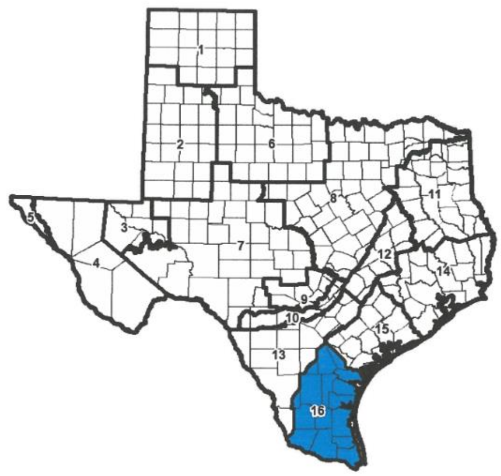
Desired Future Condition Explanatory Report for Groundwater Management Area 16

Prepared for Groundwater Management Area 16 Member Districts:

Bee Groundwater Conservation District
Brush Country Groundwater Conservation District
Corpus Christi ASR Conservation District
Duval County Groundwater Conservation District
Kenedy County Groundwater Conservation District
Live Oak Groundwater Conservation District
McMullen Groundwater Conservation District
Red Sands Groundwater Conservation District
San Patricio Groundwater Conservation District
Starr County Groundwater Conservation District



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July 2022
(amended from January 2022)

GEOSCIENTIST SEAL

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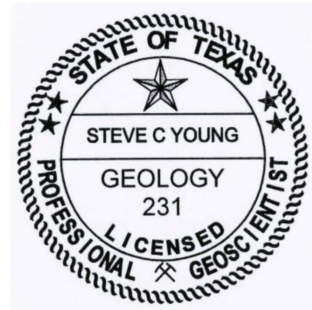

Dr. Steve Young was the technical lead responsible for assembling, interpreting, and documenting the information in the explanatory report. He is also the principal writer of the report.

Date: July 4, 2022

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ACRONYMS AND ABBREVIATIONS

%	percent
AFY	acre-feet per year
ASRCD	Aquifer Storage and Recovery District
DFC	Desired Future Condition
ft	feet
GAM	Groundwater Availability Model
GCAS	Gulf Coast Aquifer System
GCD	Groundwater Conservation District
GFM	Groundwater Flow Model
GMA	Groundwater Management Area
MAG	modeled available groundwater
NADA	Neighbors Against Destroying Aquifers
TERS	total estimated recoverable storage
TWC	Texas Water Code
TWDB	Texas Water Development Board
UWCD	Underground Water Conservation District

1.0 GROUNDWATER MANAGEMENT AREA 16

Groundwater Management Areas (GMAs) were created "in order to provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence caused by withdrawal of water from those groundwater reservoirs or their subdivisions, consistent with the objectives of Section 59, Article XVI, Texas Constitution…" (Texas Water Code [TWC] §35.001). GMA 16 is the southernmost of sixteen GMAs in the state and stretches from Corpus Christi to the Mexican border along the Gulf of Mexico coastline. (**Figure 1-1**).

GMA 16 includes all or portions of sixteen counties: Bee, Brooks, Cameron, Duval, Hidalgo, Jim Hogg, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, San Patricio, Starr, Webb, and Willacy (**Figure 1-2**). **Table 1-1** lists the sixteen counties and their projected populations through 2070. Most counties in the GMA, particularly along the Rio Grande, are expected to grow over the next 50 years with Cameron, Hidalgo, and Webb counties experiencing the highest growth rates. Hidalgo County alone is expected to add over to 1.1 million people. Projected growth is much slower in the northeast section of the GMA, with the lowest growth rates in McMullen, Live Oak, and Kenedy counties, whose populations are projected to remain about the same over the next 50 years.

As part of the joint groundwater planning process, groundwater conservation districts (GCDs) falling within a GMA are required to coordinate and develop Desired Future Conditions (DFCs) for the aquifers within the GMA. Ten GCDs participate in joint planning through GMA 16: Bee GCD, Brush Country GCD, Corpus Christi Aquifer Storage and Recovery Conservation District (ASRCD), Duval County GCD, Kenedy County GCD, Live Oak Underground Water Conservation District (UWCD), McMullen GCD, Red Sands GCD, San Patricio County GCD, and Starr County GCD (Figure 1-2). **Table 1-2** lists the names of the designated representatives for the ten districts.

Based on the Texas Water Development Board (TWDB) delineations of major and minor Texas aquifers, GMA 16 contains portions of two major aquifers, the Gulf Coast Aquifer and the Carrizo-Wilcox Aquifer, and one minor aquifer, the Yegua-Jackson Aquifer (**Figure 1-3**). The primary aquifer used in GMA 16 is the Gulf Coast Aquifer. Four formations within the Gulf Coast Aquifer are considered as separate aquifers for joint planning purposes: the Chicot Aquifer, the Evangeline Aquifer, the Burkeville confining unit, and the Jasper Aquifer. Bee, Live Oak, and McMullen counties contain small areas of the downdip portion of the Carrizo-Wilcox Aquifer. Jim Hogg, Duval, Live Oak, and Starr counties contain small areas of Yegua-Jackson Aquifer. The Carrizo-Wilcox and Yegua-Jackson aquifers are not major sources of groundwater in GMA 16. Section 2 provides additional information on the Carrizo-Wilcox and Yegua-Jackson aquifers within GMA 16.

GMA 16 overlaps the Region M (Rio Grande Valley), and Region N (Coastal Bend) Regional Water Planning Areas (RWPAs) (**Figure 1-4**). GMA 16 participates in the regional water planning process in Texas by maintaining representatives in both of these Regional Water Planning Groups.

GMA 16 held joint planning meetings September 2019 through November 2021. **Table 1-3** lists the dates and the major discussion topics of the GMA 16 meetings. The minutes for these meetings are included as **Appendix A** of this report. Following the adoption of the proposed DFCs at the meeting on March 23, 2021, the GCDs held public meetings to present and discuss the proposed DFCs and solicit public comment. Only Bee County GCD received a written comment during the public comment period. **Appendix B** contains the public comment received by Bee County.

The only public comment received by GMA 16 was discussed during GMA 16 meeting on September 21. Bee County GCD did not propose to change their DFCs in response to the public comment. The public comment was provided by Neighbors Against Destroying Aquifers (NADA). NADA expressed concerns about Bee County GCD achieving the proposed DFCs for the Gulf Coast Aquifer System (GCAS) of 7 feet (ft) drawdown between 2000 and 2080 for GMA 15, and 93 ft of drawdown between 2010 and 2070 for GMA 16. In their letter, NADA states the water level monitoring data in Bee County indicates that the GMA 16 drawdown of 93 ft is feasible whereas the GMA 15 drawdown of 7 ft is not feasible. In addition to their feasibility analysis of proposed DFCs, NADA provides recommendations regarding revised drawdown-based DFCs, addition a water quality-based DFCs, and rules changes. These recommendations were considered by Bee County GCD in their evaluation of the proposed DFCs.

The proposed DFCs for the GCDs were adopted by resolution during the GMA 16 November 2021 and 28 June 2022 meeting. The adoption in June 2022 occurred in order to accommodate suggested changes to the November 2021 DFCs. **Appendix C** provides the June 2022 resolution. The adopted DFCs are discussed in Chapter 2.

