (acre-feet)	Available Drawdown Remaining (2009 to 2070)	2070 Modeled Maximum Subsidence (feet)	2009 Modeled Recharge (acre-feet)
Austin	14,683	100%	2.4	23,219
Brazoria	5,598	100%	5.9	50,921
Chambers	884	99%	4.4	7,553
Fort Bend	168,869	72%	6.5	58,014
Galveston	9,180	95%	8.4	1,370
Grimes	2,799	100%	0.1	5,796
Hardin	30,980	100%	1.9	24,795
Harris	228,813	100%	10.3	131,187
Jasper	6,627	100%	3.9	24,539
Jefferson	8,625	99%	0.3	5,309
Liberty	17,287	100%	3.4	33,799
Montgomery	9,239	100%	4.0	35,994
Newton	2,737	99%	0.5	18,042
Orange	27,819	100%	3.1	11,504
Polk	708	99%	0.0	16,940
San Jacinto	887	100%	0.1	7,024
Tyler	642	99%	0.3	12,675
Walker	3,560	100%	0.0	6,159
Waller	9,888	100%	3.7	25,898
Washington	2,124	100%	0.0	8,449
GMA 14	551,948	99%	10.3	509,188

TABLE 2-4. PUMPING ASSOCIATED WITH MEDIAN PERCENT AVAILABLE DRAWDOWN REMAINING TARGETS BETWEEN 50 PERCENT AND 100 PERCENT. NOTE THAT PUMPING IN THE SUBSIDENCE DISTRICTS (HIGHLIGHTED) WAS NOT ADJUSTED.

		2070 Modeled Pumping by Scenario (acre-feet)					
		Percent of Remaining Median Available Drawdown - Base Year 2009					
County	2016 DFCs	100%	90%	80%	70%	60%	50%
Austin	22,296	14,683	145,489	256,568	379,151	497,538	622,858
Brazoria	50,587	5,598	50,170	93,965	138,680	185,103	231,049
Chambers	21,642	884	9,934	16,334	32,047	46,519	64,356
Fort Bend	168,869	168,869	168,869	168,869	168,869	168,869	168,869
Galveston	9,180	9,180	9,180	9,180	9,180	9,180	9,180
Grimes	13,996	2,799	25,739	60,462	87,849	117,220	146,841
Hardin	34,926	30,980	42,682	48,308	59,023	70,695	84,646
Harris	228,813	228,813	228,813	228,813	228,813	228,813	228,813
Jasper	67,482	6,627	36,008	53,546	77,682	76,833	90,924
Jefferson	2,470	8,625	2,290	2,203	2,147	2,313	1,254
Liberty	43,229	17,287	32,657	65,682	85,027	109,974	130,340
Montgomery	64,003	9,239	41,614	62,622	91,293	122,352	155,695
Newton	34,218	2,737	11,519	20,870	34,723	48,111	60,916
Orange	19,997	27,819	38,178	53,480	69,737	85,133	99,796
Polk	36,707	708	24,955	54,590	84,025	115,296	144,919
San Jacinto	20,982	887	27,528	57,539	90,464	120,406	150,519
Tyler	38,210	642	15,246	32,061	50,550	68,844	86,997
Walker	17,972	3,560	12,898	27,896	42,090	57,580	71,770
Waller	41,592	9,888	23,204	37,477	50,773	63,630	76,647
Washington	13,031	2,124	18,485	38,054	56,059	74,743	93,375
GMA 14	950,203	551,948	965,459	1,388,520	1,838,183	2,269,153	2,719,766

TABLE 2-5. ESTIMATED MEDIAN AVAILABLE DRAWDOWN REMAINING AND MODELED AVERAGE SUBSIDENCE ASSOCIATED WITH THE ADOPTED DFC.

County	Modeled Annual Pumping (acre-feet)	Maximum Demand Under State Water Plan (acre-feet)	Available Drawdown Remaining (2009 to 2080)	2080 Modeled Average Subsidence (feet)	Limiting Metric
Austin	46,599	16,586	92%	0.4	Demand Limited (30,000 ac-ft threshold)
Brazoria	55,288	420,893	87%	1.0	Subsidence Limited
Chambers	22,219	182,726	76%	1.0	Subsidence Limited
Fort Bend	168,869	168,869*	58%	2.2	Not Applicable
Galveston	9,180	9,180*	87%	1.5	Not Applicable
Grimes	51,486	23,687	70%	0.0	Available Drawdown Limited
Hardin	37,720	7,817	81%	0.6	Demand Limited (30,000 ac-ft threshold)
Harris	228,813	228,812*	83%	0.8	Not Applicable
Jasper	73,283	72,515	69%	0.3	Available Drawdown Limited
Jefferson	15,481	403,061	68%	0.6	Available Drawdown Limited
Liberty	71,728	64,294	76%	1.1	Subsidence Limited
Montgomery	97,012	286,183	68%	0.5	Available Drawdown Limited
Newton	37,587	8,155	70%	0.2	Available Drawdown Limited
Orange	25,204	65,083	91%	1.0	Subsidence Limited
Polk	40,745	10,837	82%	0.0	Demand Limited (30,000 ac-ft threshold)
San Jacinto	35,041	5,059	82%	0.1	Demand Limited (30,000 ac-ft threshold)
Tyler	34,389	4,482	78%	0.0	Demand Limited (30,000 ac-ft threshold)
Walker	42,448	15,458	70%	0.0	Available Drawdown Limited
Waller	55,491	39,686	69%	0.6	Available Drawdown Limited
Washington	40,397	10,416	77%	0.0	Demand Limited (30,000 ac-ft threshold)

highlights limiting metric

*Pumping in Subsidence District is set by the 2013 Regulatory Plan.

3. Policy and Technical Justifications

Texas Water Code Section 36.108(d-3)(2) requires that the explanatory report provide the policy and technical justifications for each desired future condition. For the current round of joint planning, the policy and technical considerations and justifications for the adopted DFCs are best explained through a review of the timeline spanning their development and adoption. This section will highlight many of the major events and meetings that influenced the development and adoption of the DFCs described in this Explanatory Report.

The timeline included below clearly illustrates both the policy and technical considerations that are weighed by the District Representatives during development and adoption of DFCs. Each district "weights" the factors included in Texas Water Code Section 38.108(d)(1-9) differently. In addition, different districts interpret the role of the joint planning process differently. Some districts view the process as primarily a planning exercise. Other districts view the process as having regulatory implications and critical for providing landowners with a "fair share" of groundwater.

The adopted DFCs represent a balance between development and conservation of groundwater. The adopted DFCs also represent the result of a negotiation among the District Representatives about the best process to follow and method for articulating DFCs. The District Representatives made a clear effort through the joint planning process to address issues identified in the petitions of the 2016 DFCs while also adopting DFCs that are more consistent across GMA 14.

<u>Adoption of DFCs for the Second Round of Joint Planning</u>

On April 29, 2016, the District Representatives in GMA 14 adopted DFCs for the individual units of the Gulf Coast Aquifer System (Chicot, Evangeline, Burkeville, and Jasper) by county and for GMA 14 overall. These DFCs were generally structured as an average drawdown over the 61-year period between 2009 and 2070 for each layer of the aquifer. Bluebonnet GCD also adopted DFCs based on maximum subsidence from pre-development conditions through 2070.

<u>Petitions Appealing DFCs Adopted by Lone Star GCD</u>

On December 2, 2016, Lone Star GCD received a petition from the Cities of Conroe and Magnolia, Texas appealing the DFCs adopted by the district. The petition was submitted to TWDB by Lone Star GCD on December 12, 2016.

On December 6, 2016, Lone Star GCD received a petition from Quadvest, L.P. appealing the DFCs adopted by the district. The petition was submitted to TWDB by Lone Star GCD on December 14, 2016.

TWDB Issues Modeled Available Groundwater

TWDB issued GAM Run 16-024 MAG report (Wade S. C., 2016) on December 15, 2016, documenting development of the estimated modeled available groundwater associated with the DFCs adopted in 2016.

Lone Star GCD Completes Strategic Planning Study, Changes Policy Goal Change and Resolves 2016 Petition

In October 2017, Lone Star GCD received the results of a three-year Strategic Water Resources Planning Study (LBG-Guyton Associates, 2017). As a result of the study, Lone Star GCD declared a change in its policy priorities and goals in October 2017. The district's stated policy goal shifted away from sustainability and toward a policy that "allows measured aquifer level declines." The Lone Star GCD Board unanimously adopted 1) increased pumping levels (from 64,000 acre-feet per year to 100,000 acre-feet per year through 2070) and resulting aquifer conditions included in what is referred to as groundwater availability model "Run D" from the final report for Task 3 of the Planning Study as the District's recommended model scenario; and 2) recommended that the district's General Manager and consultants present the results of the Strategic Water Resources Planning Study, including the recommendation for Run D, to the district representatives of GMA 14 with a request that Run D be considered in the joint planning process as either an amendment to the DFCs previously adopted in 2016 or as a new proposal.

Lone Star GCD and the cities of Conroe and Magnolia reached an agreement regarding the petition filed on December 2, 2016, which included utilizing Run D as the resolution to the petition. Quadvest LP did not oppose the agreement.

Consideration of Run D as the Basis for New or Amended DFCs

Following resolution of the petitions challenging the reasonableness of the DFCs in Montgomery County, Lone Star GCD first requested formal consideration of a "new or amended" DFC based on "Run D of Task 3 of the Lone Star GCD Strategic Water Resources Planning Study." In a letter dated March 9, 2018, Lone Star GCD requested formal consideration of Run D "only as an amendment" to the previously adopted DFC. At the March 27, 2018, meeting of the District Representatives in GMA 14, Lone Star GCD's request to consider Run D only as an amendment to the previously adopted DFC did not pass. Instead, the District Representatives voted to consider Run D in response to its request from the appeal and to develop the third cycle DFCs. This model run (which includes approximately 100,000 acre-feet per year of pumping in Lone Star GCD) and another model run provided by Lone Star GCD using the Run D well file as the base file, became the focus of discussion and consideration throughout the third cycle of joint planning.

As described in a technical analysis of the situation prepared for Bluebonnet GCD, changing the DFC for only Montgomery County (that is, Lone Star GCD) would violate the requirement in Texas Water Code Chapter 36.108(d)(8) that the DFCs be feasible (Hutchison, 2018). Adoption of the drawdowns included in Run D as the DFCs for Montgomery County would change conditions in neighboring counties to such a degree that it would necessitate reevaluation of DFCs throughout GMA 14.

<u>Meeting January 30, 2019 - Beginning Third Round of Joint Planning – Consideration of Aquifer Uses and Conditions</u>

The January 30, 2019 meeting of the Participants began the third round of joint planning in GMA 14 and included discussion and consideration of aquifer uses and conditions throughout the management area. The presentation also included a review of the basics of the joint planning process.

At the meeting, Mr. Harry Hardman, then Vice President of the Lone Star GCD Board of Directors, shared remarks with the Participants describing the status of his district's management plan and efforts to get it approved even though the DFCs in the district adopted in 2016 had been declared "no longer reasonable." Mr. Hardman also shared his desire for GMA 14 to follow a different process for the current round of joint planning that affords "every owner of a common subsurface reservoir a fair share" (also referred to as using a "common reservoir" approach when developing DFCs).

He referenced an interim report in 2018 by the Senate Committee on Agriculture, Water and Rural Affairs that concluded that "two GCDs over the same aquifer with similar science-based hydrological formations should not have dissimilar DFCs." The full comments by Mr. Hardman, as well as all other meeting materials for this and subsequent GMA 14 meetings, are included in Appendix D.

<u>Meeting March 27, 2019 – Consideration of Water Supply Needs and Management Strategies</u>

On March 27, 2019, the Participants in GMA 14 received and considered a presentation of the water supply needs and management strategies in the State Water Plan. Also, during the meeting, Mr. Mike Thornhill, a technical consultant to Lone Star GCD, provided a presentation proposing an alternative path forward for joint planning that focused on delineation of the "common reservoir" for DFCs guided by current water use, water level changes, storage, subsidence and projected future uses. LSGCD requested Run D, that was developed in the second round, to be removed on the basis that it was not developed using the common reservoir approach. The GMA 14 Consultant was directed to evaluate cost and schedule impacts associated with Mr. Thornhill's presentation for the following joint planning meeting. Mr. Hardman, the District Representative for Lone Star GCD, also moved to remove Run D from consideration as a future methodology and from the scope of work for the third round of joint planning. The motion carried unanimously.

Meeting June 26, 2019 – Consideration of Hydrological Conditions

On June 26, 2019, the Participants in GMA 14 received and considered a presentation of the hydrological conditions in GMA 14, including for each aquifer in the management area the total estimated recoverable storage and the average annual recharge, inflows, and discharge. The Participants also received options for modifying the joint planning process consistent with the presentation provided by Mr. Thornhill during the March 27, 2019 meeting. After considerable discussion, Mr. Hardman moved to postpone discussion of delineation of the DFCs to the end of the joint planning process.

Mr. Hardman elaborated on the situation Lone Star GCD was in, in light of TWDB rejecting their proposed management plan submittal.

Meeting August 15, 2019 – Balancing Test

On August 15, 2019, the Participants in GMA 14 received and considered a presentation on the 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. During this presentation, the concept of median available drawdown remaining was introduced as a potential metric for characterizing aquifer conditions in areas that are hydrologically dissimilar.

During the meeting, representatives for Lone Star GCD expressed a desire to reconsider the second round of DFCs or expedite the third round of DFCs for management plan compliance. After discussion, the Participants requested that a cost estimate for expediting the third round of joint planning be developed for the next meeting. Lone Star GCD was under the impression that the DFCs were to be developed under an expedited schedule already and that an expedited schedule was factored in the GMA 14 Consultant's proposal and would not necessarily cost more money but would just require meeting more often. Mr. Thornhill, a technical consultant to Lone Star GCD, commented that the approach taken by the group relating to the balancing test is acceptable and does not fall into "reverse engineering," which had been a criticism of previous DFCs.

Meeting November 13, 2019 – Designating common reservoirs and choosing model scenarios

During the November 13, 2019 meeting, the Participants considered various model runs including a request by Southeast GCD for 75% remaining available drawdown, a remaining available drawdown proposal by Lone Star GCD, and two remaining available drawdown scenarios by Brazoria GCD. The Participants also considered a cost estimate for expediting the third round of joint planning. Ms. Reiter, as the District Representative for Lone Star GCD, noted that the DFCs at this point would not result in DFCs being developed considerably faster given the time that had already passed though Lone Star GCD was not formally withdrawing its request. Ms. Reiter also noted that Lone Star GCD would be presenting a process for a model run that is new to GMA 14 and wanted to make sure that the GMA 14 District Representatives had adequate time to meaningfully consider and review the model.

The Participants reviewed and considered a presentation by Mr. Thornhill representing Lone Star GCD regarding methods for delineating a common reservoir. The intent of the proposal was to utilize 30 percent of regional and state water plan identified needs to evaluate the potential capability of the aquifer, if allowed, to meet those needs. In addition, Mr. Thornhill noted there would need to be interpretation of the feasibility of strategies, such as if groundwater could take the place of a surface water. Dr. Bill Hutchison representing Bluebonnet GCD suggested focusing on the physical capabilities of the aquifer. He recommended the District Representatives begin within the parameters of the modeling work performed for the balancing test and modify the pumping to more closely align with the Lone Star GCD framework and objectives of identifying favorable productivity and water quality locations to locate production near demand areas.

Dr. Hutchison noted a key highlight of the median available drawdown approach in the balancing test scenarios is that it expresses potential DFCs using available well records, defining a new way to express DFCs across the entire GMA. It removes the issue of drawdown in county-by-county delineation and the planning goal can be uniform everywhere across the GMA considering existing infrastructure, well depth differences, aquifer parameters to generate pumping and subsidence. The District Representatives moved to run a 75 percent median available drawdown remaining scenario requested by Southeast Texas GCD and then work with Lone Star GCD on a pumping distribution methodology. The District Representatives also moved to approve the run proposed by Brazoria County GCD. Both motions carried unanimously.

<u>Meeting February 24, 2020 – Model Run Results and Potential Paths Forward</u>

On February 24, 2020, the Participants in GMA 14 received and considered two presentations relating to model run results. The first presentation was by technical consultants for Lone Star GCD. As described by Mr. Thornhill representing Lone Star GCD, the approach used in the model runs performed by Lone Star GCD's technical consultants emphasizes management of aquifers across the region, a groundwater rights holder's opportunity to produce a fair share, and the requirement for balancing use with conservation to find availability. Mr. Mike Keester representing Lone Star GCD presented the model results for available drawdown scenarios, which seek to simulate what would happen if all expected future needs are met by groundwater projects.

The GMA 14 Consultant presented results for the 75 percent median available drawdown remaining proposal by Southeast Texas GCD. He noted that the two median remaining available drawdown runs proposed by Brazoria County GCD were consistent with model runs completed and presented previously. Discussion by the Participants noted that the group had not yet settled on a clear path forward for further decision-making.