Table 1-1 GMA 16 County Population Projections (from Region M & Region N draft Regional Water Plans)

COUNTY	2020	2030	2040	2050	2060	2070
Bee	33,478	34,879	35,487	35,545	35,579	35,590
Brooks	7,783	8,252	8,722	9,181	9,595	9,979
Cameron	478,974	559,593	641,376	729,461	820,068	912,941
Duval	12,715	13,470	14,098	14,644	15,080	15,435
Hidalgo	981,890	1,219,225	1,457,502	1,696,257	1,935,015	2,167,137
Jim Hogg	5,853	6,356	6,790	7,274	7,694	8,082
Jim Wells	44,987	48,690	52,052	55,533	58,600	61,410
Kenedy	463	498	504	507	508	508
Kleberg	35,567	38,963	42,202	45,324	48,251	50,989
Live Oak	11,683	11,690	11,690	11,690	11,690	11,690
McMullen	734	734	734	734	734	734
Nueces	374,157	407,534	428,513	440,797	449,936	456,056
San Patricio	68,760	72,114	74,043	75,451	76,405	77,049
Starr	70,803	80,085	88,633	97,107	104,687	111,555
Webb	318,028	393,284	464,960	530,330	591,945	647,433
Willacy	25,264	28,479	31,559	34,840	38,012	41,121

Table 1-2 Designated Representatives of the Ten Districts in Groundwater Management Area 16

Groundwater Conservation District	Designated Representative
Corpus Christi Aquifer Storage and Recover Conservation District	Esteban Ramos
Bee GCD	Lonnie Stewart
Brush County GCD	Luis Pena
Duval County	George Gonzalez
Kenedy County GCD	Andy Garza
Live Oak UWCD	Scott Bledsoe
McMullen GCD	Lonnie Stewart
Red Sands GCD	Armando Vela
San Patricio County GCD	Charles Ring
Starr County GCD	Reyna Guerra

Table 1-3 GMA 16 Joint Planning Meeting Dates and Topics of Discussion

Date	Major Discussion Topics
9/24/2019	▪ Discuss joint planning requirements and roles of consultant (INTERA) and Districts ▪ Discuss approach for non-GCD counties, non-relevant aquifers, and timeframe for simulations ▪ Solicit updated pumping data from GCDs
1/28/2020	▪ Discuss results of modeled pumping scenarios, using updated pumping data from GCDs ▪ Discuss options for calculating DFC/MAG values, including alternatives to TWDB assumptions ▪ Discuss 1st factor “Aquifer Uses and Conditions”
7/28/2020	▪ Discuss 2nd factor “Hydrologic Conditions” ▪ Discuss 3rd factor “Water supply needs and management strategies” ▪ Discuss 4th factor “Impact on private property rights” ▪ Discuss 5th factor “Impact on subsidence”
10/27/2020	▪ Discuss 6th factor “SocioEconomic Impacts” ▪ Discuss 7th factor “Other Environmental Impacts” ▪ Discuss TWDB update of the conceptual model for Gulf Coast Aquifer System GAM
1/28/2021	▪ TWDB reported on; (1) regional water plans; (2) brackish production zones; (3) ASR study assessment; (4) agricultural grants ▪ Discussed the TWDB flowchart and schedule for the DFC and MAG process ▪ INTERA presented the DFC model simulations for pumping scenarios # 1 and #2.
3/23/2021	▪ Discussed the TWDB flowchart and schedule for the DFC and MAG process ▪ INTERA presented the average drawdowns for DFC model simulations for pumping scenario #2 ▪ Agree to propose the DFCs that are generated from pumping scenario #2
9/21/2021	▪ TWDB explain the submittal process for the explanatory report ▪ INTERA provided an update on the writing of the explanatory report ▪ Discuss the public comments received by Bee County GCD, which were the only set of public comments received. ▪ Discussed appointing a representative for Region M and N ▪ Starr County reported they had an approved management plan and adopted rules
11/23/2021	▪ Approve Resolution for Adopting the Desired Future Conditions ▪ Declare Carrizo-Wilcox and Yegua-Jackson as non-relevant aquifers ▪ Review Explanatory Report

06/28/2022	▪ Approve Revised Resolution for Adopting the Desired Future Conditions ▪ Approved Revised Explanatory Report

*ASR = aquifer storage and recovery, MAG = modeled available groundwater

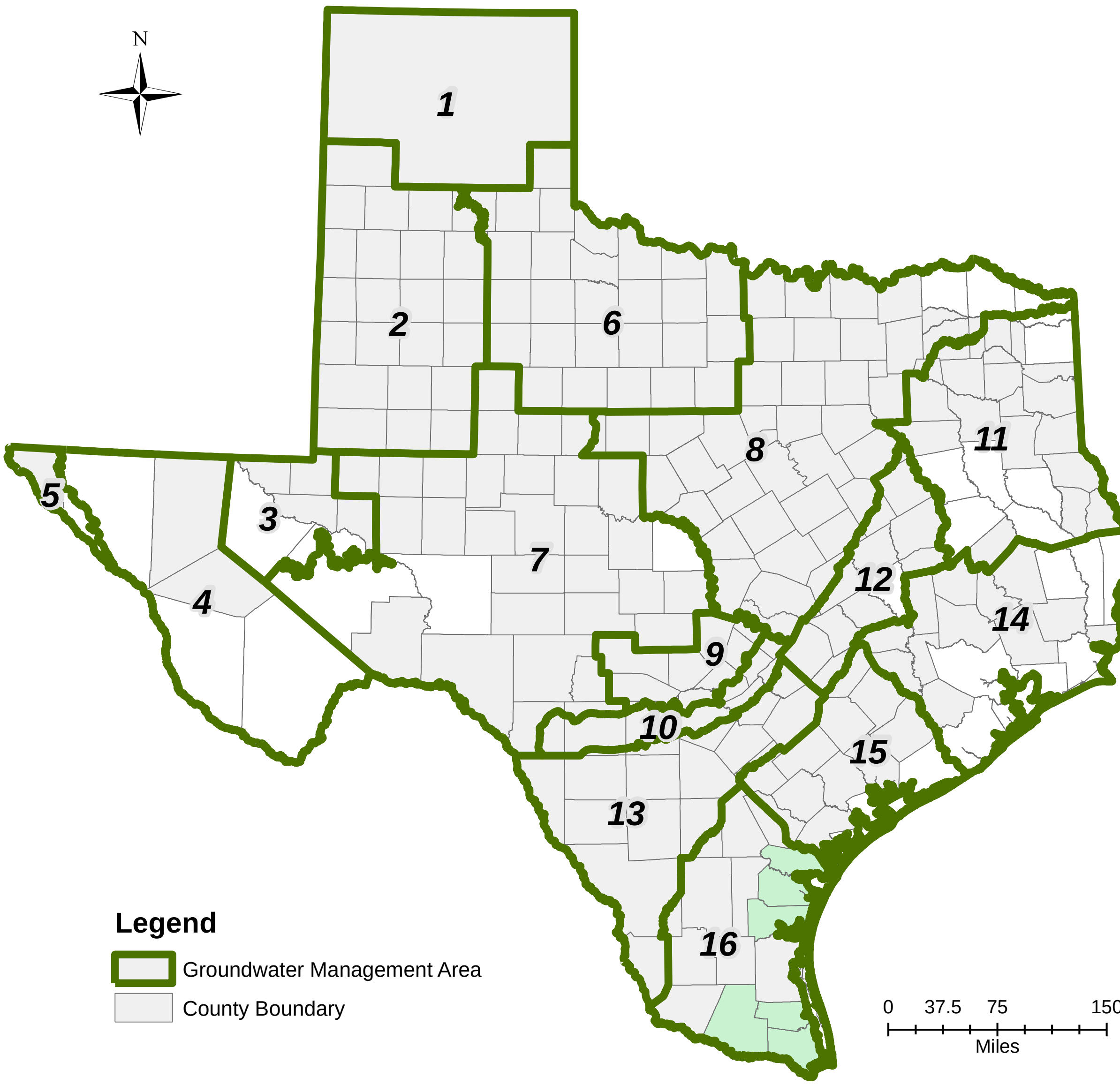

Figure 1-1 Location of Groundwater Management Area 16

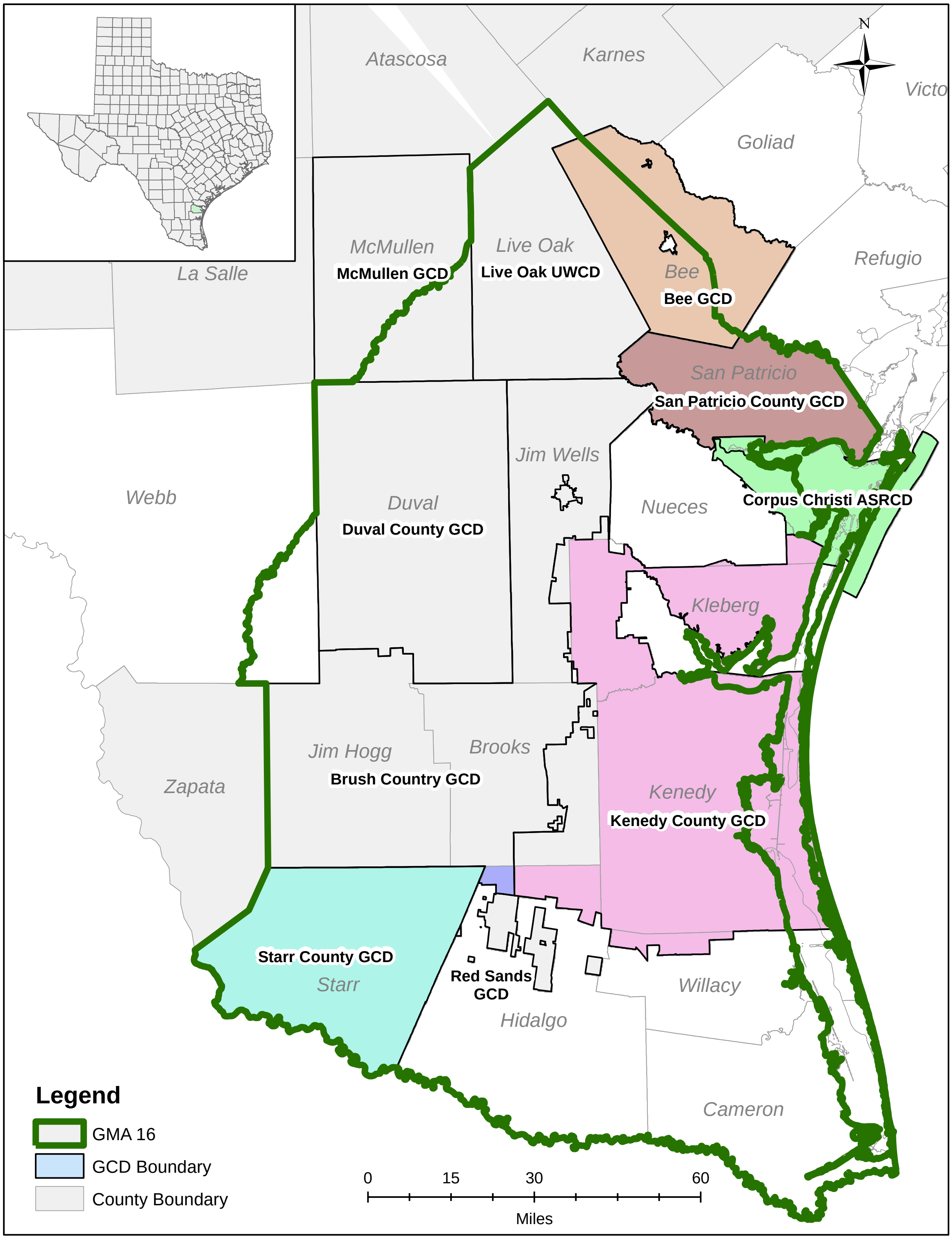

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Figure 1-2 Counties and GCDs in GMA 16

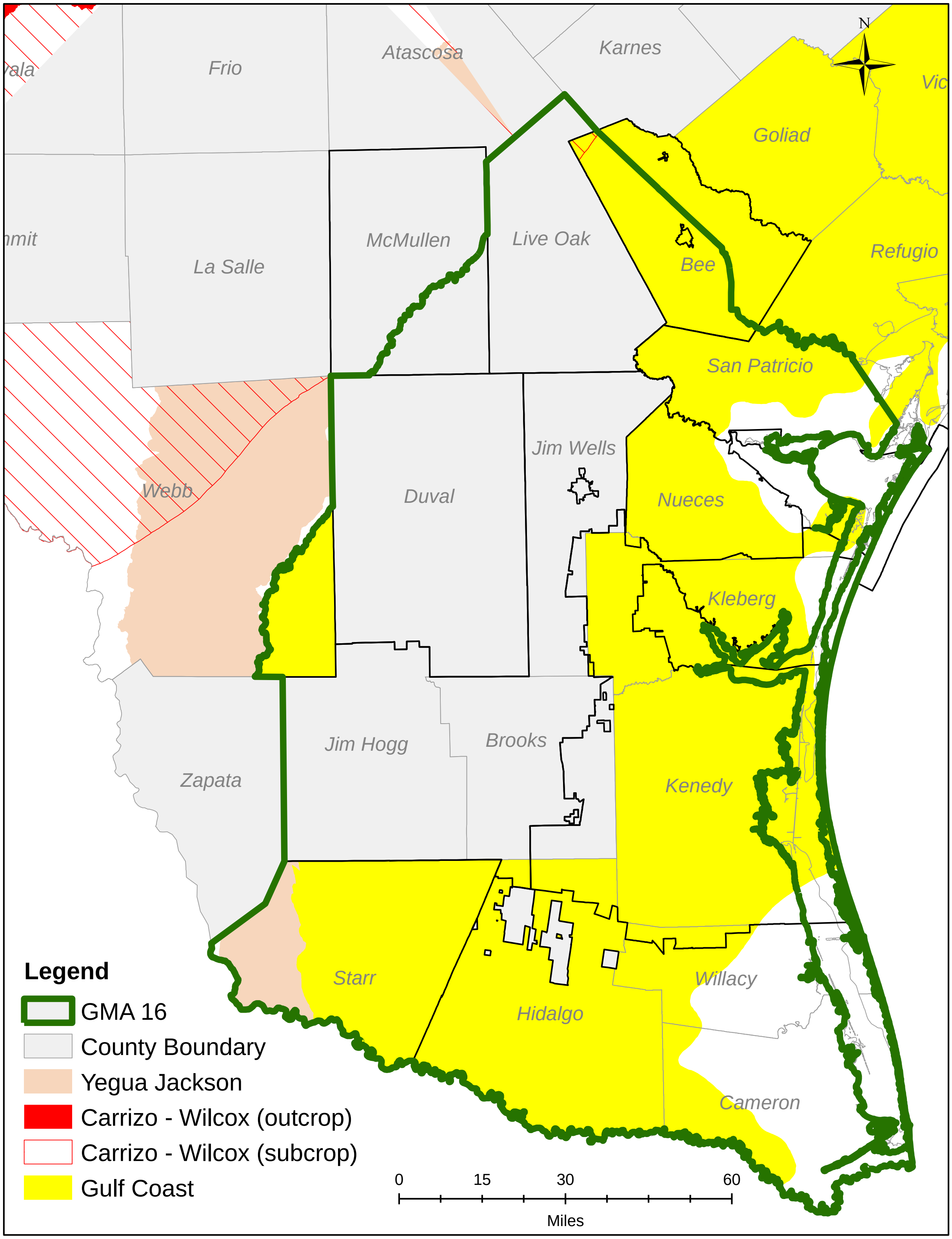

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Figure 1-3 Aquifers in GMA 16