Meeting April 29, 2020 – Additional Model Run Results and Potential Paths Forward

On April 29, 2020 meeting, the Participants in GMA 14 received and considered a presentation from the GMA 14 Consultant relating to the selection of DFC metrics and a review of model run results. The discussion on selection of meaningful DFC metrics included posing questions such as (1) does the metric capture the limiting factor on groundwater availability, (2) how robust is the dataset for the base year, (3) do GCDs have access to monitor the selected metric, (4) how directly can the DFC be monitored, and (5) how well does the DFC cover the aquifer?

The GMA 14 Consultant's presentation also included discussion of single metric versus multiple metric DFCs. The GMA 14 Consultant introduced the District Representatives to a multi-metric approach he had developed that considered median percent remaining available drawdown thresholds of 70 percent, 80 percent, and 90 percent; and average additional subsidence thresholds of 0.1 feet, 0.3 feet, and 0.5 feet in each county. To address the HAGM limitation resulting from the general head boundaries (as discussed above and also in Chapter 4), and to allow for growth while ensuring the distribution of pumping in the model runs remained realistic, the modeled pumping in each county was not allowed to be increased to more than 30,000 acre-feet per year above the maximum projected water demand in the 2017 State Water Plan if neither the available drawdown nor subsidence thresholds were reached. One potential disadvantage of single metric DFCs (such as average drawdown) is that while it can account for varying aquifer conditions, it can be difficult to explain why there are differences between DFCs in different areas. A potential benefit of multiple metric DFCs is that they allow for consistent DFCs throughout the GMA while accounting for local differences in conditions. It allows for both the process of DFC development and the results to directly address statutory factors and has a less direct link to the existing pumping distribution, which addresses concerns about "reverse engineering." A potential drawback of multiple metric DFCs is that multi-county Districts would have to monitor more than one aquifer characteristic. District Representatives reviewed multiple metric modeling results for each county that considered median available drawdown remaining, average additional subsidence, and received information regarding which metric acted as the limiting factor in each county in various simulations.

The Participants also reviewed and considered a presentation by consultants for Lone Star GCD showing modeling results. Mr. James Beach representing Lone Star GCD noted that the district weights private property rights the highest among the nine statutory factors in Texas Water Code Section 36.108(d). Lone Star GCD also discussed that while it was not opposed to using the multiple metrics as modeling constraints within a common reservoir type approach, Lone Star GCD did not support a DFC statement incorporating water level and subsidence. Lone Star GCD indicated that a subsidence DFC was not appropriate for Lone Star GCD, and it believed the petition issues were adequately addressed using the "percent remaining available drawdown" metric as it has been simulated in the previous modeling scenarios. Lone Star GCD reiterated that it was not opposed to using the "multi-metric" approach for modeling purposes, but that Lone Star GCD never needed or requested the multi-metric approach nor agreed to adopt it in a DFC statement. Lone Star GCD's objection to a subsidence DFC metric ultimately led to Lone Star GCD requesting the proposed DFCs to be revised to replace the "and" with an "or" so that each district has the flexibility to adopt the applicable metric in the DFC statement as needed for local management. *See* Lone Star GCD's Summary and Position Paper in Appendix C.

Following the review of varied model results, the Participants discussed and requested additional information on the maximum subsidence associated with each scenario, how the results would differ with a higher average additional subsidence metric to address issues with the modeling results identified in Brazoria County, and using different well files prepared by Lone Star GCD consultants as the base file for the simulations.

Meeting May 29, 2020 – Selecting a Path Forward

On May 29, 2020, the Participants in GMA 14 considered additional model run results based on the multiple metric approach using both median available drawdown and subsidence remaining. The discussion included input by Mr. James Beach representing Lone Star GCD stating that Lone Star GCD does not intend to use subsidence as a metric in their DFC statement. Mr. Beach stated that this was because there are causes of subsidence within Montgomery County that Lone Star GCD does not control. Lone Star GCD objected to the inclusion of a subsidence metric in a DFC statement for Montgomery County for a number of reasons including because the subsidence metric was not the limiting factor in Montgomery County in the modeling. *See* Lone Star GCD's Summary Report and Position Paper in Appendix C. It was discussed amongst the group that the specifics of a DFC statement can be adjusted near the end of the joint planning process.

Following review of the modeling results and considerable discussion, the Participants unanimously selected three model runs to consider during evaluation of the remaining factors in Texas Water Code Section 36.108(d). The selected runs were (1) 70 percent median available drawdown remaining, with no more than 1-foot average additional subsidence using Run D as the base pumping distribution, (2) 70 percent median available drawdown remaining, with no more than 1-foot average additional subsidence using the 2016 base pumping distribution, and (3) 80 percent median available drawdown remaining, with no more than 1-foot average additional subsidence using the 2016 base pumping distribution.

Meeting July 15, 2020 – Consideration of Subsidence

On July 15, 2020, the Participants in GMA 14 received and considered a presentation regarding the impacts on subsidence for the three model run scenarios selected during the May 29, 2020 joint planning meeting. This included discussion on the difference between compaction and subsidence and how they are evaluated in the HAGM. Following the presentation, the Participants agreed that faulting should be evaluated as part of the “Other Information” factor referenced in Texas Water Code Section 36.108(d)(9).

Meeting September 16, 2020 – Consideration of Environmental and Socioeconomic Impacts

On September 16, 2020, the Participants in GMA 14 received and considered presentations on environmental and socioeconomic impacts. Information on environmental impacts primarily focuses on the potential impact of groundwater pumping on interaction with surface water features such as rivers and creeks. The consideration of socioeconomic impacts included review of quantitative evaluations available through the regional water planning process, reviews of the cost of water and potential costs of addressing water level declines in wells, as well as other qualitative considerations.

Meeting November 18, 2020 – Consideration of Private Property Rights

On November 18, 2020, the District Representatives in GMA 14 received and considered four presentations by practicing water attorneys relating to private property rights and a fifth presentation relating to takings claims.

Meeting January 20, 2021 – Considering Feasibility and Faulting

On January 20, 2021, the Participants in GMA 14 received and considered presentations relating to the feasibility of achieving desired future conditions and “any other information relevant” to the DFC, which was decided at the July 15, 2020 meeting, would include faulting. The discussion by the Participants regarding feasibility centered around the process for monitoring subsidence and potential costs. The discussion on faulting showed the methods for identifying faults and rates of fault movement. The Participants also reviewed information demonstrating the link between groundwater production and rates of fault movement.

As in some prior meetings, Lone Star GCD reiterated that it cannot support a DFC statement that includes subsidence for Montgomery County. The Participants discussed and considered this in the context of multiple metric approach.

Meeting February 24, 2021 – Review of Factors

On February 24, 2021, the Participants in GMA 14 received and considered a presentation reviewing the information presented in previous meetings including the balancing test and the factors included in Texas Water Code Section 36.108(d)(1-9). Though the agenda for the meeting included potential proposal of DFCs for adoption, there was considerable discussion among the Participants about Lone Star GCD's desire to not have subsidence as a component of its DFCs. The District Representatives chose to delay action on proposing DFCs for adoption until the next meeting. The next meeting was originally planned for March 31, 2021, but was subsequently rescheduled to April 9, 2021.

Meeting April 9, 2021 – Proposal of DFCs for Adoption

On April 9, 2021, the Participants met to discuss proposed DFCs. Each of the three scenarios selected during the May 29, 2020 meeting were under consideration and there was extended discussion about the best way to translate these scenarios into the language of a DFC. Lone Star GCD's District Representative noted her objections to a subsidence metric for Montgomery County and that the resolution language did not address each county's applicable DFC based on the modeling. Following this discussion and a decision not to include a formal resolution approving proposed DFCs, a motion was made to propose DFCs in each county of no less than 70 percent median available drawdown remaining in 2080 and no more than 1.0 additional foot of average subsidence between 2009 and 2080, using the HAGM pumping distribution without an associated resolution. The motion passed unanimously by the District Representatives.

Meeting October 5, 2021 – Consideration of Public Comments, District Summary Reports, Proposed Revisions to Resolution Language, and Draft Explanatory Report

On October 5, 2021, the Participants reviewed, discussed, and considered each District's summary reports regarding written comments received by each GCD during the public comment period and at its public hearing, and considered any GCD's suggested revisions to the proposed DFCs. The majority of comments received by each District related to the DFCs as applied to Lone Star GCD and positions for and against a change in the DFC statement of the "and" to an "or." After discussion, four of five of the District Representatives voted to approve a form resolution (Southeast Texas GCD abstained) that will be used to guide completion of the report. The District Representatives finalized a proposed resolution for use when the DFCs are adopted at a later meeting. Following the finalized proposed resolution language and discussion on the draft explanatory report, the District Representatives emphasized the desire to attain a unanimous vote of support for the proposed DFCs and proposed resolution. Furthermore, the District Representatives did not initiate the 60-day submission deadline with the draft explanatory report.

Meeting January 5, 2022—Review of Draft Explanatory Report and Adoption of DFCs

At the January 5, 2022 GMA 14 meeting, the District Representatives unanimously adopted DFCs as shown in GMA 14 Resolution 2021-10-5., and listed below.

> *In each county in GMA 14, no less than 70 percent median available drawdown remaining in 2080 or no more than an average of 1.0 additional foot of subsidence between 2009 and 2080.*

This started the 60-day submission deadline for the draft explanatory report. The resolution changes the “and” to an “or” in the DFC statement. The District Representatives agreed to meet again on February 23, 2021 for the purpose of reviewing and approving the explanatory report.

4. Factor Consideration

4.1. Aquifer Uses and Conditions

Texas Water Code Section 36.108(d)(1) requires District Representatives in a GMA to consider "aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another." District Representatives in GMA 14 reviewed and considered this factor on January 30, 2019, and again as part of the review of all factors considered on February 24, 2021. The presentation from this meeting and supplemental materials are shown in Appendix I. Also included in Appendix I is the water use information by both aquifer and use type, which was prepared for each county and considered by the Participants.

To consider aquifer uses and conditions, the Participants evaluated the distribution of well depths and yields across the area. This included information from over 100,000 wells from the TWDB Groundwater and Submitted Drillers Reports databases (Texas Water Development Board, 2019). The distribution of well depths is shown in Figure 4-1. The average well depth in GMA 14 is approximately 226 feet. Many of the deepest wells are in more developed areas such as Fort Bend, Harris, and Montgomery, counties.

The distribution of well yields is shown in Figure 4-2. Approximately 46,000 wells in GMA 14 had available well yield information. The distribution of well yields is similar to the distribution of well depths shown in Figure 4-1 in that the higher yield wells are likely to be deeper and located in areas with the highest water demands. Well yield in GMA 14 averages 75 gallons per minute, though many wells have yields that exceed 1,000 gallons per minute. It is important to note that well yield does not represent the maximum that the aquifer can produce at any one location. It is very strongly influenced by factors such as well depth, construction technique, and pump size.

Maps like those in Figure 4-1 and Figure 4-2 showing the well depths and yields at the county scale were also developed and considered by the Participants. These are shown in Appendix I.

The Participants also considered the annual pumping by aquifer throughout GMA 14, shown in Figure 4-3. Most of the groundwater pumping in the GMA is from the Gulf Coast Aquifer System. Overall, groundwater use has been declining since 2000 from approximately 700,000 acre-feet per year to approximately 500,000 acre-feet per year in 2016. The spike in water use in 2011 corresponds to a severe drought experienced statewide. Note that this declining trend is not universal for every county in GMA 14 (see Appendix I).

Note in Figure 4-3 that, beginning in 2010, approximately one-third of the pumping is classified as coming from "Other Aquifer." This is a consistent feature of the groundwater pumpage data across Texas and corresponds to the time during which surveys of water use switched from paper to electronic submission. In the electronic submission process, it is our understanding that the aquifers within the Gulf Coast Aquifer System are not provided as options (for example, the Evangeline or Jasper aquifers). It appears that many individuals submitting water use surveys may not have known from which aquifer their wells produce, at least in the parlance used by TWDB and in the joint planning process. The District Representatives interpret the shift to “Other Aquifer” beginning in 2010 to be associated with a change in data collection methodology and not a change in the way groundwater resources are used.