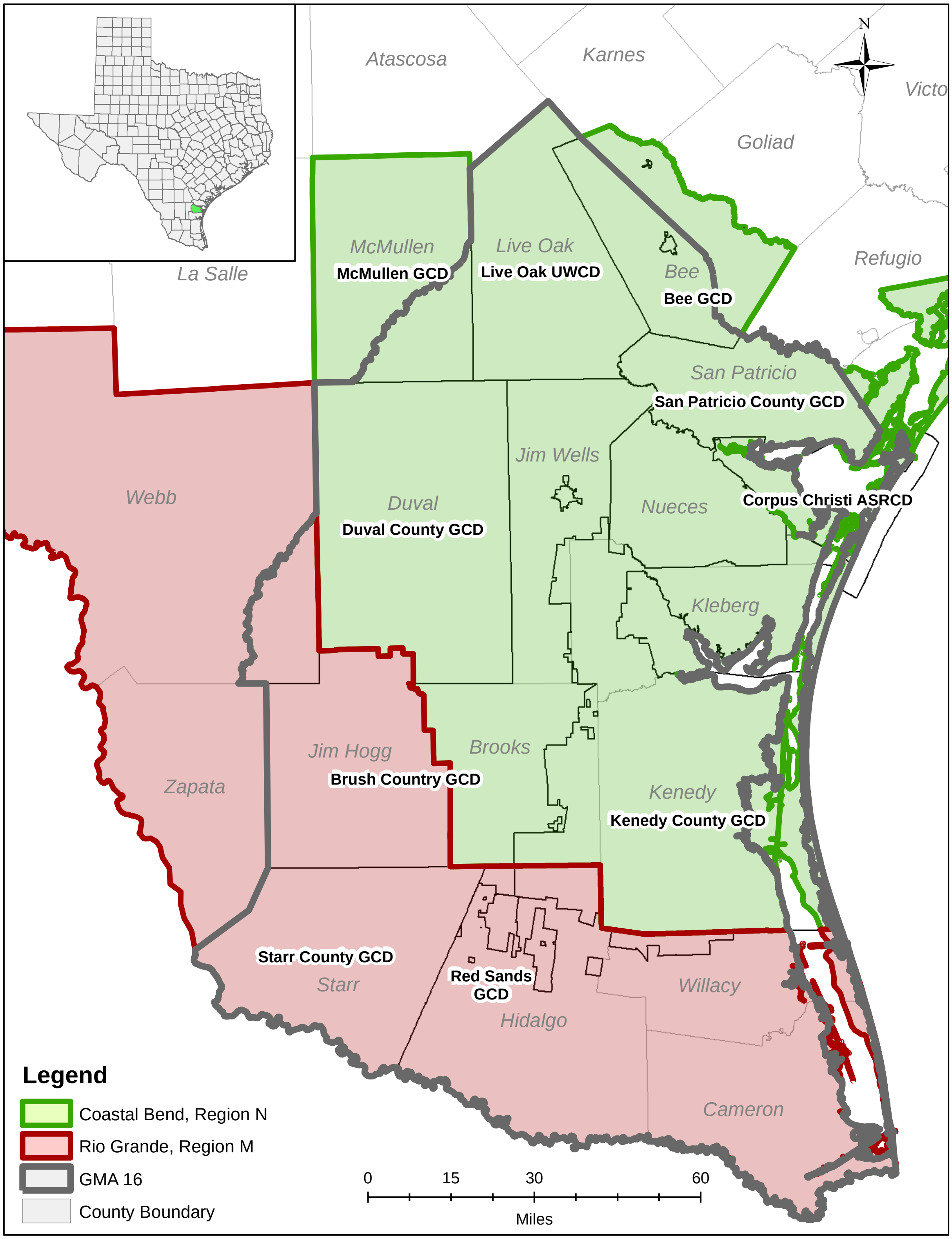

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Figure 1-4 RWPAs overlapping GMA 16

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2.0 GMA 16 DFCS

The current round of joint planning followed the same approach for developing DFCs as used previously in 2011 and 2017. Alternative pumping scenarios were simulated using the GMA 16 Groundwater Availability Model (GAM) (Hutchison et al, 2011) and different methods for calculating DFCs and accounting for pumping were discussed. GMA 16 also considered the nine factors discussed in Section 3 when developing future pumping and evaluating the results of the model simulations. In particular, the GMA considered future water management strategies as proposed in the Regional Water Plan when evaluating pumping scenarios. The model results and the nine factors were discussed in public meetings (Table 1-2) prior to adopting these DFCs.

2.1 Gulf Coast Aquifer

The primary aquifer used in GMA 16 is the Gulf Coast Aquifer. Four formations within the Gulf Coast Aquifer are considered as separate aquifers for joint planning purposes: the Chicot Aquifer, the Evangeline Aquifer, the Burkeville confining unit, and the Jasper Aquifer. Regionally, the Burkeville Formation is considered a confining unit between the Evangeline and the Jasper aquifers. However, this formation is a local source of water in several areas of the GMA and so is treated as an aquifer for joint planning purposes.

On November 23, 2016, GMA 16 representatives approved a resolution titled Resolution to Adopt the DFCs for GMA 16 (**Appendix C**). In this resolution, GMA 16 adopted DFCs for each GCD (except for the Corpus Christi ASRCD) and non-District county within the GMA (District-specific DFCs) and a DFC for the entire (GMA-wide DFC). The GMAs adopted District-specific DFCs and GMA-wide DFCs for the Chicot Aquifer, the Evangeline Aquifer, the Burkeville Confining Unit, and the Jasper Aquifer individually as well as for the entire Gulf Coast Aquifer (these four formations combined). The adopted DFCs represent acceptable levels of drawdown for each District/non-District county and for the entire GMA as measured from 2010 to 2080. This timeline was chosen in order to be consistent with the timeline for the next round of regional/state water planning.

The adopted DFCs are presented in **Table 2-1**. All of Districts adopted a single DFCs for the Gulf Coast Aquifer System. The adopted DFCs are based on the average simulated drawdown within each region as calculated using the GMA 16 GAM (Hutchison and others, 2011) using the pumping rates provided in GMA 16 Pumping Scenario #2.

Table 2-2 lists average drawdowns from 2010 to 2080 for the Chicot, Evangeline, Burkeville Confining Unit, and the Jasper produced from Pumping Scenario #2. The average drawdowns were calculated using the boundaries for counties, GCDs, GMAs, and active aquifers as defined in the grid file "alt1_gma16_grid_poly05114.shp" produced by TWDB (available at https://www.twdb.texas.gov/groundwater/models/alt/gma16/gma16.asp). The average drawdowns calculations included cells that go dry during the GMA simulation. Each calculated average drawdown is assigned a tolerance of ± 3 ft. The variance of ± 3 ft accounts for slight differences in the calculate average drawdown that result as a result of different assumptions used by algorithms processing the GAM output. The incorporation of the variance was the only change in the DFCs for the GCDs between the GMA DFC resolutions adopted in November 2021 and June 2022. The GAM simulation of Pumping Scenario #2 was provided to the

TWDB along with the explanatory report. Table 2-2 provides the average drawdowns from 2010 to 2080 for the Chicot Aquifer, Evangeline Aquifer, Burkeville Confining Unit, and the Jasper Aquifer.