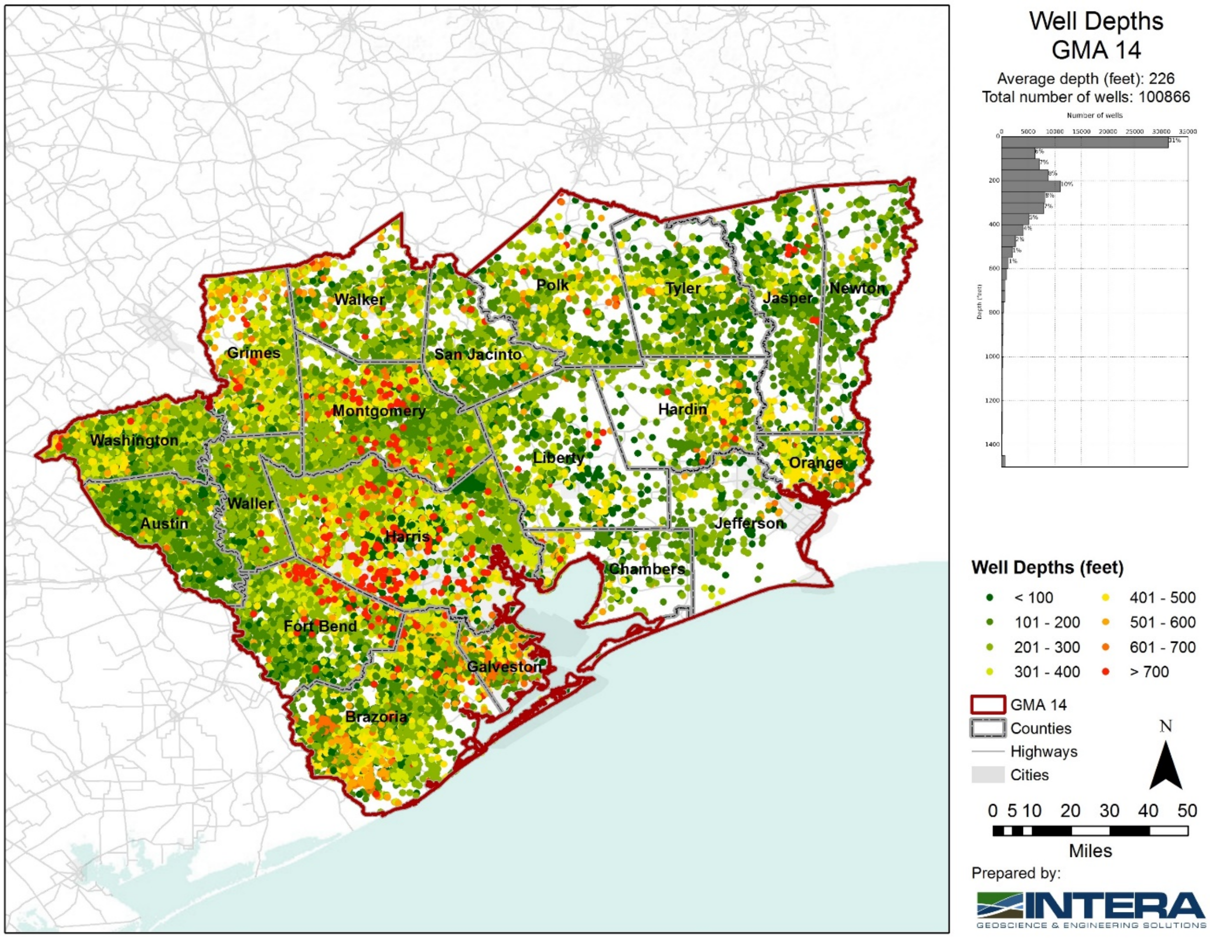

FIGURE 4-1. DISTRIBUTION OF WELL DEPTHS IN GMA 14

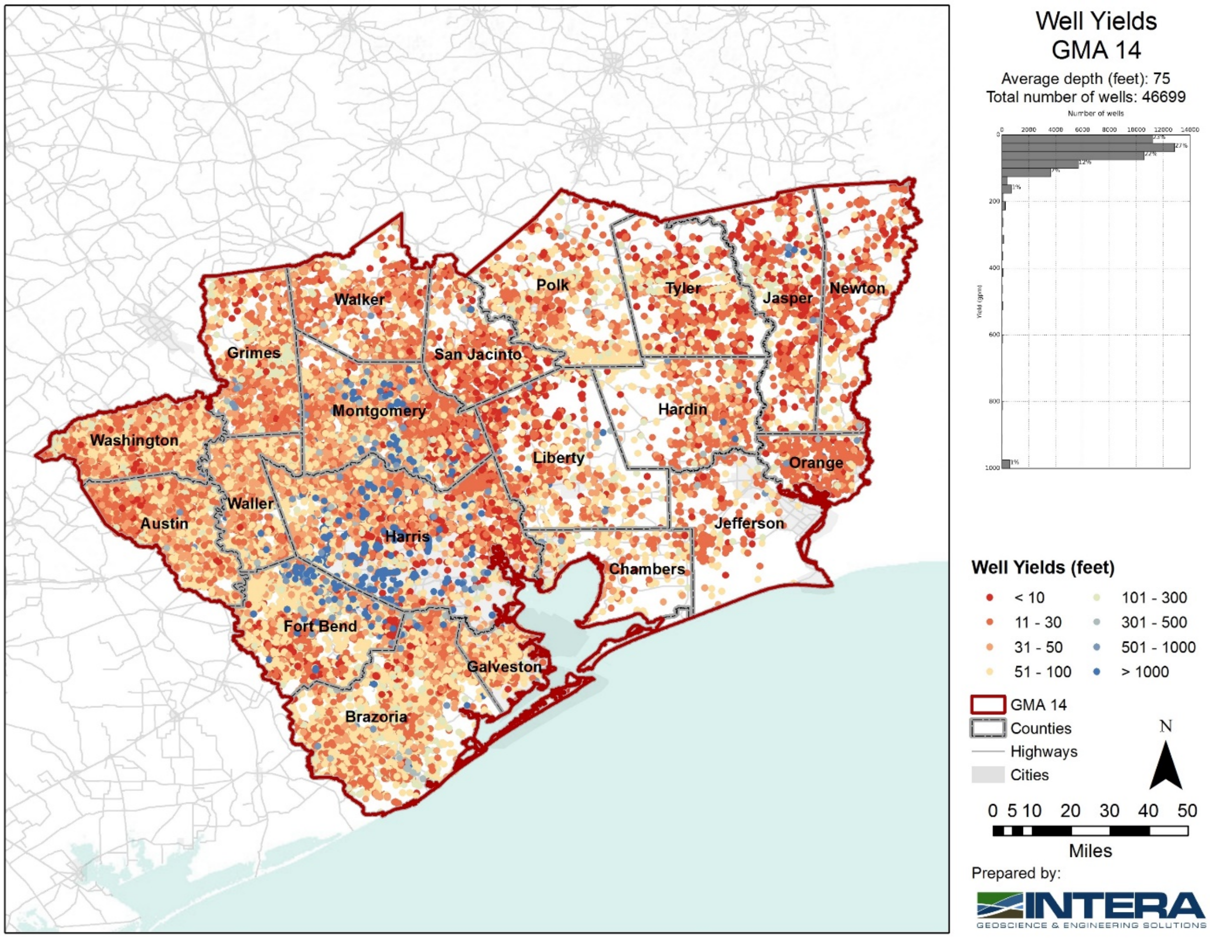

FIGURE 4-2. DISTRIBUTION OF WELL YIELDS IN GMA 14

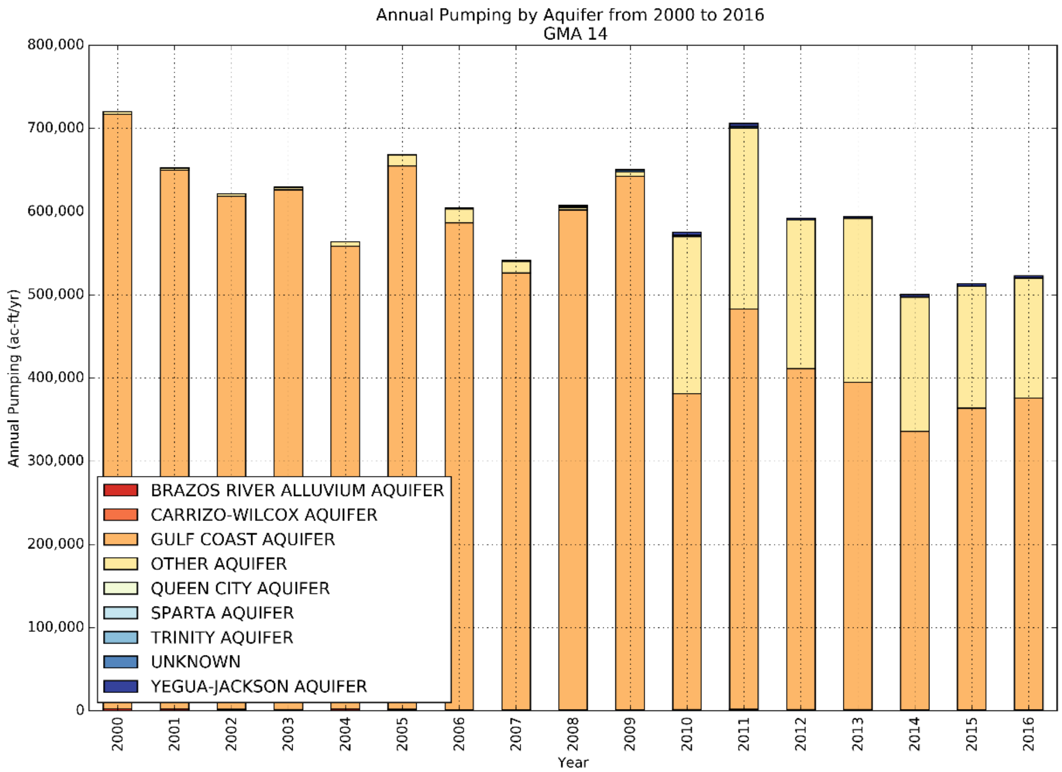

FIGURE 4-3. ANNUAL PUMPING BY AQUIFER IN GMA 14 (TEXAS WATER DEVELOPMENT BOARD, 2019)

4.2. Water Supply Needs and Water Management Strategies

GMA 14 District Representatives are required by Texas Water Code Section 36.108(d)(2) to review the water supply needs and water management strategies contained in the State Water Plan. Consideration of these components in addition to projected population growth was completed through review of the Texas Water Development Board adopted population and water demand projections for the 2022 State Water Plan and the final 2017 State Water Plan. An overview of the information considered is provided in this section, while detailed information presented to the Participants during the March 27, 2019, meeting is provided in Appendix J.

GMA 14 is a diverse region containing both urban and rural communities. Three regional water planning areas intersect with GMA 14— Region G (Brazos), Region H, and Region I (East Texas). The 20 counties of GMA 14 comprise less than 10 percent of the State's landmass, but represent around a quarter of the State's population.

The population of GMA 14 and the state of Texas is expected to increase over the 50-year planning horizon by 58 and 73 percent respectively; likewise, the population of all counties within GMA 14, apart from Newton County, is projected to grow over that time (Table 4-1). Most GMA 14 residents (92 percent) currently live in six of the twenty counties (Brazoria, Fort Bend, Galveston, Harris, Jefferson, and Montgomery), with 60 percent of residents residing in Harris County. The remaining fourteen counties had an average population of 46,600 in 2020. This distinct divide between urban and rural counties is evident in the variation of municipal water use across GMA 14.

In the 2017 State Water Plan, water needs are the difference between projected water demand and existing water supplies. At the county level, existing water supplies may in aggregate appear sufficient to meet the water needs, suggesting excess supply and zero needs, but because water supply is not distributed evenly some areas may experience shortages while others have ample supplies. This distribution issue is particularly apparent in Figure 4-5. In 2020, the difference between total water supplies and demand is approximately 125,000 acre-feet, while water needs totaled throughout GMA 14 are approximately 560,000 acre-feet. Water needs are met through exploration and implementation of water management strategies. Strategies are a plan to meet a need for additional water by a discrete water user group, which can be through increasing the total water supply or maximizing an existing supply, including through reducing demands. Identifying water needs and realistic strategies is imperative for water management. Prior to identifying water needs, projected water demand and existing supplies must be quantified.

Within the State Water Plan, water demand is the volume of water required to carry out the anticipated domestic, public, and/or economic activities of a water user group during drought of record conditions. The State Water Plan divides water demand into six categories: irrigation, livestock, manufacturing, mining, municipal, and steam electric power. Water demand estimates for the 2022 State Water Plan were significantly lower for GMA 14 than in previous State Water Plans (Figure 4-4). This decrease was due to updated methodology for projecting irrigation, manufacturing, and steam electric power demands. More detail on the changed methodology and how demand forecasts changed within the individual sectors are provided in Appendix J. Over the 50-year planning horizon, GMA 14's total water demand is expected to increase primarily due to the increase in municipal water use as population grows.

The 2017 State Water Plan projects existing water supplies to increase slightly through 2070. Most existing supplies are from surface water. Groundwater provides approximately 20 percent of the total existing supplies, while direct reuse is only a small fraction of existing supplies.

Potential water management strategies identified by the 2017 State Water Plan aim to provide water to meet the identified needs. Figure 4-5 presents how water demands, existing supplies, identified needs, and potential strategies are projected to grow through 2070. Figure 4-6 further disaggregates the potential strategies and compares them to the identified need. Surface water is the leading strategy identified, while water reuse and demand reduction follow. Groundwater strategies including new groundwater wells, brackish groundwater desalination, and conjunctive use represent 5 percent of overall identified strategies and are expected to increase slightly over the projected timeframe.

Evaluation of the supplies, strategies, and demands of each individual county within GMA 14 demonstrates the variable reliance on groundwater for meeting water needs (Figure 4-7, Figure 4-8). Groundwater comprises over 98 percent of the projected 2070 total supplies of Austin, Hardin, and Waller counties; over half of the 2070 water supply of Montgomery, Polk, San Jacinto, and Tyler counties is from groundwater. All other counties are projected to utilize other existing supplies and strategies more so than groundwater. Across GMA 14, a decrease in water demands from 2017 and 2022 State Water Plans is typically observed. Many counties will require similar or fewer strategies than what was projected by the 2017 State Water Plan to meet projected water demands identified for the 2022 State Water Plan.

TABLE 4-1. PROJECTED POPULATION OF COUNTIES IN GMA 14 INCLUDED IN THE BOARD-ADOPTED VALUES FOR THE 2022 STATE WATER PLAN.

COUNTY	BOARD-ADOPTED VALUES FOR 2022 STATE WATER PLAN PROJECTED POPULATION					
	2020	2030	2040	2050	2060	2070
AUSTIN	33,014	38,257	43,886	50,483	57,721	65,756
BRAZORIA	359,935	411,387	463,886	519,696	581,368	648,568
CHAMBERS	42,162	50,543	59,210	68,541	78,519	88,999
FORT BEND	881,966	1,095,123	1,259,307	1,421,933	1,583,782	1,755,164
GALVESTON	343,570	377,373	403,820	427,547	447,126	465,193
GRIMES	29,441	32,179	34,258	36,454	38,277	39,867
HARDIN	59,477	63,986	67,194	69,560	71,410	72,798
HARRIS	4,707,870	5,058,144	5,376,099	5,678,242	5,974,068	6,272,346
JASPER	36,878	37,695	37,849	37,849	37,849	37,849
JEFFERSON	267,379	284,620	302,744	323,802	347,030	373,041
LIBERTY	86,303	97,227	107,618	118,048	128,028	137,560
MONTGOMERY	627,917	811,252	1,019,278	1,267,916	1,576,135	1,946,063
NEWTON	14,445	14,445	14,445	14,445	14,445	14,445
ORANGE	86,327	90,233	92,984	94,848	96,269	97,298
POLK	51,870	57,943	62,722	66,796	70,120	72,799
SAN JACINTO	29,610	32,627	34,996	37,614	39,789	41,714
TYLER	22,288	22,396	22,396	22,396	22,396	22,396
WALKER	71,800	75,243	77,724	80,050	81,859	83,324
WALLER	52,538	63,443	75,535	88,736	103,314	119,122
WASHINGTON	36,199	38,516	40,095	41,664	42,884	43,880
GMA 14 TOTAL	**7,840,989**	**8,752,632**	**9,596,046**	**10,466,620**	**11,392,389**	**12,398,182**
STATE TOTAL	**29,683,671**	**33,898,444**	**38,045,103**	**42,273,134**	**46,739,153**	**51,458,748**
GMA 14 PERCENT of STATE TOTAL	**26.4%**	**25.8%**	**25.2%**	**24.8%**	**24.4%**	**24.1%**

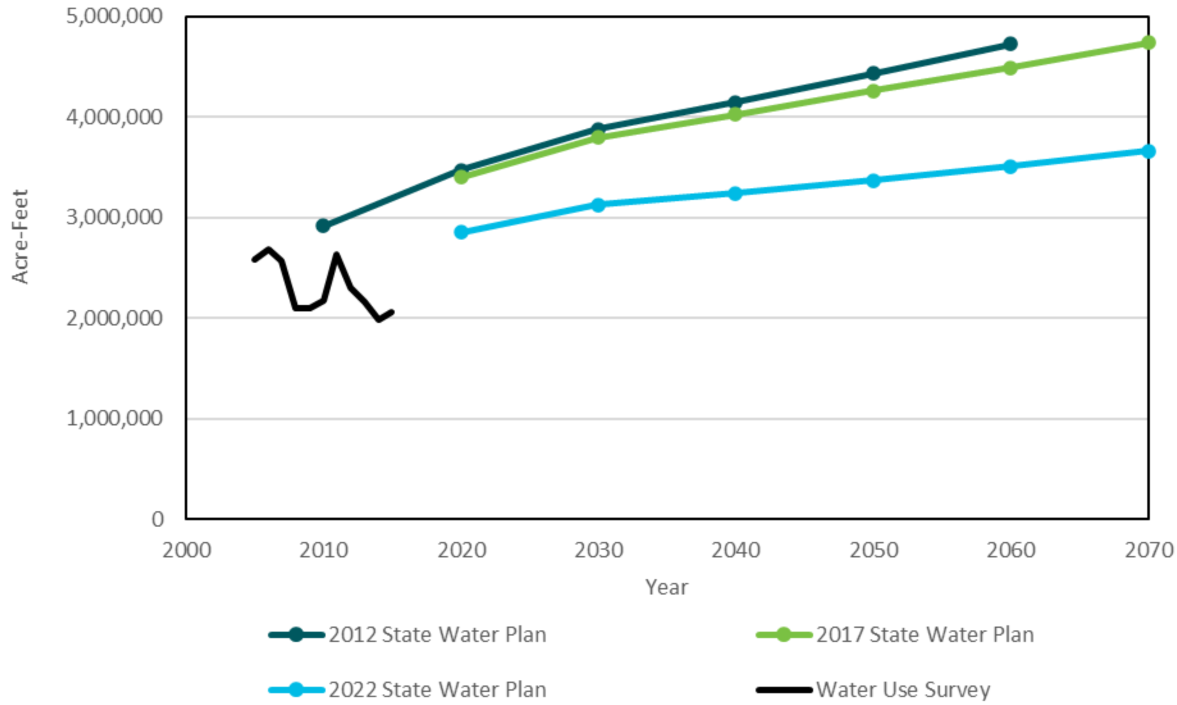

FIGURE 4-4. TOTAL PROJECTED WATER DEMANDS IN GMA 14 UNDER THE 2012, 2017 AND 2022 STATE WATER PLANS.

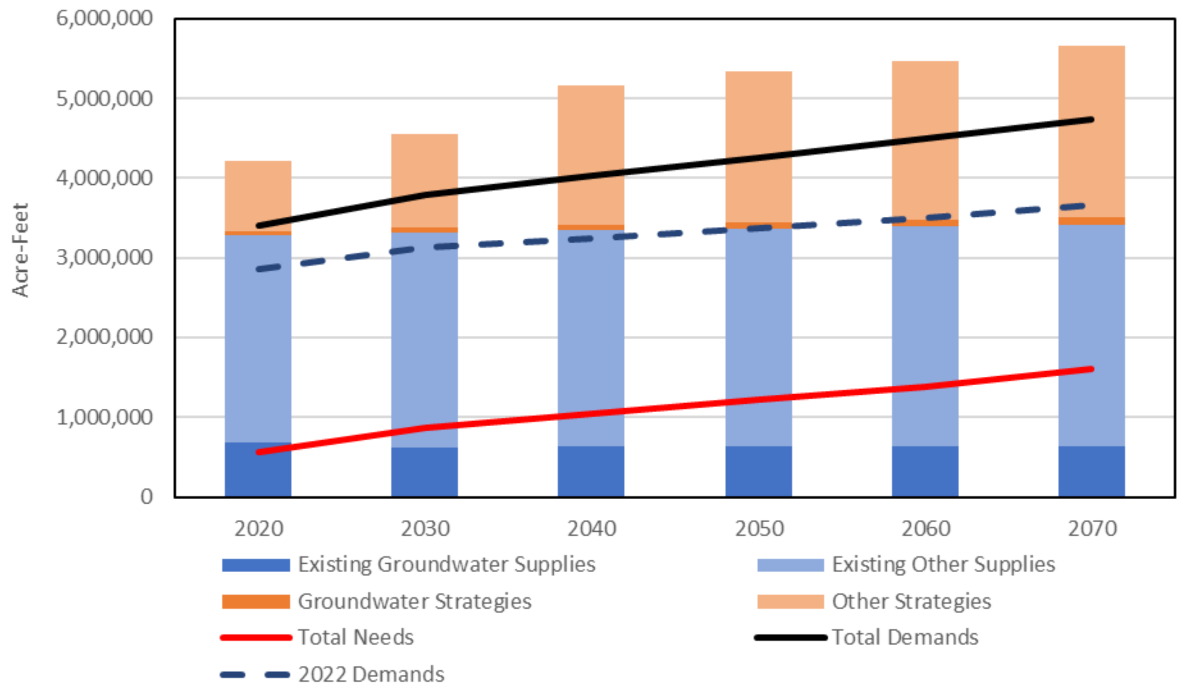

FIGURE 4-5. GMA 14 PROJECTED SUPPLIES AND STRATEGIES COMPARED TO TOTAL NEEDS AND DEMANDS AS REPORTED IN THE 2017 TEXAS STATE WATER PLAN AND DRAFT WATER DEMANDS OF THE 2022 STATE WATER PLAN.