2.2 Carrizo-Wilcox Aquifer

Appendix D contains the GMA 16 memorandum that declares the Carrizo-Wilcox Aquifer in GMA 16 as a non-relevant aquifer for the purposes of joint planning. The decision to assign the Carrizo-Wilcox Aquifer as a non-relevant aquifer was discussed during the 9/24/2019, 1/28/2020, 11/23/2021 GMA 16 meetings. The portion of Carrizo-Wilcox Aquifer falling within the GMA is small (Figure 1-3), occurring only in Bee, Live Oak, and McMullen counties. While McMullen County does report pumping from the Carrizo-Wilcox Aquifer (based on TWDB historical groundwater pumping values), this pumping mainly occurs outside the GMA 16 boundary and so falls under the GMA 13 joint planning process. Otherwise, the portion of Carrizo-Wilcox Aquifer within GMA 16 occurs at depths (greater than 5,000 ft) that are generally considered economically infeasible for development (Kelley et al., 2004) and so current and estimated future Carrizo-Wilcox pumping is considered to be insignificant. Another important consideration in DFC development is the ability to monitor whether a DFC is achieved. Given the depth and lack of wells in this aquifer, monitoring this aquifer would be difficult and costly. Due to monitoring considerations, combined with the insignificant amount of current and predicted future pumping, GMA 16 declared the Carrizo-Wilcox Aquifer as non-relevant for joint planning purposes.

2.3 Yegua-Jackson

Appendix E contains the GMA 16 memorandum that declares the Yegua-Jackson Aquifer in GMA 16 as a non-relevant aquifer for the purposes of joint planning. The decision to assign the Carrizo-Wilcox Aquifer as a non-relevant aquifer was discussed during the 9/24/2019, 1/28/2020, 11/23/2021 GMA 16 meetings. The portion of Yegua-Jackson Aquifer falling within the GMA 16 is shown in Figure 1-3. The aquifer occurs in Duval, Jim Hogg, Live Oak, and Starr counties. For 2018 and 2019 (the latest years with data) the TWDB historical pumping is less than 50 acre feet per year for Duval, Jim Hogg, and Live Oak counties. Starr County historical pumping for 2018 and 2019 is less than 175 acre-ft per year. As with the Carrizo- Wilcox Aquifer, monitoring this aquifer would be difficult and costly. Due to high costs for groundwater monitoring and the relatively small amount of current pumping, and minimum impact on the water levels in the Gulf Coast Aquifer, GMA 16 declared the Yegua-Jackson Aquifer as a non-relevant aquifer. GMA 16 plans to re-elevate the status of the Yegua-Jackson as a non-relevant aquifer during future joint planning cycles.

Table 2-1 GMA 16 Adopted DFCs

Groundwater Conservation District	Average Drawdown (ft) Across the GCD in the Gulf Coast Aquifer System from January 1, 2010 to December 31, 2079
Bee GCD	93
Brush County GCD	89
Duval County	137
Kenedy County GCD	27
Live Oak UWCD	45
McMullen GCD	12
Red Sands GCD	60
San Patricio County GCD	69
Starr County GCD	94

Table 2-2 Average Drawdown Calculated for the Gulf Coast Aquifer System from January 2010 to December 2079 for each GCD for the Purpose of Establishing DFCs in Table 2-1.

GCD or Region	Simulated Averaged Drawdown (ft) 2010-2080*				
	Chicot	Evangeline	Burkeville	Jasper	Gulf Coast Aquifer System
Bee GCD	126(± 3)	102(± 3)	90(± 3)	75(± 3)	93 (± 3)
Brush County GCD	60(± 3)	101(± 3)	88(± 3)	89(± 3)	89(± 3)
Duval County	99(± 3)	183(± 3)	121(± 3)	109(± 3)	137(± 3)
Kenedy County GCD	18(± 3)	56(± 3)	18(± 3)	18(± 3)	27(± 3)
Live Oak UWCD	100(± 3)	83(± 3)	79(± 3)	25(± 3)	45(± 3)
McMullen GCD	0(± 3)	0(± 3)	0(± 3)	12(± 3)	12(± 3)
Red Sands GCD	48(± 3)	62(± 3)	61(± 3)	60(± 3)	60(± 3)
San Patricio County GCD	114(± 3)	84(± 3)	39(± 3)	39(± 3)	69(± 3)
Starr County GCD	0(± 3)	112(± 3)	100(± 3)	76(± 3)	94(± 3)
Cameron	125(± 3)	196(± 3)	78(± 3)	78(± 3)	119(± 3)
Hidalgo	153(± 3)	170(± 3)	119(± 3)	117(± 3)	138(± 3)
Kleberg	15(± 3)	46(± 3)	11(± 3)	11(± 3)	21(± 3)
Nueces	33(± 3)	40(± 3)	15(± 3)	15(± 3)	26(± 3)
Webb	0(± 3)	226(± 3)	0(± 3)	91(± 3)	161(± 3)
Willacy	47(± 3)	85(± 3)	23(± 3)	23(± 3)	44(± 3)
GMA 16 TOTAL	61(± 3)	110(± 3)	67(± 3)	65(± 3)	78(± 3)

- Time period is from 1/1/2010 to 12/31/2079. The variance of ± 3 is included to account for the inherent difficulty in exactly matching calculated average drawdown using different mathematical scripts and to account for slight adjustments in establishing the DFCs in Table 2-1.

3.0 TECHNICAL JUSTIFICATION

A groundwater model is a tool that can be used to better understand the cause-and-effect relationship that different groundwater management strategies have on a groundwater system. To make informed decisions while developing DFCs, the GMA must consider the effects or the impacts of a DFC on each of the nine statutory factors listed in TWC §36.108(d). A groundwater model can be used to evaluate the impacts of various management strategies and provide the information that GCDs need as they consider these factors and develop DFCs.

3.1 GMA 16 Groundwater Flow Model

As discussed in Section 2, the proposed DFCs for the Gulf Coast Aquifer in GMA 16 were developed based on simulations of future pumping using the GMA 16 Groundwater Flow Model (GFM) (Hutchison et al, 2011). Since neither the existing groundwater models for the southern portion or the central portion of the Gulf Coast Aquifer fully encompass GMA 16, TWDB specifically developed this alternative model to use as a tool for the development of DFCs for GMA 16. It should be noted that the TWDB is currently developing a new Gulf Coast Aquifer System GAM that encompasses the combined areas of GMAs 15 and 16. However, until this model is completed, the 2011 GMA 16 GFM remains the most appropriate tool for joint planning purposes.

The GMA 16 GFM consists of six model layers. Model layers 1 through 4 represents the Chicot Aquifer, the Evangeline Aquifer, the Burkeville Confining Unit, and the Jasper Aquifer, respectively. Layer 5 represents the Yegua-Jackson Aquifer, including some portions of the Catahoula Formation. Layer 6 represents the combined strata of the Sparta, Queen City, and Carrizo-Wilcox Aquifers. **Figure 3-1** is a conceptual diagram of flow through and between each of the six model layers.

3.2 Simulations of Desired Future Conditions

During the previous joint planning cycle, the GMA 16 GFM was used to generate simulations of DFCs. The DFC simulations focused on predicting changes in water levels caused by changes in pumping during the time period 2010 through 2060. During the current joint planning cycle, the DFC simulations were extended to be 70-year simulations, representing the period 2010 through 2080. Drawdown was calculated from January 1, 2010 to December 31, 2079.

GMA 16 developed two updated pumping files and ran groundwater model simulations, the results of which were discussed and approved in public meetings. The first pumping file was based on the pumping file approved by the GMA 16 Board during the last joint planning cycle. The updated version of the pumping file added stress periods that extended pumping at an unchanged rate from 2060 to 2080 (**Figure 3-2**). The second pumping file also extended pumping to 2080 but incorporated pumping changes submitted by the member districts and their representatives (**Figure 3-3**). For districts that did not request pumping changes, pumping was left at an unchanged rate from 2060 to 2080.

Although the GMA 16 GFM remains the most appropriate tool for evaluating GMA 16 DFCs, the groundwater model and the simulated results should be considered tools to help the GMA make decisions, rather than as the sole source of DFC-related decisions. All groundwater models have inherent uncertainty due to gaps in field data, ranges of potential input parameters, and assumptions made due to a model's spatial resolution, among other factors. The following section reviews some technical details that should be considered when evaluating these model results.