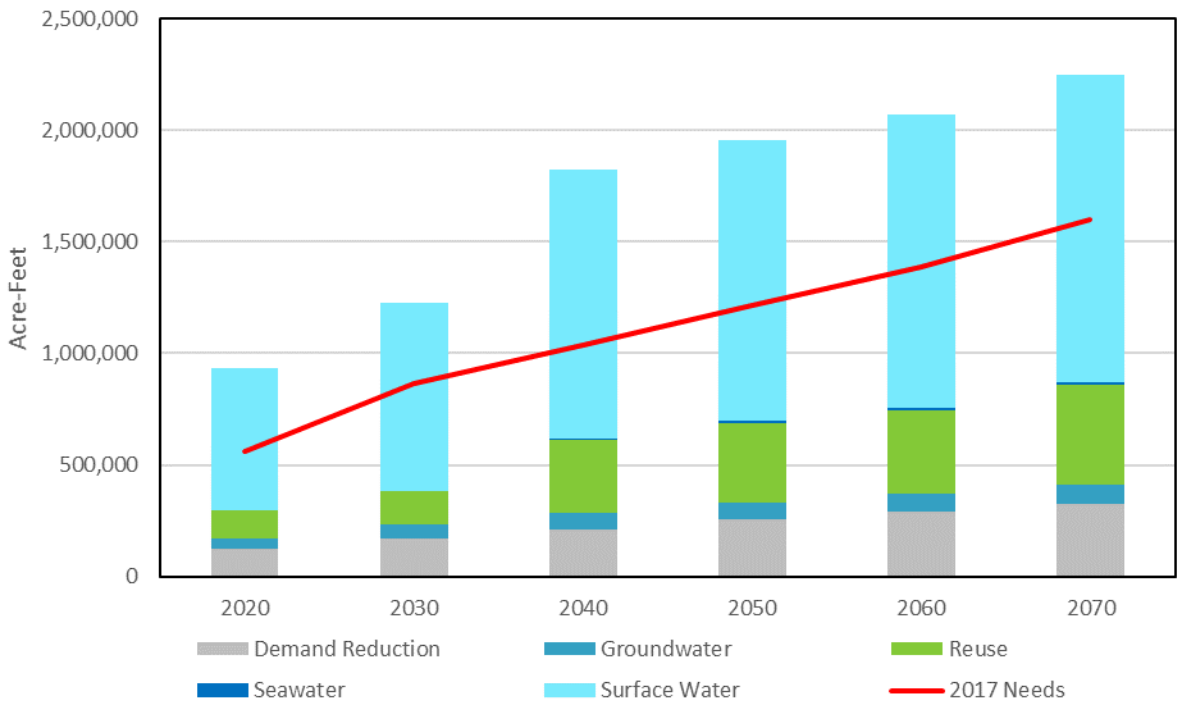

FIGURE 4-6. GMA 14 TOTAL NEEDS AND IDENTIFIED STRATEGIES AS PRESENTED IN THE 2017 STATE WATER PLAN.

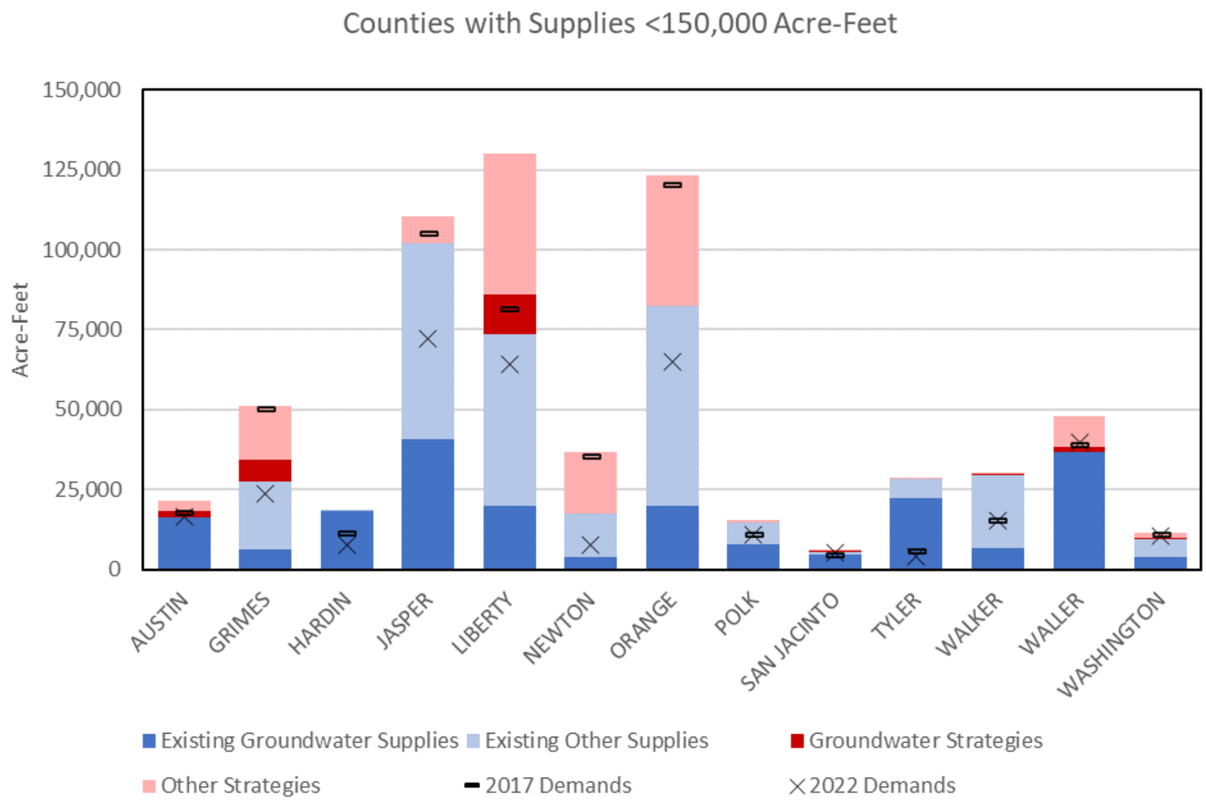

FIGURE 4-7. EXISTING SUPPLIES, STRATEGIES, AND DEMAND FOR COUNTIES WITH LESS THAN 150,000 ACRE-FEET OF TOTAL SUPPLIES.

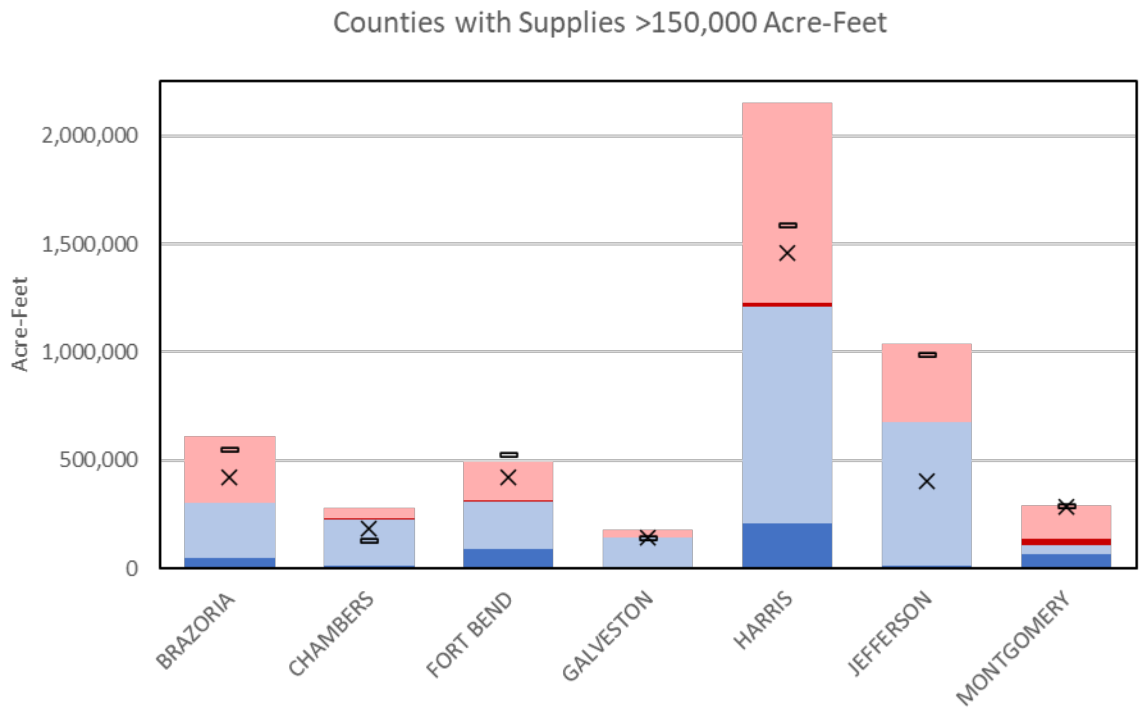

FIGURE 4-8. EXISTING SUPPLIES, STRATEGIES, AND DEMAND FOR COUNTIES WITH MORE THAN 150,000 ACRE-FEET OF TOTAL SUPPLIES.

4.3. Hydrological Conditions

Texas Water Code Section 36.108(d)(3) requires District Representatives in a GMA to consider "hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage [TERS] as provided by the executive administrator [of TWDB], and the average annual recharge, inflows, and discharge." As part of the joint planning process, Participants in GMA 14 reviewed and considered estimates of TERS, inflows, recharge, and discharge based on results from the HAGM (Kasmarek, 2012). Estimates of total estimated recoverable storage were provided by the TWDB executive administrator for review and consideration during the joint planning process, as required by statute. Participants reviewed information on hydrological conditions on June 26, 2019, and again as part of the review of all factors considered on February 24, 2021. The presentation and supplementary materials from this meeting are shown in Appendix K.

Figure 4-9 shows a hydrogeologic cross-section of the Gulf Coast Aquifer System through GMA 14. The Chicot Aquifer is the shallowest unit of the Gulf Coast Aquifer System and outcrops (is exposed at land surface) throughout most of GMA 14. The Evangeline Aquifer underlies the Chicot Aquifer. The Chicot and Evangeline aquifers make up the primary source of groundwater for the southeastern half of GMA 14, with a combined thickness ranging from approximately 1,000 feet to over 3,500 feet near the coast. The Burkeville Confining Unit underlies the Evangeline Aquifer and provides hydrogeologic separation between the Evangeline and Jasper aquifers. The Jasper Aquifer is one of the main sources of groundwater for the northwestern half of GMA 14 where it is shallower. In the HAGM (Kasmarek, 2012), portions of the upper Catahoula formation are included in the Jasper Aquifer layer of the model. Figure 4-10 shows the correlation between the stratigraphic and hydrogeologic units of the Gulf Coast Aquifer System.

Texas Administrative Code Rule 356.10 defines the total estimated recoverable storage as "the estimated amount of groundwater within an aquifer that accounts for recoverable storage scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume." The total estimated recoverable storage values for the Gulf Coast Aquifer were provided by TWDB as GAM Task 13-037 (Wade, Thorkildsen, & Anaya, GAM Task 13-037, 2014) and are shown in Figure 4-11.

Total estimated recoverable storage can be an important indicator of groundwater availability for some aquifers – and is a required consideration for all aquifers – but it is not synonymous with groundwater availability. There are many factors that influence groundwater availability that are not incorporated into the total estimated recoverable storage calculation, such as:

- Aquifer water quality,

- Water levels dropping below pumps,
- Land surface subsidence,
- Degradation of water quality,
- Changes to surface water-groundwater interaction,
- Recharge from precipitation, and
- The practicality and economics of development.

For some unconfined aquifers that are highly transmissible such as the Ogallala Aquifer in the Texas Panhandle, the total estimated recoverable storage can be useful for determining groundwater availability. In aquifers with many clay interbeds that dip toward the coast such as those in GMA 14, the above limitations make interpretation and use of the total estimated recoverable storage for water planning challenging. As calculated, the 25 percent to 75 percent range applied to the total storage represents the approximate fraction of the total storage in each aquifer in GMA 14 that is in the water-producing zones (that is, sands), not what is practically “recoverable” from those zones. Figure 4-12 illustrates this well where many of the intervals in each of the geophysical logs shown are black, indicating clays that are not water producing. For the sandy intervals in each log, the estimated water quality is shown and symbolized by color. The light blue intervals indicate fresh water with a total dissolved solids (TDS) concentration below 1,000 milligrams per liter (mg/L).

In addition to the consideration of total estimated recoverable storage, the GMA 14 District Representatives also considered the water budget for GMA 14 and the water budgets for each county and aquifer within GMA 14, including recharge from land surface, pumping, interaction with surface water features, lateral inflows and outflows, and vertical inflows and outflows to overlying and underlying units. The GMA 14-wide budget for the Gulf Coast Aquifer is shown in Table 4-2. Note in the water budget in Table 4-2 as well as those in Appendix K for the Gulf Coast Aquifer, the recharge, evapotranspiration, and inflows and outflows from streams are all modeled together in the HAGM using the MODFLOW General Head Boundary Package. In GMA 14, the Evangeline Aquifer is the primary aquifer pumped with nearly 450,000 acre-feet per year on average between 2000 and 2009. Most of the recharge and stream inflows are into the Chicot Aquifer – about 554,000 acre-feet per year. There is also significant vertical flow downward from the Chicot Aquifer into the underlying Evangeline Aquifer. The water budgets for each county for each of the aquifers in GMA 14 was considered by the Participants and is shown in Appendix K.

TABLE 4-2. WATER BUDGET FOR THE GULF COAST AQUIFER IN GMA 14.

GMA 14				
Inflow	**Chicot**	**Evangeline**	**Burkeville**	**Jasper**
Recharge/Stream Loss (GHB)	554,080	73,293	20	41,358
Storage	268,814	35,291	3,836	53,877
Leakage Upper Unit	0	416,219	2,188	3,683
Leakage Lower Unit	24,525	4,143	2,403	0
Lateral Flow from other areas	49,224	32,833	8	2,399
Total Inflow	896,643	561,778	8,455	101,317

Outflow	Chicot	Evangeline	Burkeville	Jasper
Wells	399,080	449,976	0	64,708
Evapotranspiration/Stream Gain (GHB)	4,459	49,257	17	30,106
Storage	27,655	2,965	606	1,861
Leakage Upper Unit	0	24,525	4,143	2,403
Leakage Lower Unit	416,219	2,188	3,683	0
Lateral Flow from other areas	49,224	32,833	8	2,399
Total Outflow	896,636	561,745	8,457	101,476

All values are average acre-feet per year from 2000 through 2009.

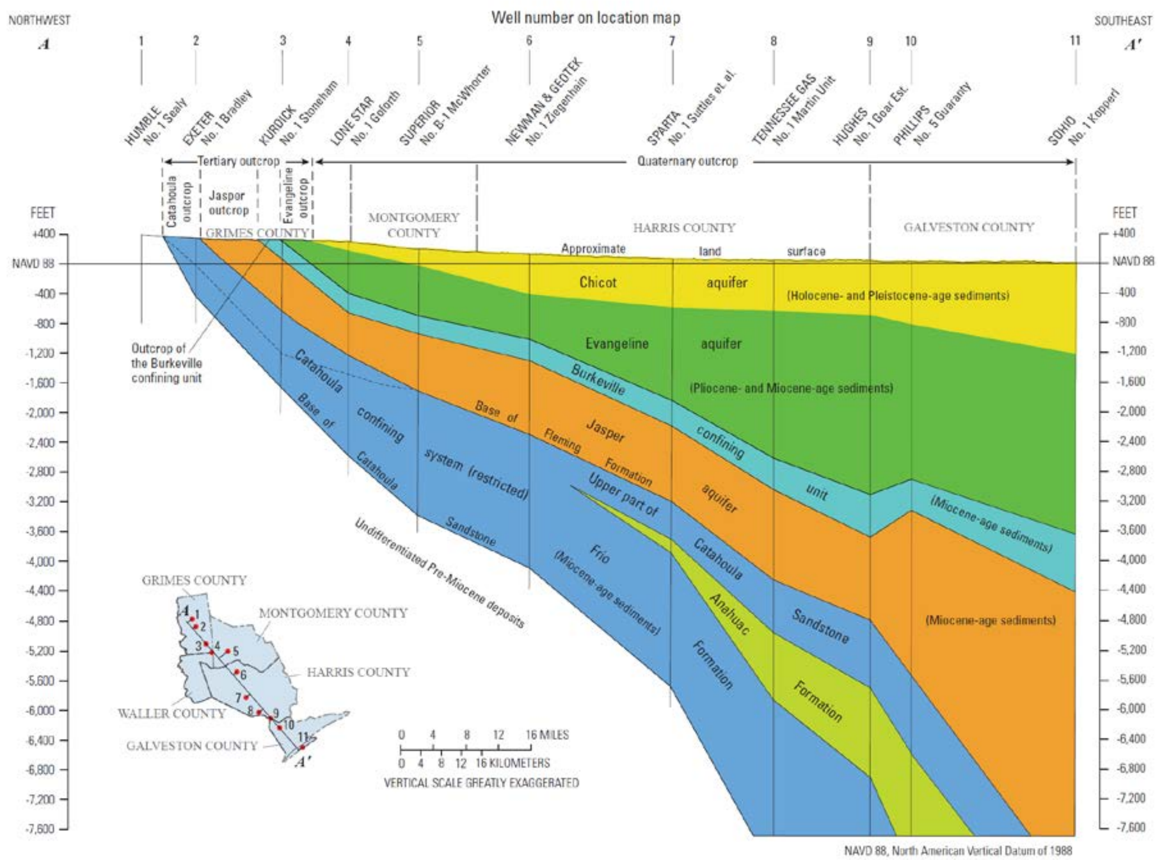

FIGURE 4-9. HYDROGEOLOGIC CROSS-SECTION OF THE GULF COAST AQUIFER SYSTEM IN THE HAGM (KASMAREK, 2012)

Geologic (stratigraphic) units			Hydrogeologic units	Model layer
System	**Series**	**Formation**	**Aquifers and confining units**	
Quaternary	Holocene	Alluvium	Chicot aquifer	1
	Pleistocene	Beaumont Formation		
		Montgomery Formation		
		Bentley Formation		
		Willis Formation		
Tertiary	Pliocene	Goliad Sand	Evangeline aquifer	2
	Miocene	Fleming Formation	Burkeville confining unit	3
		Oakville Sandstone	Jasper aquifer	4
		Catahoula Sandstone		
		Anahuac Formation[1]	Catahoula confining system	
		Frio Formation[1]		

[1]Present only in subsurface.