In the GMA 16 GFM, all model layers are considered fully confined even though outcrop areas in reality would typically be considered unconfined. Confined aquifers respond more quickly to pumping because the draining of unconfined pore space occurs more slowly than the reduction of potentiometric pressure in a confined aquifer. As a result, simulated drawdowns in the outcrop areas of the Gulf Coast Aquifer should be considered conservative estimates, in that model results likely represent greater drawdowns than would realistically be expected in the outcrop areas.

Another consequence with the GMA 16 GFM assuming all model layers are fully confined is that the model confined cells to continue pumping even when a cell "goes dry" (the potentiometric surface falls below the bottom elevation of the pumping cell). Dry cells occur in the updip areas of the Gulf Coast model layers during the simulations. As a result, the simulated drawdowns would produce physically unrealistic model results that overestimate drawdown, particularly in the outcrop areas.

GMA 16 discussed preliminary DFC simulations during their meeting on January 28, 2020. One of the key discussion topics was the development of Modeled Available Groundwater (MAG) from the DFC simulations performed by GMA 16 during the last planning cycle. Several GMA 16 stakeholders had questions about why the MAGs for several counties did not include all of the pumping that had occurred in the county. During their presentation, INTERA explained that the TWDB excluded all pumping outside of the official TWDB boundary for the Gulf Coast Aquifer system from the MAG. **Figure 3-4** shows, for example, that a portion of San Patricio County, lies outside of the TWDB official boundary for the Gulf Coast aquifer system. **Appendix F** provides a copy of the INTERA presentation that discusses several technical aspects related to the determination of MAG and DFCs.

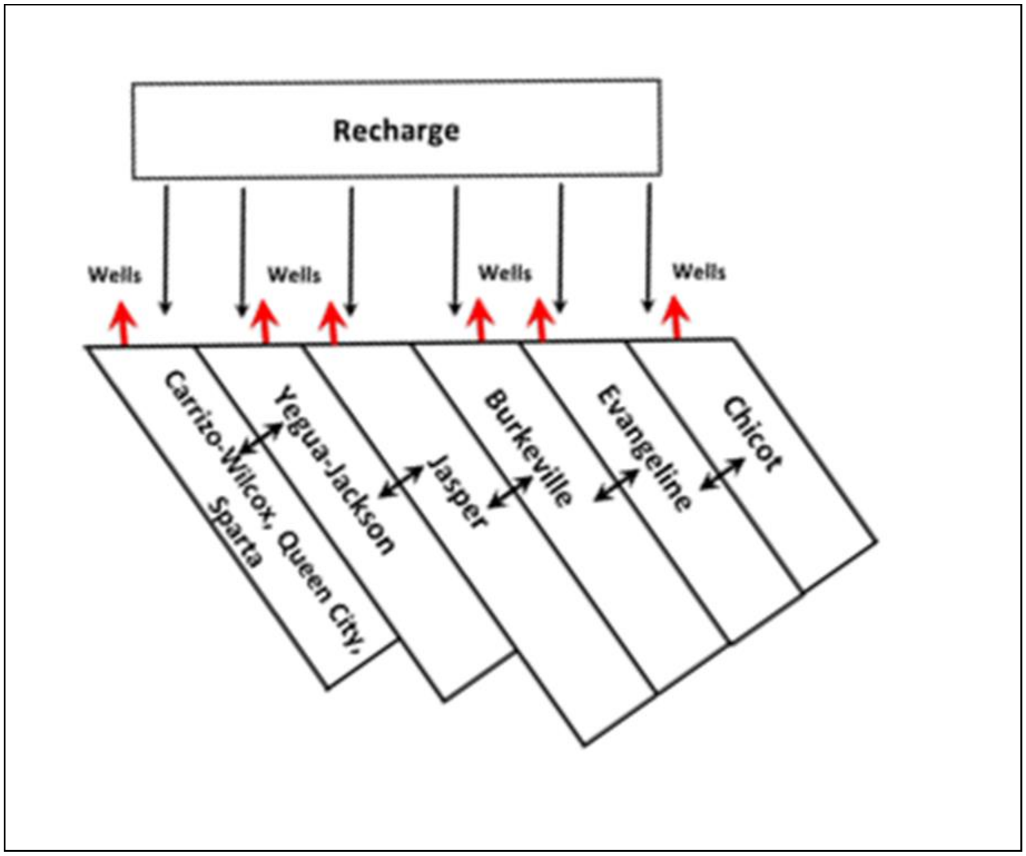

Figure 3-1 Conceptual model of flow in GMA 16 GAM (O'Rourke, 2017)