FIGURE 4-10. STRATIGRAPHIC AND HYDROGEOLOGIC UNITS IN THE HAGM (KASMAREK, 2012)

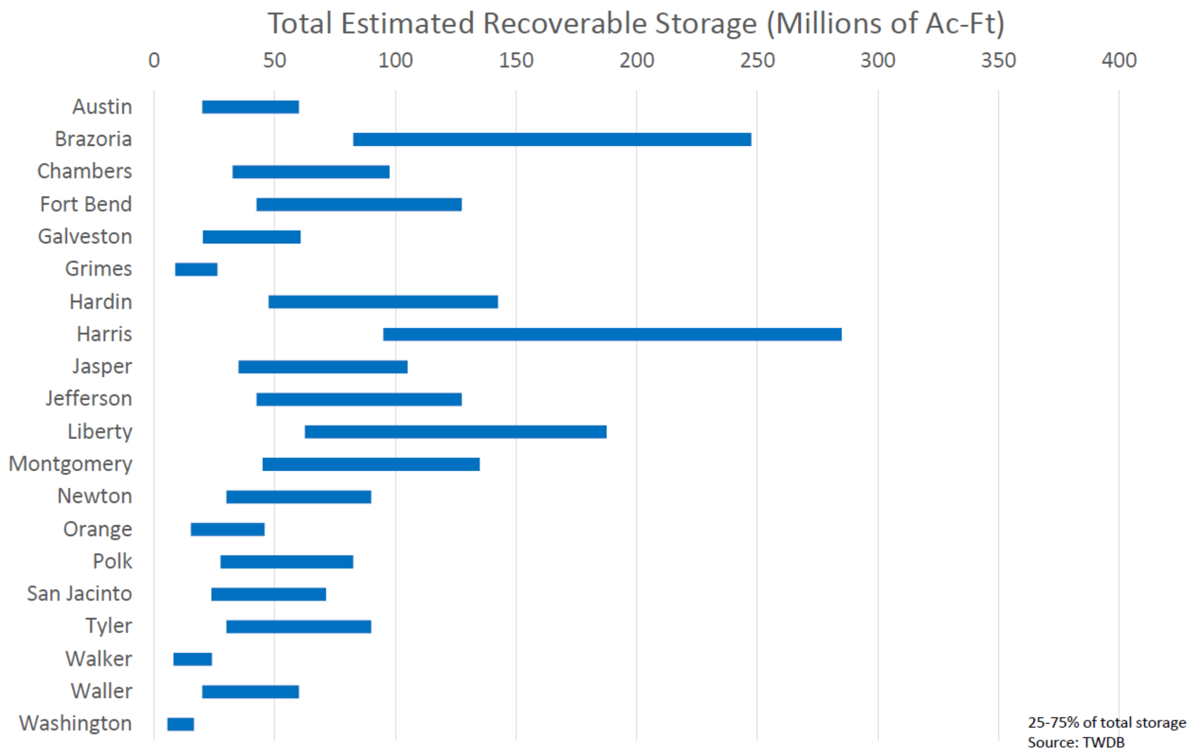

FIGURE 4-11. TOTAL ESTIMATED RECOVERABLE STORAGE FOR THE GULF COAST AQUIFER IN GMA 14 AS PROVIDED BY TWDB (WADE, THORKILDSEN, & ANAYA, GAM TASK 13-037, 2014).

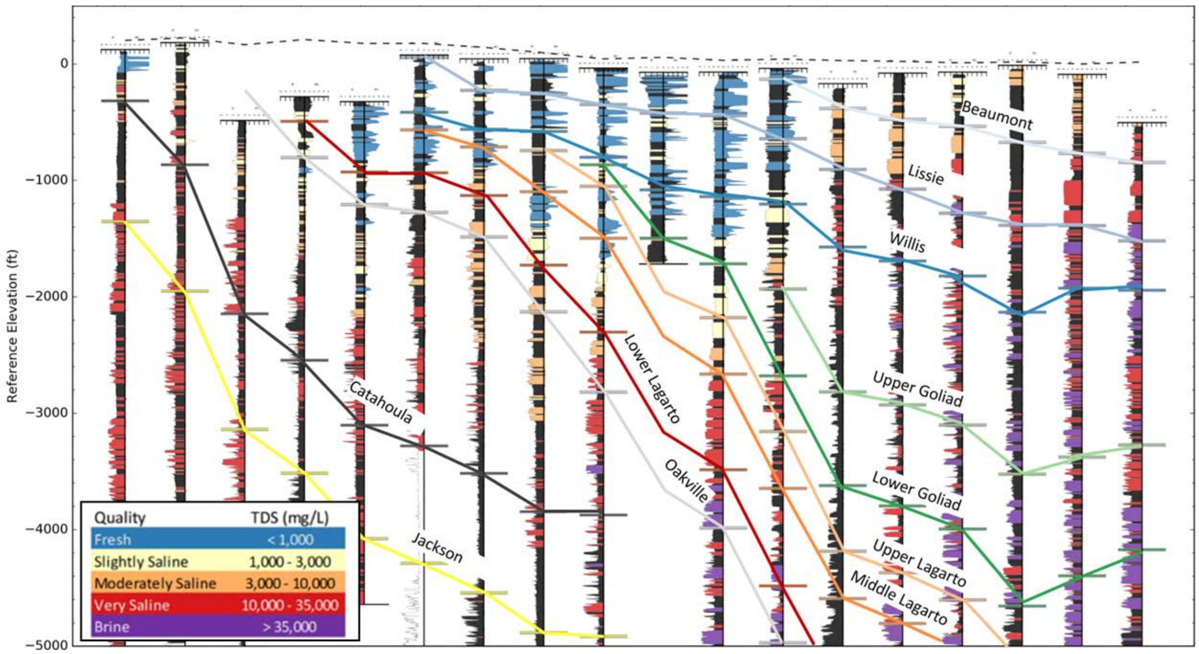

FIGURE 4-12. CROSS-SECTION FROM NORTH TO SOUTH THROUGH TYLER, HARDIN AND JEFFERSON COUNTIES SHOWING WATER QUALITY IN SANDY INTERVALS. BLACK INTERVALS REPRESENT CLAYS. MODIFIED FROM (YOUNG, ET AL., 2016).

4.4. ENVIRONMENTAL IMPACTS

Texas Water Code Section 36.108(d)(4) requires District Representatives in a GMA to consider environmental impacts, including interactions between groundwater and surface water. Unlike the first three factors described above (aquifer uses and conditions, water supply needs and water management strategies, and hydrological conditions), an evaluation of environmental impacts is specific to the adopted DFCs. The Participants in GMA 14 voted to formally consider three potential modeling of DFC scenarios, which are described in Section 2.1 above, before the District Representatives formally proposed and adopted the final DFC statement. For consideration of environmental impacts, the model run labeled “70%-1 ft Run” is consistent with the DFCs proposed for adoption and with the change of “and” to “or” in the DFC statement final adoption. Environmental impacts were reviewed and considered by the Participants on September 16, 2020 and again as part of the review of all factors considered on February 24, 2021. The presentation from this meeting is included in Appendix L.

Consideration of environmental impacts focused on the interaction between groundwater and surface water in GMA 14 and potential changes to this interaction due to the DFCs. Other impacts of DFCs that could be considered “environmental” such as subsidence or faulting are addressed in this report below.

As described in the Hydrological Conditions section above, the HAGM uses the MODFLOW General Head Boundary Package to collectively represent recharge from precipitation, evapotranspiration, outflow to springs, and interaction with surface water features such as creeks, bayous, and rivers. Though these aspects are included together in the same model package, TWDB developed an approach to separate the portion of this interaction that represents outflow to springs and interaction with surface water features from recharge due to precipitation for their use in developing model information for GCD management plans (Wade S. , 2020). In this approach, the U.S. Environmental Protection Agency’s RF1 database of streams and waters of the U.S. (U.S. Environmental Protection Agency, 2020) was intersected with the HAGM grid (Texas Water Development Board, 2020). Those model cells that intersect the surface water features in the RF1 dataset are considered stream cells while those that do not are considered non-stream cells.

Following the same approach used by TWDB, stream cells were identified throughout GMA 14 and the MODFLOW General Head Boundary Package budget results were extracted for the model runs representing the three potential DFC statements. Figure 4-13 shows the net change (total inflows minus total outflows) for the stream cells in GMA 14. During the historical/calibration period of the model from 1980 to 2009, all three scenarios are identical as the pumping was not changed. Beginning in 2010 with the general increase in pumping relative to the historical period, the rate of flow from surface water features into the aquifer increases. For GMA 14 as a whole, the model indicates that flows into the aquifer from surface water features would increase from approximately 100,000 acre-feet per year in 2010 to approximately 215,000 acre-feet per year in 2080 under the run consistent with the adopted DFCs ("70%-1 ft Run"). Figures like Figure 4-13 were prepared, presented to, and considered by the District Representatives in GMA 14. These are shown in Appendix L.

As discussed during the meeting on September 16, 2020, the model results for changes to interaction with surface water hinge on a known limitation of the model inherent with the MODFLOW General Head Boundary Package – that is, that there is an unlimited supply of surface water available as a source for inflows to the groundwater system. For that reason, the results should be used with caution. Despite this limitation, the model results illustrate an important dynamic: increases in pumping can lead to water level declines in aquifer outcrop areas, which can reduce surface water availability by either lessening outflows to surface water or increasing inflows from surface water to the aquifer.

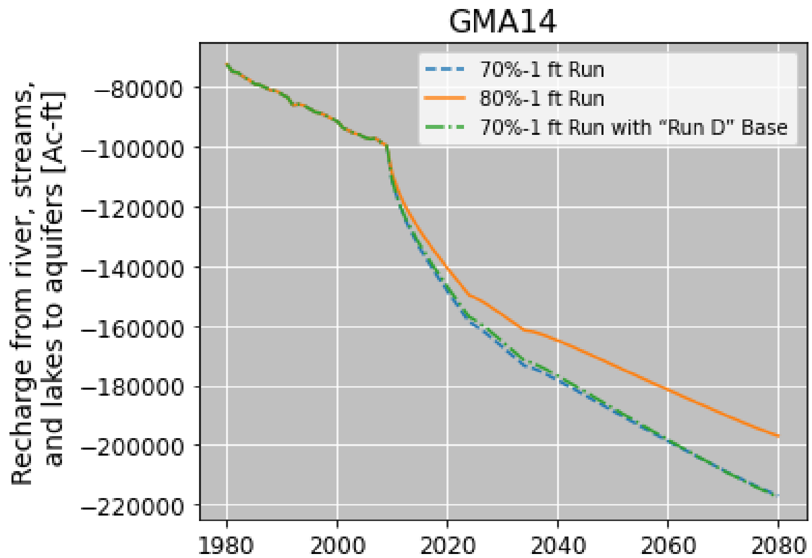

FIGURE 4-13. CHANGES TO GROUNDWATER-SURFACE WATER INTERACTION IN GMA 14 ASSOCIATED WITH DFC OPTIONS CONSIDERED.

4.5. Subsidence Impacts

Texas Water Code Section 36.108(d)(5) requires District Representatives in a GMA to consider the impacts of proposed desired future conditions on subsidence. The Participants considered information on subsidence during many meetings, but formally reviewed subsidence information on July 15, 2020. The presentation from this meeting and supplemental information is provided in Appendix M.

Subsidence occurs when the land surface sinks due to compaction of underlying geologic units (Figure 4-14). Compaction – a decrease in the volume or thinning of the geologic unit – occurs primarily within clay-rich portions of the aquifer. While groundwater wells generally target sandy portions of the Gulf Coast Aquifer, there are considerable clay intervals interspersed throughout the aquifer (see Figure 4-12). While sand grains are large, round, and not very susceptible to compaction; clay grains are small, flat, and much more susceptible to reorientation and compaction. The compaction occurs due to groundwater pumping because the pumping reduces the pressure in the aquifer (as indicated by the water level). This water pressure drop in the sandy intervals of the aquifer propagates to clay-rich portions of the aquifer and reduces the ability of the water to hold open the pore spaces. When this occurs, the flat clay grains can collapse, squeezing out the water and compacting the formation. This compaction is considered permanent because there is no mechanism for reopening the pore spaces between the clay grains once they are closed.

Subsidence is an important consideration in GMA 14 because it is directly caused by pumping of groundwater and can lead to serious impacts at land surface such as flooding, damage to infrastructure, and increased movement along growth faults [(Campbell, Wise, & Bost, 2014) (Jones & Larson, 1975) (Coplin & Galloway, 1999) (Holzschuh, 1991)]. The last of these issues – faulting – is discussed in more detail in Section 4.9.

In GMA 14, subsidence caused by pumping of groundwater has been observed for decades. Figure 4-15 shows a comparison between the simulated subsidence in the HAGM (Kasmarek, 2012) and the measured subsidence (Gabrysch & Neighbors, 2005). In some areas near the Houston Ship Channel as much as 10 feet of subsidence has been observed historically. Over a much broader region covering approximately the southeastern half of Harris County and portions of Galveston County at least 6 feet of subsidence has been observed. As shown in Figure 4-15, many other counties in GMA 14 have also experienced subsidence (for example, Brazoria, Fort Bend, Waller, Montgomery, Chambers, and Jasper counties).

Subsidence in GMA 14 has been monitored in many ways including releveling of National Geodetic Survey benchmarks, Global Positioning System (GPS) subsidence monitoring stations, and remote sensing techniques such as Interferometric Synthetic Aperture Radar (InSAR). The current standard for monitoring subsidence in GMA 14 is the network of GPS stations shown in Figure 4-16. The stations are clustered around areas of historical subsidence, especially Harris, Galveston, and Fort Bend counties, but stations are also found in many other areas of GMA 14.

Trends in subsidence rates monitored at GPS stations in areas that have reduced groundwater production (e.g., Harris, Galveston, Fort Bend and Montgomery counties) show that as aquifer water levels recover, rates of subsidence slow. Figure 4-17 and Figure 4-18 show this at stations in Fort Bend and Montgomery counties, respectively. Lone Star GCD has noted concerns about reliability of GPS data. *See* Lone Star GCD's Summary Report and Position Paper and Attachment K.

Figure 4-19 shows the modeled additional subsidence from 2009 to 2080 associated with the adopted DFCs. Most of the additional subsidence in Figure 4-19 corresponds with suburban areas surrounding the City of Houston. The modeled additional subsidence is also greatest in the southeastern half of GMA 14 closer to the coast where the Chicot and Evangeline aquifers are predominantly used. Subsidence contours for each county were also developed and are shown in Appendix M.

The Jasper Aquifer, which is more widely used in the northwestern half of GMA 14 farther from the coast, can compact in the HAGM. However, there was very limited data available to inform the Jasper Aquifer compaction properties during model development, so they were set to a low value such that the modeled compaction was minimal (Kasmarek, 2012). This is a known limitation of the HAGM. At the time the HAGM was developed by the U.S. Geological Survey, the focus of the modeling effort was primarily on characterizing subsidence within the subsidence districts. The subsidence districts did not at that point have large volumes of pumping from the Jasper Aquifer and did not anticipate significant further development of the Jasper Aquifer within the districts. For this reason, characterizing the compaction potential of the Jasper Aquifer was not a focus of the model development effort. Though the model was still adopted by TWDB as the "best available science" for the northern portion of the Gulf Coast Aquifer, the compaction results associated with groundwater production from the Jasper Aquifer are considered more uncertain.

Since the HAGM was developed, the susceptibility of the Jasper Aquifer to compaction and its contribution to subsidence has been the subject of considerable debate and additional research (Kelley, Deeds, Young, & Pinkard, 2018). Historically, the monitoring of subsidence and compaction in the Gulf Coast Aquifer System was not designed to isolate the contribution of the Jasper Aquifer. As additional GPS monitoring stations and extensometers that can directly monitor compaction are installed, it is the hope of the GMA 14 District Representatives that the data collected will clarify the extent to which the Jasper Aquifer is susceptible to compaction to inform future groundwater planning efforts. Lone Star GCD is conducting a subsidence study focused on where compaction may be occurring in the aquifers within Montgomery County and surrounding areas, and its causes. The results of Phase I of the study was provided to the Participants. The results of future phases will be provided as they are completed. *See also* Attachment K to Lone Star GCD's Summary Report and Position titled "Correlation between Land-Surface Movement, Water-Level Change, and Groundwater Production Within Montgomery County and Surrounding Areas. " Similarly, the Houston Advanced Research Center (HARC) convened a Science Advisory Committee to review and analyze research findings describing groundwater resources and subsidence in Montgomery and Harris counties in Southeast Texas. The Phase I findings of the HARC report were presented to the Participants.

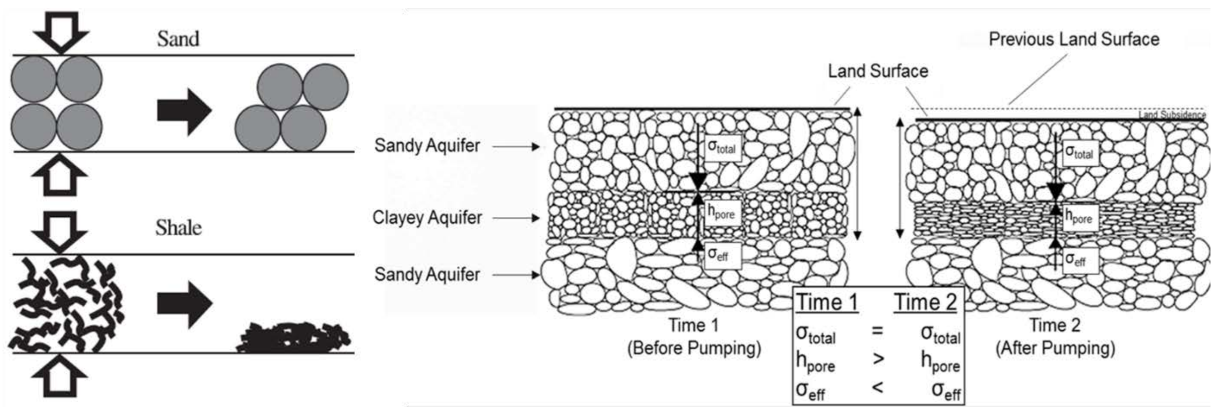

FIGURE 4-14. BASIC CONCEPTS OF SUBSIDENCE.

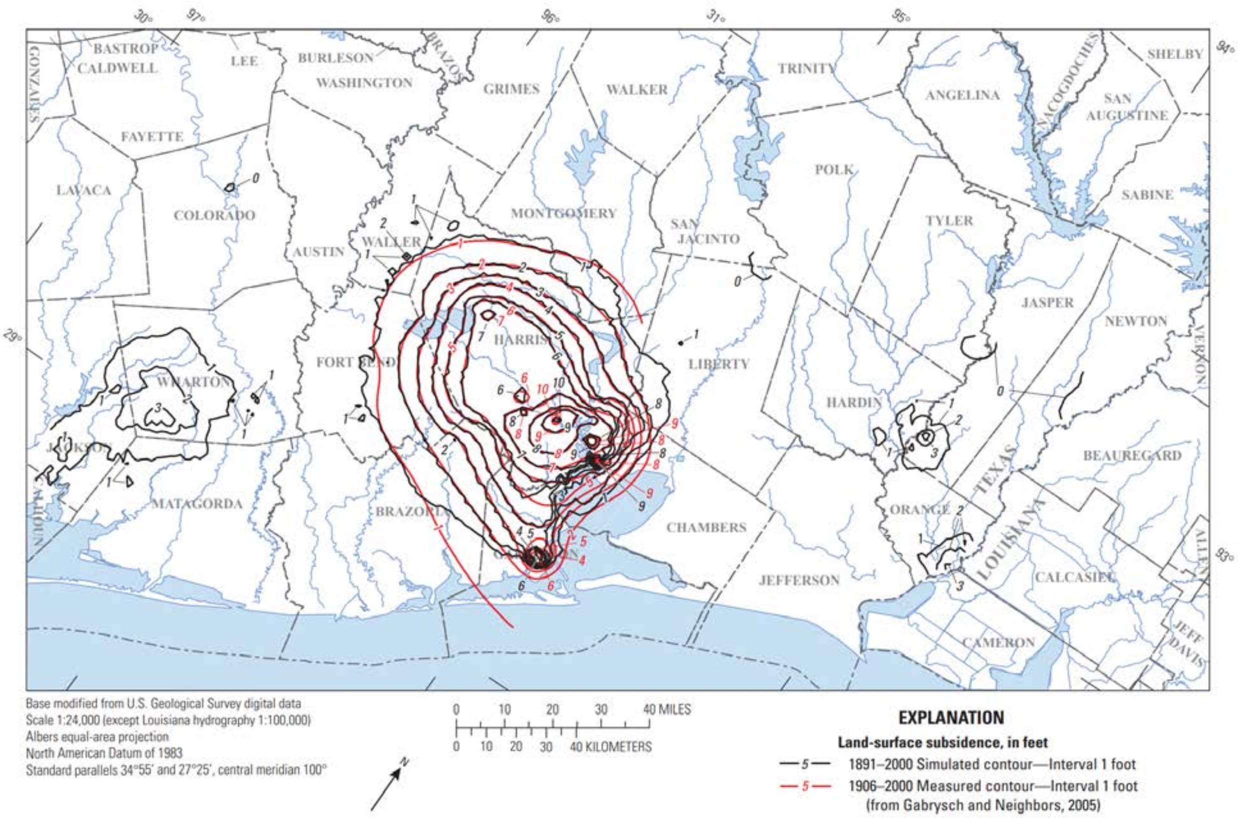

FIGURE 4-15. SIMULATED AND MEASURED SUBSIDENCE IN THE HAGM FROM PRE-DEVELOPMENT TO 2000 (KASMAREK, 2012)

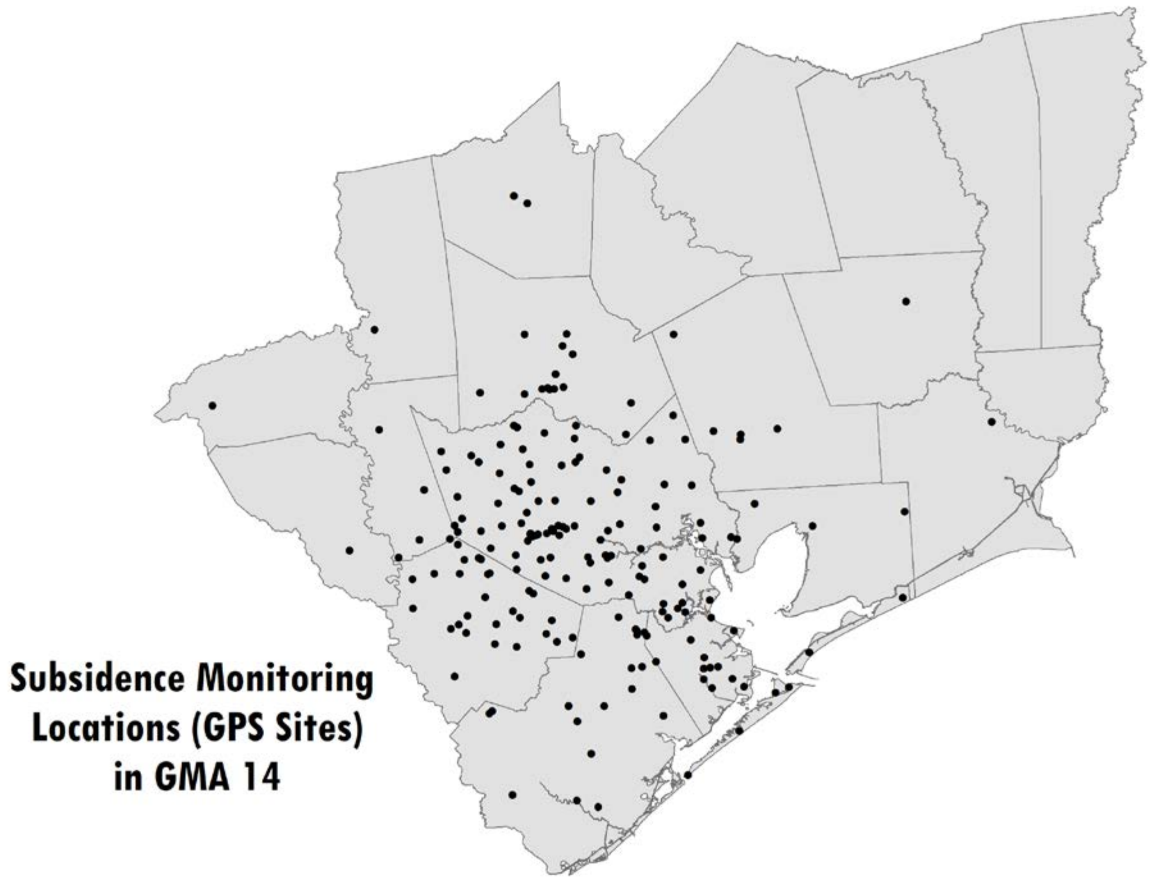

FIGURE 4-16. GPS SUBSIDENCE MONITORING STATIONS IN GMA 14

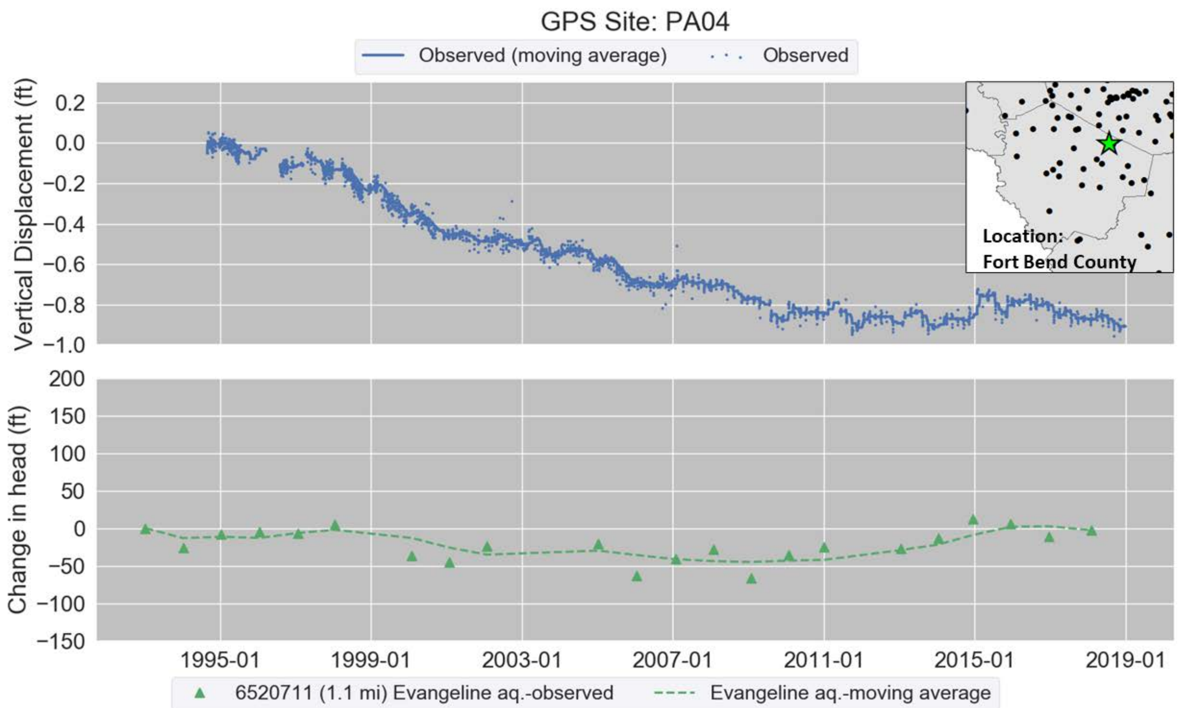

FIGURE 4-17. VERTICAL DISPLACEMENT (FEET) AT GPS STATION PA04 IN FORT BEND COUNTY AND WATER LEVEL CHANGES (FEET) NEARBY AT TWDB STATE WELL NUMBER 6520711.

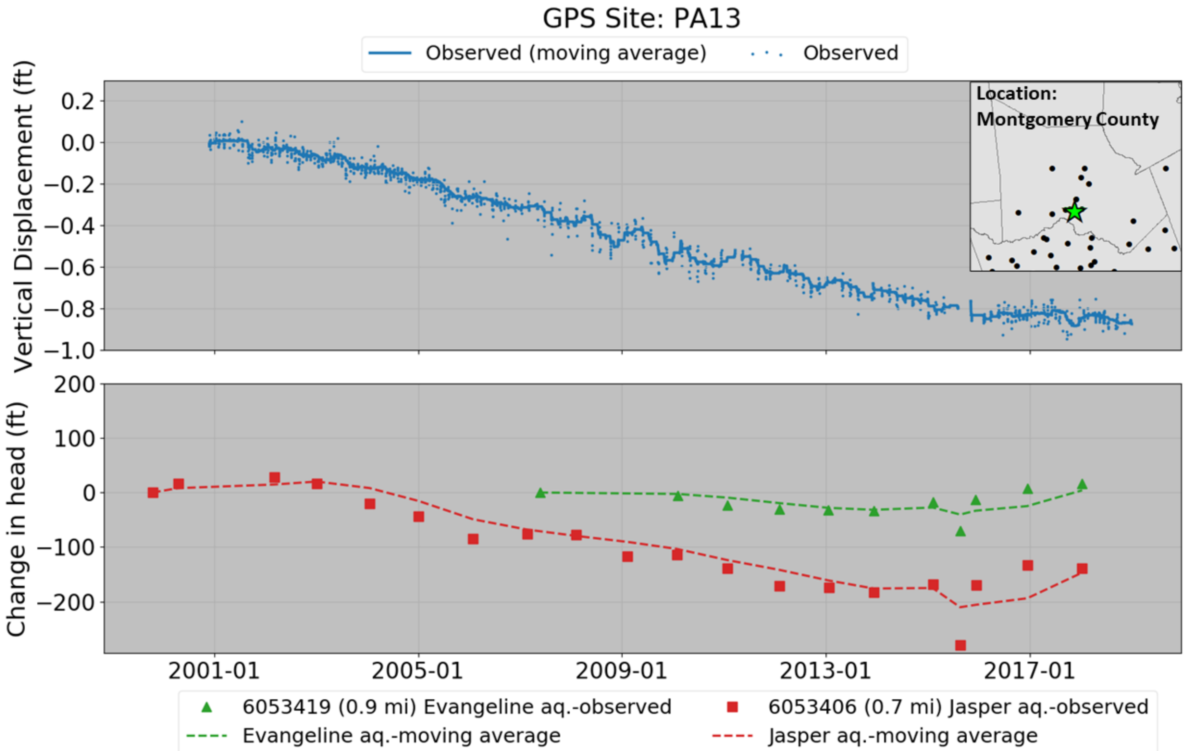

FIGURE 4-18. VERTICAL DISPLACEMENT (FEET) AT GPS STATION PA13 IN MONTGOMERY COUNTY AND WATER LEVEL CHANGES (FEET) NEARBY AT TWDB STATE WELL NUMBERS 6053419 AND 6053406.