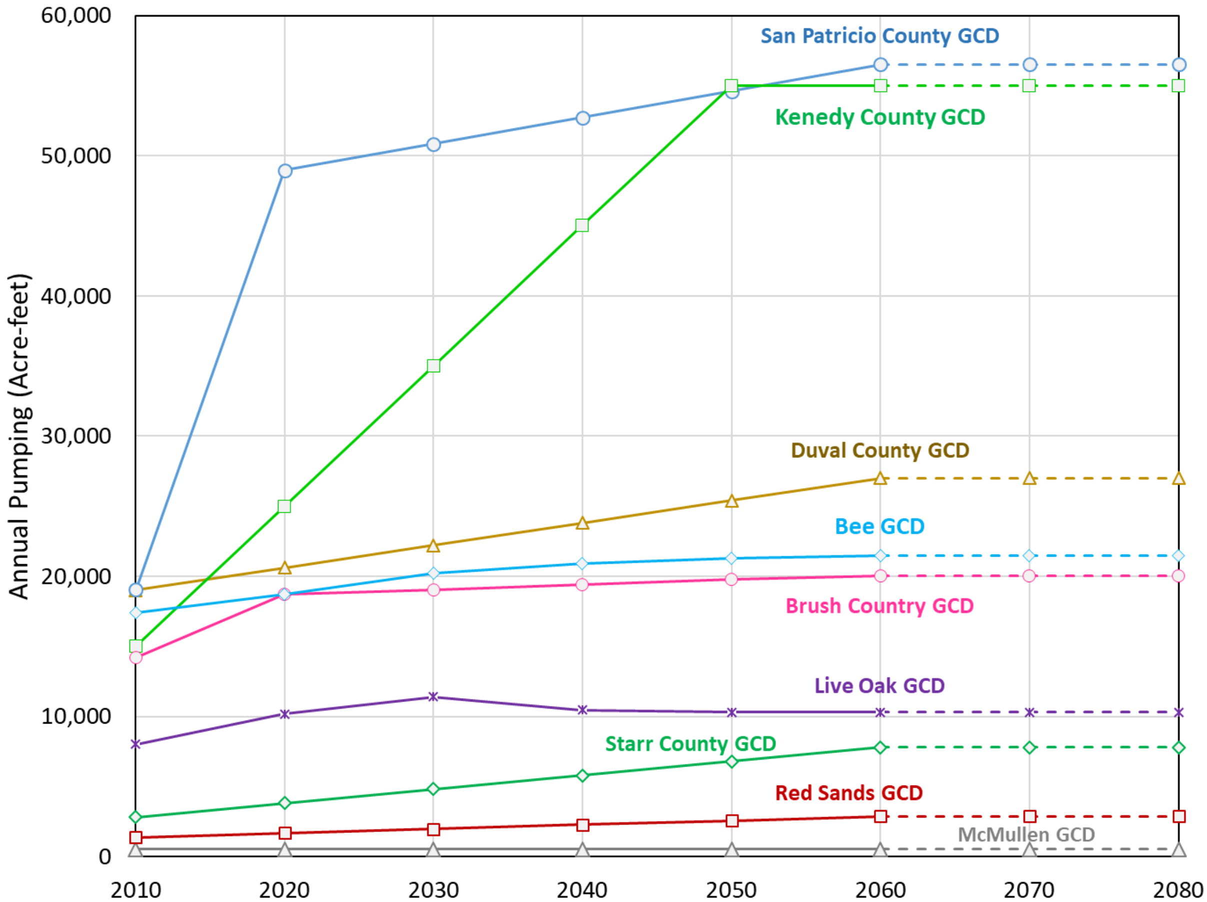

Figure 3-2 Pumping Scenario 1 with unchanged pumping extended from 2060 to 2080

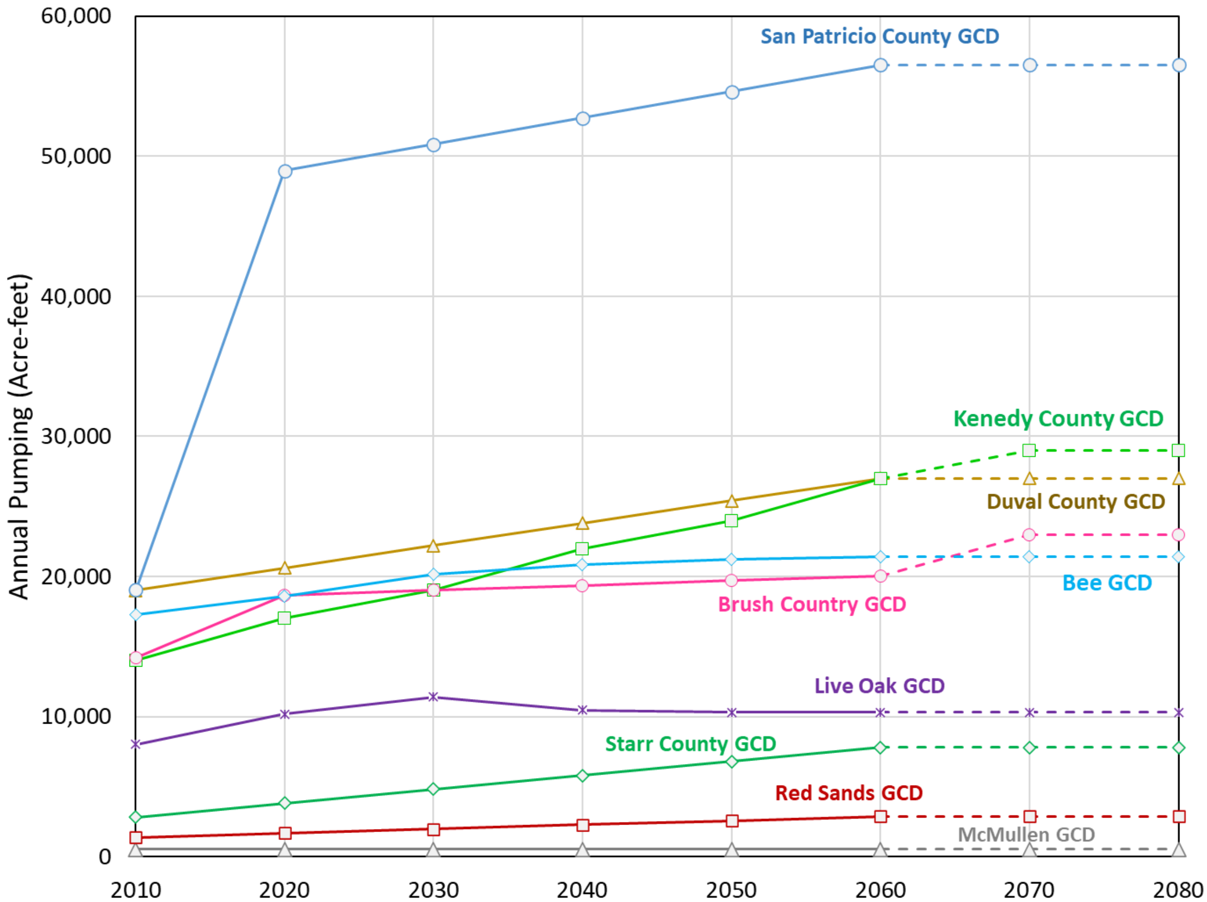

Figure 3-3 Pumping Scenario 2 with pumping updates extended from 2060 to 2080

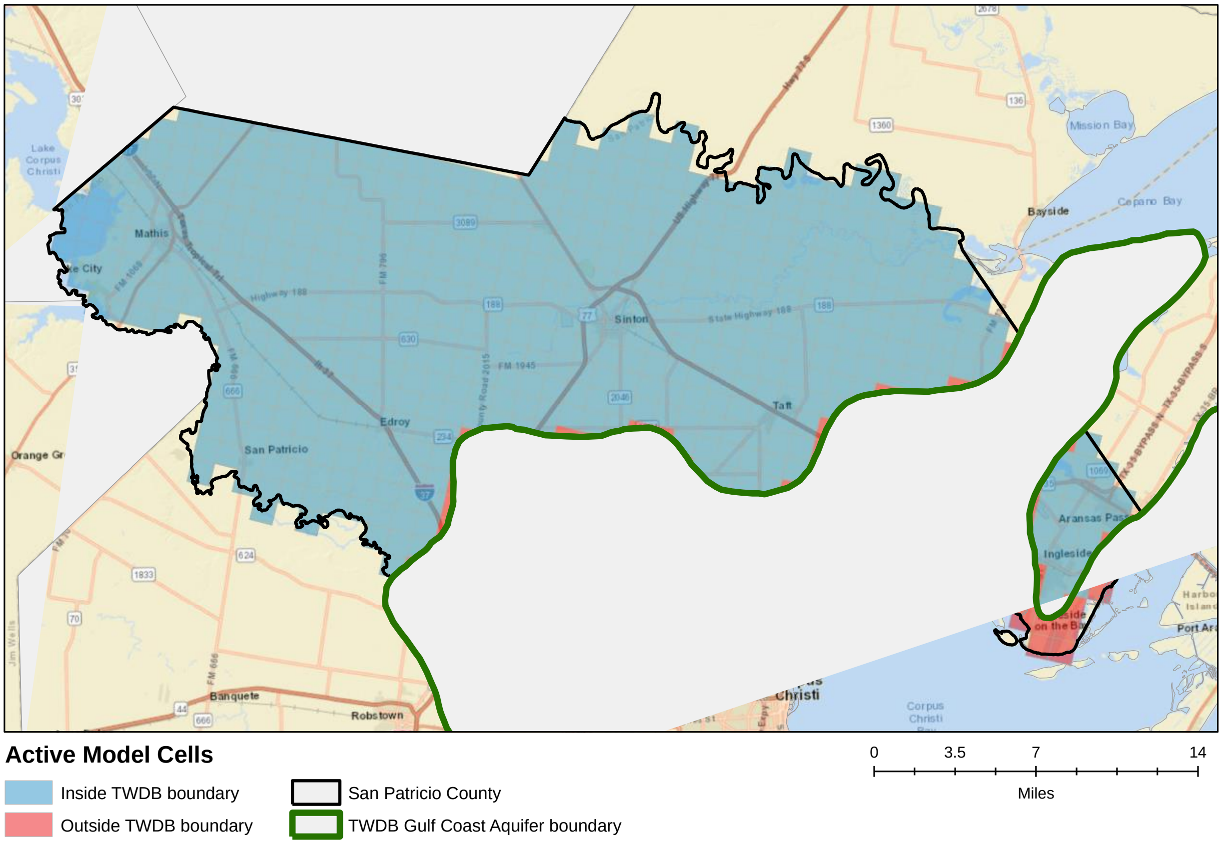

Figure 3-4 Map of San Patricio County showing the portions of the county are inside and outside of the TWDB official boundary for the Texas Gulf Coast Aquifer System

4.0 CONSIDERATION OF TEXAS WATER CODE NINE FACTORS

The following sections summarize the information that GMA 16 and each of its member districts used in its deliberations and discussions to evaluate the proposed DFCs with regard to the nine factors required by Texas Water Code Section 36.108(d).