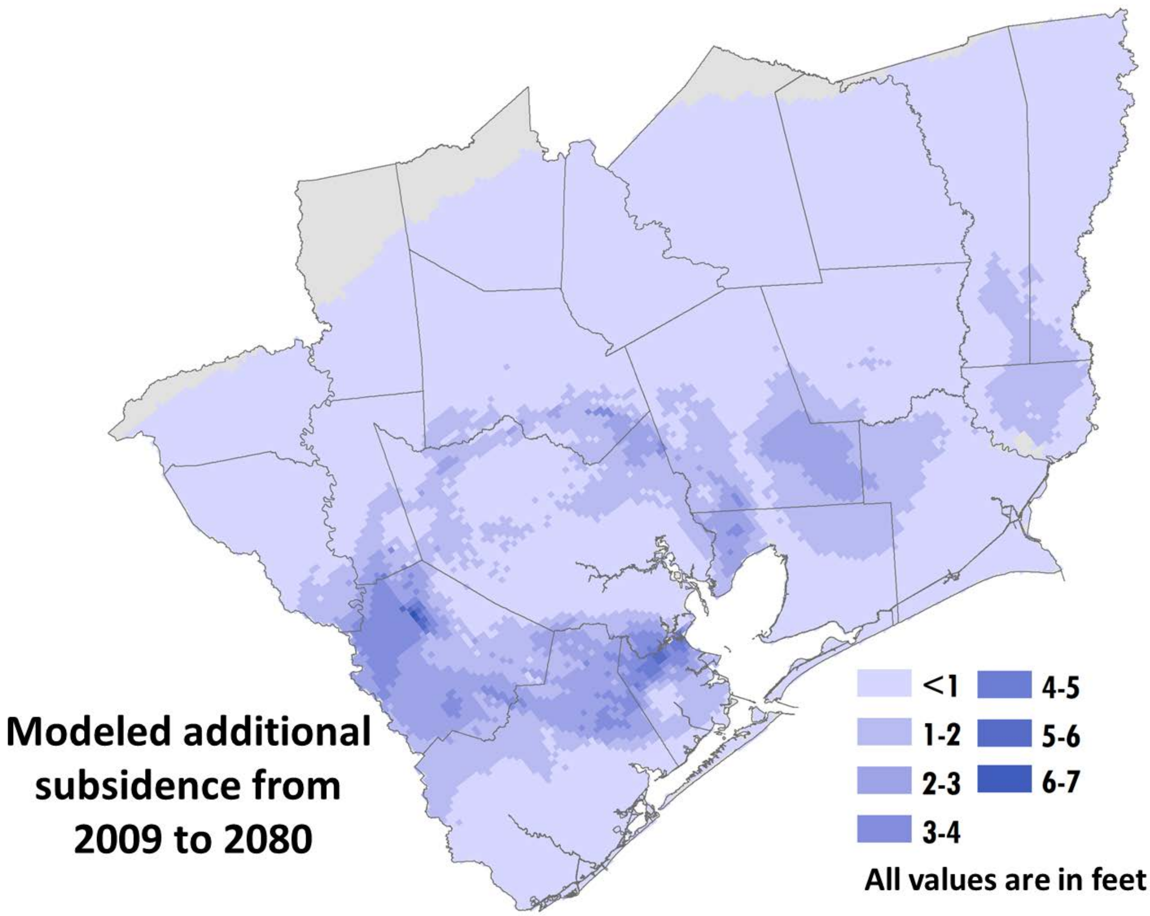

FIGURE 4-19. MODELED ADDITIONAL SUBSIDENCE BETWEEN 2009 AND 2080 ASSOCIATED WITH THE ADOPTED DFCS.

4.6. Socioeconomic Impacts

Texas Water Code Section 36.108(d)(6) requires District Representatives in a GMA to consider socioeconomic impacts reasonably expected to occur due to the proposed desired future conditions for relevant aquifers. The Participants received, reviewed, and considered information on socioeconomic impacts on September 16, 2020 and January 20, 2021. The presentation and supplementary materials from the September 16, 2020 meeting are available in Appendix N. The presentation provided by Ms. Samantha Reiter on behalf of Lone Star GCD is included in Appendix D.

Consideration of socioeconomic impacts as part of water planning in Texas, both at the regional and state level, has been a fundamental element of the planning process dating back to the 1990s. Texas Water Code Section 16.051(a) states that TWDB "shall prepare, develop, formulate, and adopt a comprehensive state water plan that…shall provide for…further economic development." Title 31 of Texas Administrative Code, Section 357.7(4)(A) states, "The executive administrator shall provide available technical assistance to the regional water planning groups, upon request, on water supply and demand analysis, including methods to evaluate the social and economic impacts of not meeting needs." This technical assistance and analysis provided by the executive administrator is the only consistent analysis of socioeconomic impacts available for joint planning. Title 31 of the Texas Administrative Code, Section 357.40(a) states that regional water plans "shall include a quantitative description of the socioeconomic impacts of not meeting the identified water needs pursuant to [Section] 357.33(c) of this title (relating to Needs Analysis: Comparison of Water Supplies and Demands)." This analysis, executed by the executive administrator at TWDB, is performed at the request of the individual regional water planning groups and is based on water supply needs from the regional water plans. This analysis consists of a series of point estimates of 1-year droughts at 10-year intervals. The socioeconomic impacts analysis attempts to measure the impacts if water user groups do not meet their identified water supply needs associated with a drought of record for one year. For this analysis, multiple impacts are examined, including:

- Sales, income, and tax revenue,
- Jobs,
- Population, and
- School enrollment.

Results from this analysis are then incorporated into the final regional water plans and then comprehensively presented in the subsequent state water plan.

As part of the GMA 14 District Representative's considerations of socioeconomic impacts reasonably expected to occur, the analyses provided by TWDB to Brazos G (Ellis, 2019a), Region H (Ellis, 2019b), and the East Texas (Ellis, 2019c) regional water planning groups for the 2021 regional water plans were considered. These reports are included in their entirety in Appendix N.

While the socioeconomic impact analyses developed for regional water planning is quantitative, they do not directly translate to the evaluation of desired future conditions. This is because they are limited to the impacts of unmet needs, influenced by the availability of other supply sources, and do not consider potential negative socioeconomic impacts associated with groundwater production. The District Representatives incorporated the information available from the regional water planning process into consideration of socioeconomic impacts that are not as easily quantified and that balance potential impacts of developing groundwater with potential impacts of not developing groundwater. Potential impacts of developing groundwater include subsidence and associated impacts, lowering pumps and/or deepening wells, potential impacts on water quality, impacts on groundwater production efficiency, and influence on economic growth based on water availability. Potential impacts of not developing groundwater include unmet water supply needs (as quantified for regional water planning), conversion to more expensive water supply alternative(s), and influence on economic growth based on the reliability and diversity of water supplies.

To help inform the evaluation of socioeconomic impacts due to water level declines and the potential need to lower pumps or deepen wells, the Participants reviewed maps of drawdown in the Chicot, Evangeline and Jasper aquifers for each county. These drawdown maps, along with subsidence for each county, are shown in Appendix R.

A representative from the City of Conroe addressed socioeconomic considerations specific to the City of Conroe by evaluating drawdown results from Run D of the Lone Star GCD Strategic Planning Study. Results suggested City of Conroe's wells 1 and 2, the oldest wells, would go dry under expected drawdown impacts and the remaining wells would see minor impacts. Note, the report documents supporting these results were requested, but not received.

The Participants also reviewed a comparison of the modeled available groundwater (MAGs) developed during the 2016 round of joint planning to the potential future modeled available groundwater based on the DFC options considered. This is shown in Figure 4-21. For all counties in GMA 14 except Tyler and Chambers, the adopted DFCs are expected to result in higher MAGs than the 2016 round of joint planning. Note that the subsidence districts (Harris, Galveston, and Fort Bend counties) and the counties in which there are no GCDs do not implement DFCs although the Texas Water Development Board does calculate MAGs for all counties within a GMA irrespective of whether there is a GCD with jurisdiction in the county.

These counties were included in Figure 4-21, because the pumping associated with the regulatory plans for the subsidence districts was included in the model runs.

To support the evaluation of socioeconomic impacts, Lone Star GCD collected information of base rates, tier levels, administration fees, groundwater reduction plan (GRP) fees, and average household monthly bill from Montgomery County entities. Ms. Reiter provided a presentation that summarized the data collected by Lone Star GCD and emphasized the significant cost differences between surface water and groundwater. According to the analysis presented by Lone Star GCD, the average monthly water bill in Montgomery County for 10,000 gallons of use can range from as little as $19.10 to as much as $114.44. These cost differences are one of the most significant socioeconomic considerations within GMA 14.

The information presented and discussed in this section on the potential socioeconomic impacts of DFCs is by necessity a mix of quantitative and qualitative considerations. No uniform quantitative analysis has been performed by TWDB or any other entity to directly address the socioeconomic impacts of specific DFCs. Any potential socioeconomic impacts that may occur, either positive or negative, will be influenced by the DFCs and the specifics of an individual GCD's regulated community and the regulatory approach taken by that GCD to achieve the DFC.

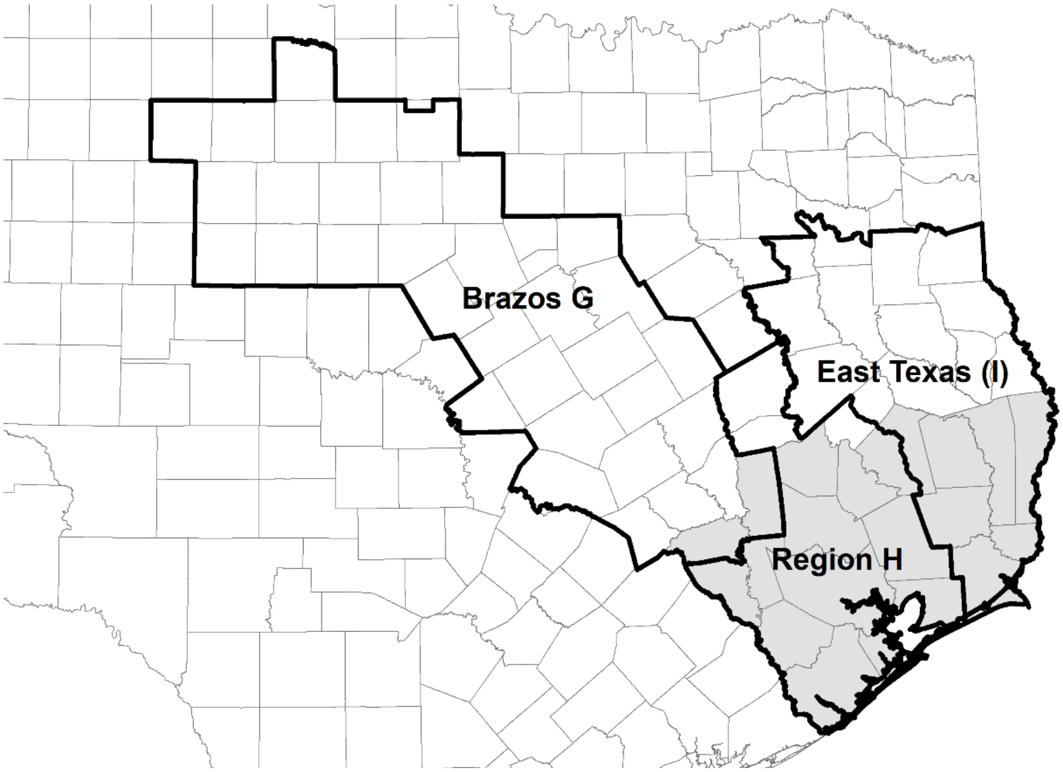

FIGURE 4-20. REGIONAL WATER PLANNING AREAS IN GMA 14

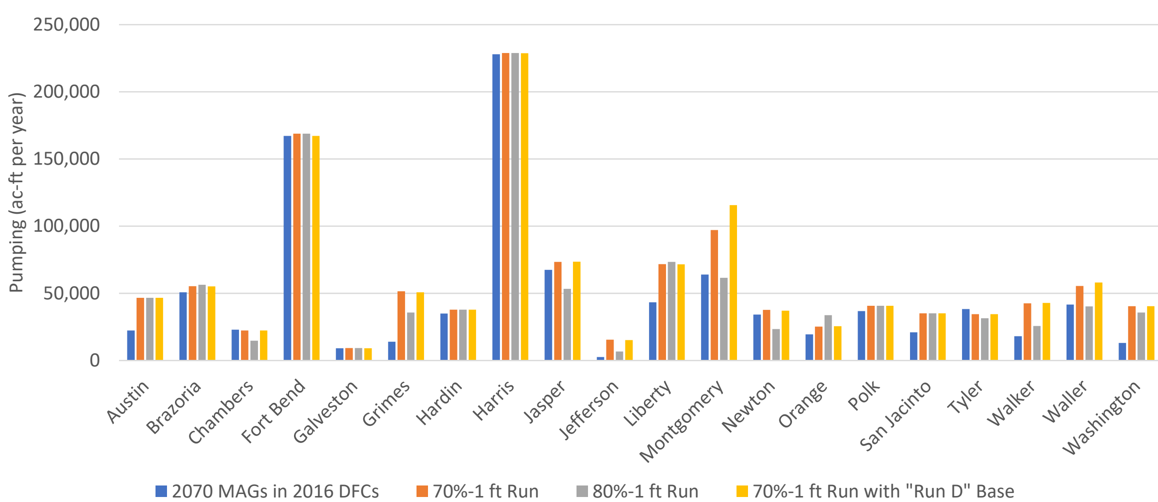

FIGURE 4-21. COMPARISON OF PUMPING ASSOCIATED WITH THE 2016 ROUND OF JOINT PLANNING AND THE THREE SCENARIOS EVALUATED DURING THE CURRENT ROUND OF JOINT PLANNING

4.7. Private Property Impacts

Texas Water Code Section 36.108(d)(7) requires that District Representatives in a GMA consider the impact of proposed DFCs 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 under Texas Water Code Section 36.002. For reference, Texas Water Code Section 36.002 reads as follows:

Sec. 36.002. OWNERSHIP OF GROUNDWATER.

(a) The legislature recognizes that a landowner owns the groundwater below the surface of the landowner's land as real property.

(b) The groundwater ownership and rights described by this section entitle the landowner, including a landowner's lessees, heirs, or assigns, to:

(1) drill for and produce the groundwater below the surface of real property, subject to Subsection (d), without causing waste or malicious drainage of other property or negligently causing subsidence; and

(2) have any other right recognized under common law.

(b-1) The groundwater ownership and rights described by this section do not:

(1) entitle a landowner, including a landowner's lessees, heirs, or assigns, to the right to capture a specific amount of groundwater below the surface of that landowner's land; or

(2) affect the existence of common law defenses or other defenses to liability under the rule of capture.

(c) Nothing in this code shall be construed as granting the authority to deprive or divest a landowner, including a landowner's lessees, heirs, or assigns, of the groundwater ownership and rights described by this section.

(d) This section does not:

(1) prohibit a district from limiting or prohibiting the drilling of a well by a landowner for failure or inability to comply with minimum well spacing or tract size requirements adopted by the district;

(2) affect the ability of a district to regulate groundwater production as authorized under Section 36.113, 36.116, or 36.122 or otherwise under this chapter or a special law governing a district; or

(3) require that a rule adopted by a district allocate to each landowner a proportionate share of available groundwater for production from the aquifer based on the number of acres owned by the landowner.

(e) This section does not affect the ability to regulate groundwater in any manner authorized under:

(1) Chapter 626, Acts of the 73rd Legislature, Regular Session, 1993, for the Edwards Aquifer Authority;
(2) Chapter 8801, Special District Local Laws Code, for the Harris-Galveston Subsidence District; and
(3) Chapter 8834, Special District Local Laws Code, for the Fort Bend Subsidence District.

The Participants formally considered impacts on private property rights during the joint planning meeting on November 18, 2020. The issue of private property rights and impacts, however, was discussed and considered throughout the joint planning process. During the November 18, 2020 meeting, the Participants received and considered four presentations from practicing attorneys with a specialty in water law offering various perspectives on private property rights as they relate to groundwater ownership and management. These presentations are summarized below and described in further detail in the meeting minutes (Appendix D). In addition, the Participants received an introductory presentation highlighting the above-referenced sections of the Texas Water Code, which is included in Appendix O. The public comments received during this meeting are listed below and included in their entirety in Appendix D.

<u>Summary of Public Comments Regarding Private Property</u>

Laura Norton, representing herself, provided comments regarding subsidence, private property rights and flooding issues.

Edward Chapman, President of Grogan's Mill Village Board of Directors, was called upon to provide comment but was not present. He provided written comments regarding groundwater withdrawals, impact of reducing the water table, and surface property rights harm from further subsidence.

Bob Lux, representing himself, provided comments related to long-term impacts of accelerated withdrawals, drought cycles, and the public good of planning for all.

Glenna Sloan, representing herself, provided comments regarding subsidence and excessive withdrawals and planning being frugal.

Ron Kelling, Deputy General Manager of San Jacinto River Authority, provided comments regarding private property rights of producers and those experiencing subsidence, should guidance be given by TWDB on private property rights considerations.

John Yoars, representing himself as a Grogan's Mill Village Resident, provided written comments.

Robert Leilich, President of The Woodlands MUD No. 1, provided comments related to flooding events experienced, subsidence, opposing increased pumping in Montgomery County.

Penny Bradshaw, representing herself, provided comments related to the Texas Water Code, planning balance between producers and conservers.

Simon Sequeira, representing Quadvest, provided comments related to defense of those who cannot defend themselves against the government, defending rights of private business, and the flawed planning system.

James Beach, representing Lone Star GCD, provided written comments related to Lone Star GCD, the balance test, and private property rights.

Presentation by Mr. Marty Jones

The Participants considered a presentation by Mr. Marty Jones of Sprouse Shrader Smith PLLC, which is included as Appendix O. Mr. Jones highlighted that constitutionally protected rights are different than an interest in a right. He stated that, while GCDs have the right to regulate production of groundwater and must consider subsidence in connection with establishing DFCs, landowners own constitutionally protected rights in groundwater. Mr. Jones noted that GCDs usefully function to modify the rule of capture to provide a fair opportunity to produce a fair share of groundwater. He also noted that production limits are important to protect the integrity of the aquifer with recognition of ownership of the groundwater.

Presentation by Mr. Greg Ellis

The Participants considered a presentation by Mr. Greg Ellis of GM Ellis Law Firm PC titled "Property Rights and Groundwater Law." This presentation is included here as Appendix O. Mr. Ellis highlighted the rule of capture and groundwater ownership throughout Texas groundwater law. Mr. Ellis noted that, because groundwater is privately owned, GCDs must protect three distinct groups of property rights owners (1) well owners who have been and continue to produce groundwater; (2) applicants who desire to produce groundwater in the future; and (3) landowners who do not own a well and do not have current plans to drill a well but nevertheless want to protect their groundwater. Mr. Ellis discussed case law relating to private property rights and groundwater including *Elliff v. Texon Drilling Co., Edwards*

Aquifer Authority v. Day, Marrs v. Railroad Commission, Bragg v. Edwards Aquifer Authority, and *Friendswood Development Co. v. Smith-Southwest Industries*.

Presentation by Ms. Stacey Reese

The Participants considered a presentation by Ms. Stacey Reese of Stacey V. Reese Law, PLLC. Ms. Reese highlighted the focus of Chapter 36 of the Texas Water Code on ownership of groundwater. Ms. Reese provided key points for District Representatives to consider property rights within the context of development of DFCs including (1) the different ownership schemes for groundwater and surface water in Texas; (2) regulatory takings claims arise when action goes too far to impair a right, not from regulatory inaction; (3) Chapter 36 of the Texas Water Code does not provide weight to the nine factors, though consistent with Mr. Jones remarks, noted that private property rights is the only factor constitutionally protected; and (4) the adopted DFCs should consider fair share, even though this is a planning effort only, and the management standard impact on GCD implementation of regulation. Ms. Reese noted the difficulty of managing the common reservoir without common rules, highlighting that the GMA consists of areas with GCDs, without GCDs, and with special districts who each have different rules and charges related to groundwater.

Presentation by Mr. Jason Hill

The final presentation considered by the Participants during the November 18, 2020 joint planning meeting was by Mr. Jason Hill of JT Hill & Co. Mr. Hill provided a broad picture of the relationship between the private property rights of a landowner and a neighboring landowner. Mr. Hill noted that every property owner has a neighboring property owner and the individual decisions of one owner has impacts on neighboring property owners. Mr. Hill provided an analogy of noise ordinances and the ability to play music as loud as one chooses, but as soon as the neighbor does the same it can be called in as a violation. Mr. Hill noted the constitutional tension between the obligation to justly compensate a disaffected landowner for a taking and the obligation of the Legislature to create laws to preserve and conserve the natural resources of the State of Texas. According to Mr. Hill, there is no easy answer of how to regulate the resource responsibly with all the factors of conservation, development and all other rights included.

4.8. Achievement Feasibility

Texas Water Code Section 36.108(d)(8) requires District Representatives in a GMA to consider the feasibility of achieving the proposed desired future conditions. This factor was reviewed by the Participants on January 20, 2021, and again as part of the review of all factors considered on February 24, 2021. This presentation and other supporting materials are included in Appendix P.

As part of the joint process, the feasibility of achieving the DFCs generally addresses two elements: physical feasibility and regulatory feasibility. During the TWDB's review of multiple petitions during the first round of DFCs in 2010 and 2011, the evaluation of whether an adopted DFC was physically possible was based on whether the DFC(s) could reasonably be simulated using the groundwater availability model for the aquifer in question. This was a valid approach because if an adopted DFC was not physically possible, then under the physical laws of hydrogeology incorporated into the model, the model would not be able to complete the simulation successfully. As the DFCs adopted by the District Representatives have been incorporated into a simulation of the TWDB accepted HAGM, it has been demonstrated that the DFCs are physically feasible.

Regulatory feasibility refers to whether the DFCs can be achieved using the existing regulatory tools available to GCDs. One example of when DFCs were found through the petition process to not be feasible was for GMA 9 in 2009. In that example, the District Representatives in GMA 9 adopted DFCs that resulted in a modeled available groundwater that was less than the estimated amount of groundwater production from exempt use wells. In that case, the GCDs would not have the regulatory authority to achieve the adopted DFCs. Given the consideration of the factors described in this explanatory report and the expected modeled available groundwater associated with the adopted DFCs, the District Representatives in GMA 14 determined that the adopted DFCs are regulatory feasible.

Bluebonnet GCD performed an evaluation of the proposed DFC and the feasibility of managing to it given the district's existing permitting and regulatory structure. This evaluation was discussed at the April 9, 2021 joint planning meeting and is included in Appendix P. In this evaluation, the Bluebonnet GCD concludes that the proposed DFCs can be feasibly implemented within the existing structures and using the existing monitoring network.

Each GCD can decide its own tracking and monitoring system for achievement of the applicable DFCs developed this round. More generally, Chapter 36 provides the regulatory tools necessary for the five GCDs in GMA 14 to implement pumping limits to achieve the proposed DFCs in 2080.

4.9. Other Information Considered

Texas Water Code 36.108(d)(9) requires District Representatives in a GMA to consider any other information relevant to the specific desired future conditions. As GMA 14 District Representatives worked through the considerations process required in Texas Water Code Section 36.108(d)(1-8), they identified faulting as an item needing additional consideration. The Participants received and considered a presentation on faulting on January 20, 2021. The presentation is available as Appendix Q.

GMA 14 contains many faults, most of which are growth faults aligned parallel to the coast. Figure 4-22 shows mapped faults and salt domes in GMA 14 from several available sources (Huffman, 2004; Shah & Lanning-Rush, 2005; and Khan, Stewart, Otoum, & Chang, 2013) The faulting along the Texas Gulf Coast is aseismic and gravitationally induced. No significant earthquake has occurred on these faults in historic times, though infrastructure damage can occur. Figure 4-23 shows an example of fault damage to a home in West Houston as identified by the Houston Geological Society.

Faults have the capacity to be hydraulic conduits connecting deep and shallow groundwater as well as barriers to horizontal flow. Because of this, faults can be identified in many ways in the field including by hydraulic gradients (that is, water level changes over short distances), pumping tests, abrupt changes in water quality, and groundwater temperature anomalies. Faults can also be identified through remote sensing techniques such as aerial photography, LiDAR and InSAR.

Faulting in GMA 14 has been correlated with groundwater pumping in studies dating back to the 1970s. The number of recognizable faults from aerial photography increased tenfold between 1930 and 1970 in the areas of Greater Houston with the highest rates of subsidence while only moderate faulting was observed elsewhere (Verbeek, Ratzlaff, & Clanton, 1979). Though a natural cause has not been ruled out, the surface fault density in the Houston-Galveston region is far greater than any other area along the Texas Gulf Coast (Engelkemeir & Khan, 2008). The relationship between groundwater pumping and movement of the Long Point Fault was evaluated in Liu and others (2019). This study revealed that the fault was most active in the 1960s and 1970s, which coincided with substantial groundwater withdrawals. The authors also note that fault movement has slowed in areas where water levels have recovered, but movement continues unabated in areas where groundwater levels continue to decline (Liu, et al., 2019).

Figure 4-24 shows rates of movement of the land surface derived from interferometric synthetic aperture radar (InSAR) for an area in northern Harris and southern Montgomery counties (Qu, Lu, Kim, & Zheng, 2019). Water level changes are also shown. Based on the relationship between drawdowns in the Jasper Aquifer and observed land surface movement rates across faults, the authors conclude that new faulting in the area appears related to groundwater pumping in the Jasper Aquifer (Qu, Lu, Kim, & Zheng, 2019).

Though the analyses included here are not unique to a particular DFC, they highlight that faulting does occur within the Gulf Coast Aquifer System. Faulting is naturally occurring. The Participants considered how faulting can be accelerated by groundwater pumping and associated subsidence. Since faulting can impact both water levels and water quality, it is an important consideration for GMA 14 GCDs when monitoring progress toward achieving DFCs.

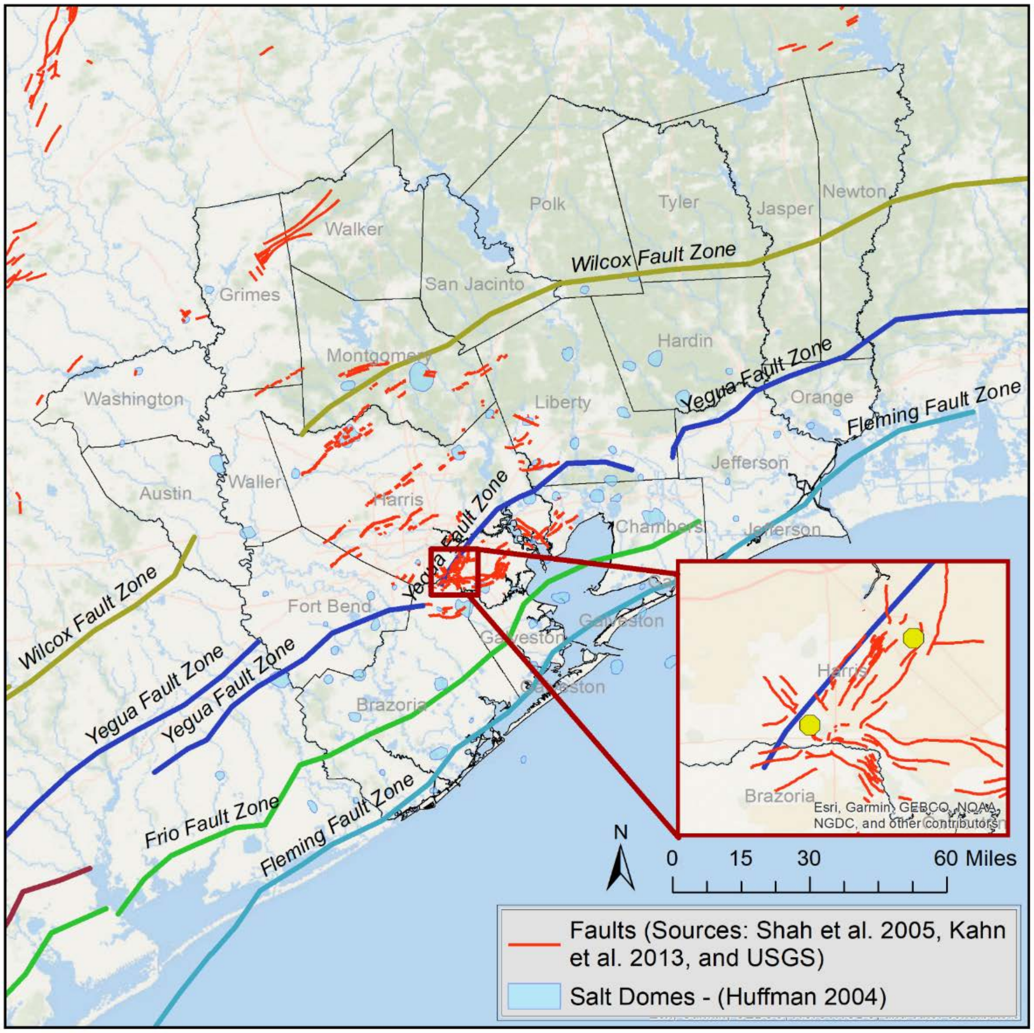

FIGURE 4-22. MAPPED FAULTS IN AND NEAR GMA 14

FIGURE 4-23. EXAMPLE OF FAULT IMPACTS ON A HOME IN GMA 14 (HOUSTON GEOLOGICAL SOCIETY, 2019)

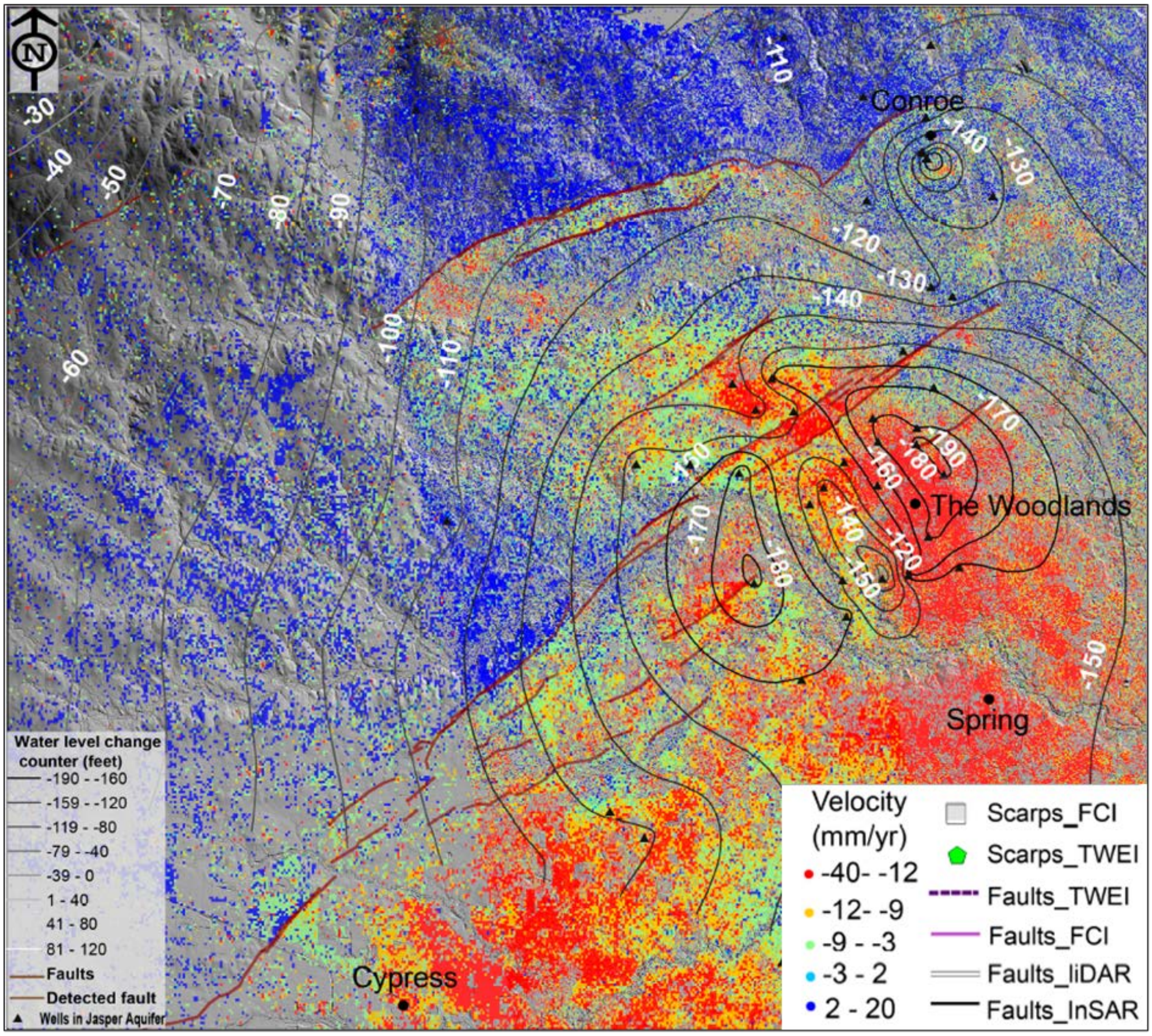

FIGURE 4-24. FAULTS, LAND SURFACE VELOCITY, AND WATER LEVEL CHANGE IN SOUTHERN MONTGOMERY COUNTY AND NORTHERN HARRIS COUNTY (QU, LU, KIM, & ZHENG, 2019)

5. Discussion of Other Desired Future Conditions Considered

As described in the sections above, the Participants considered many studies, modeling evaluation results, and metrics throughout the joint planning process. While some of the required factors for consideration – Aquifer Uses and Conditions, Water Supply Needs and Management Strategies, and Hydrological Conditions – are independent of the specific DFCs under consideration, the other factors are not. For this reason, following consideration of the first three factors and several iterations reviewing model run results, on May 29, 2020, the Participants voted to formally consider three potential DFC scenarios. These three scenarios were:

- In each county in GMA 14, no less than 70 percent median available drawdown remaining and no more than 1.0 feet average additional subsidence between 2009 and 2080.
- In each county in GMA 14, no less than 80 percent median available drawdown remaining and no more than 1.0 feet average additional subsidence between 2009 and 2080.
- In each county in GMA 14, no less than 70 percent median available drawdown remaining and no more than 1.0 feet average additional subsidence between 2009 and 2080 using the "Run D" well file as a base pumping distribution in Montgomery County.

Each of the above scenarios employed the qualifier that, to allow for growth while ensuring the distribution of groundwater availability remains realistic, modeled pumping in each county will not exceed 30,000 acre-feet per year above the maximum projected water demand between 2020 and 2070 in the State Water Plan.

No other DFC options were formally considered and evaluated against the factors listed in Texas Water Code Section 36.108(d)(1-9).

6. Discussion of Other Recommendations Including Public Comments

At each of the meetings held by the GMA 14 District Representatives, the public was invited to provide comments on the proceedings and recommendations on DFCs. These comments regularly included discussion of private property rights, subsidence, socioeconomic impacts and other factors of concern to individuals and entities within GMA 14. These comments are included in the meeting documentation presented in Appendix D.

In addition, each of the GMA 14 Districts held public hearings and collected public comments following proposal of the DFCs. The majority of the comments received by each District related to the DFCs in Lone Star GCD. Each District developed a summary report of comments received. These summary reports as well as the comments are included in Appendix C.

Throughout the joint planning process, public comments addressed and informed the consideration of factors and balancing test underlying the development of DFCs.

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