4.1 Aquifer Uses and Conditions

Texas Water Code Section 36.108 (d)(1) requires that, during the joint-planning process, GCDs shall consider "aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another." In developing the proposed DFCs, GMA 16 and each of its member districts considered the following information regarding aquifer uses and conditions:

- Estimates of pumping from 2000 to 2017 from the TWDB Historical Groundwater Pumpage database from the Gulf Coast Aquifer and non-relevant aquifers.
- Estimates of Gulf Coast Aquifer pumping from 2000 to 2017 by use type from the TWDB Historical Groundwater Pumpage database.
- Groundwater monitoring data (aquifer water-level elevations and calculated drawdowns from 2000) from the TWDB Groundwater database for the years 2000 to 2019.

On January 28, 2020, INTERA discussed the information cite above in a titled "Groundwater Management Area 16 Joint Planning Cycle 2019-2022 : Aquifer Uses & Conditions" at the public GMA 16 Board meeting. This presentation is included as **Appendix G**. This information was used to evaluate baseline hydrogeologic conditions prior to the start of the seventy-year period being considered for the new DFC. In general, the Gulf Coast Aquifer in GMA 16 has not been as heavily developed as in other parts of the state and reported pumping in most counties appears either stable or in decline over the past 10 years. The monitoring well water level hydrographs are sparse across GMA 16, but in general do not indicate declining water levels in the period between 2000 and 2020. Several counties had individual wells with increasing water levels since 2000. However, in most counties, water levels appear essentially static, with water levels in most wells remaining within +/- 10 feet of 2000 water levels.

4.2 Water Supply Needs and Water Management Strategies

Texas Water Code Section 36.108 (d)(2) requires that, during the joint-planning process, GCDs shall consider "the water supply needs and water management strategies included in the state water plan." The State Water Plan is a combination of regional water plans created by regional planning groups across the state. Portions of GMA 16 fall within Regional Water Planning Areas M and N. For the current joint-planning process, GMA 16 relied on the draft 2021 Regional Water Plans for Region M (Rio Grande Valley), and Region N (Coastal Bend), as these were the most up-to-date estimates of future water needs and water management strategies within the GMA during the current joint planning process. GCD representatives from GMA 16 regularly attended the planning meetings for Regions M and N. In addition, the consultants from Regions M and N provided GMA 16 with in-person or written comments on the Regional Water Plan which improved the Board's understanding of this topic and provided insight for consideration during the DFC development process. GMA 16 and each of its member districts considered the following information regarding water supply needs and water management strategies:

- Existing Groundwater Supplies data from the draft 2021 Regional Water Plans
- Predicted Demand data from the draft 2021 Regional Water Plans
- Proposed Water Management Strategies (with groundwater source) data from the draft 2021 Regional Water Plans
- Future pumping estimates used in developing the proposed DFCs

On July 28, 2020, INTERA discussed the information cited above in a presentation titled "Groundwater Management Area 16 Joint Planning Cycle 2019-2022 : Water Supply Needs & Management Strategies" at the public GMA 16 Board meeting. This presentation is included as **Appendix H** In general, water demand is estimated to remain relatively stable in most counties, with 2070 demand remaining within 10 percent (%) of 2020 demand. The exceptions include McMullen and Willacy counties where demand is projected to decline 60 and 15% respectively, over this period. In addition, demand is projected to increase about 15% in Nueces County and a little over 20% in both Jim Wells and Kleberg counties. In counties where existing water supplies do not meet predicted demand, the Regional Water Plans provide Proposed Water Management Strategies to cover the deficit. While the GMA 16 counties in Region M (with the exception of Jim Hogg County) largely rely on non-groundwater Water Management Strategies, a majority of the new water supply for the GMA 16 counties in Region N is expected to come from increased groundwater production in the Gulf Coast Aquifer. The pumping scenario used to develop the proposed DFCs was evaluated against the Regional Water Plan and found to sufficiently account for both existing groundwater supplies and proposed water management strategies that use groundwater as a source.

4.3 Hydrologic Conditions within GMA 16

Texas Water Code Section 36.108 (d)(3) requires that, during the joint-planning process, GCDs shall consider "hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge." In developing the proposed DFCs, GMA 16 and each of its member districts considered the following information regarding hydrologic conditions within the GMA:

- Geology and hydrogeology of the four component hydrogeologic layers of the Gulf Coast Aquifer system: the Chicot Aquifer, Evangeline Aquifer, Burkeville Confining Unit, and the Jasper Aquifer.
- Total estimated recoverable storage (TERS) from the Gulf Coast Aquifer by county and GCD from the TWDB report GAM RUN 12-025 (Jigmond and Wade, 2013)
- Average annual recharge, inflows, and discharge from the Gulf Coast Aquifer by GCD from TWDB GAM run reports.
- Comparison of modeled pumping used to develop the DFCs to TERS and the average annual recharge, inflows and discharge calculations.

On July 28, 2020, INTERA discussed the information cite above in a presentation titled "Groundwater Management Area 16 Joint Planning Cycle 2019-2022: Hydrological Conditions" at the public GMA 16 Board meeting. This presentation is included as **Appendix I**.

4.3.1 Total Estimated Recoverable Storage

TWDB provided calculations of TERS by county and GCD in GMA 16 in Jigmond and Wade (2013). A copy of this report is included as **Appendix J**. The calculated TERS values by GCD are provided in **Table 4-1**.

The TERS is the amount of groundwater represented by recovery scenarios from 25 to 75% recovery of the total porosity-adjusted aquifer volume. As shown in Table 4-1, the TERS for GMA 16 ranges from approximately 251 to 752 million acre-feet of groundwater, or 25 and 75%, respectively, of the total storage volume of about one billion acre-feet.

The calculated TERS value is an estimate of physical availability and is considered during the DFC development process because it can be useful for illustrating the large volumes of groundwater in storage in a given aquifer. However, the TERS calculation relies on several simplifying assumptions that also factored into GMA 16's consideration of TERS. For instance, the TERS calculation does not distinguish between fresh and brackish or saline water and so can include water that is not fit for use without extensive treatment. The TERS calculation includes groundwater within the entire aquifer thickness and so can include water that is deep and not economically feasible to develop. The TERS calculation also does not take into account other pumping effects that the GMA has to consider during DFC development, such as spring flow or subsidence. In GMA 16, the calculated TERS value is much greater than the highest practicable level of groundwater production, and this is reflected in the pumping scenarios used for developing the proposed DFCs.

4.3.2 Average Annual Recharge, Inflows and Discharge

TWDB provided calculations of Annual Recharge, Inflow and Discharges for each GCD in the following GAM Run reports : GAM Run 17-015 (Bee GCD), GAM Run 17-001 (Brush Country GCD), GAM Run 18-012 (Corpus Christi ASRCD), GAM Run 16-011(Duval County GCD), GAM Run 16-009 (Kenedy County GCD), GAM Run 14-014 (Live Oak UWCD), GAM Run 17-011 (McMullen GCD), GAM Run 16-008 (Red Sands GCD), GAM Run 16-003 (San Patricio GCD), and GAM Run 18-016 (Starr County GCD). These inflows and outflows represent the average annual value in the over the historical period of 1980 to 2000. These values were calculated from the alternative numerical groundwater flow model for the Gulf Coast Aquifer in GMA 16 (Hutchison et al., 2011) for Brush Country GCD and Kenedy County GCD, from the southern portion of the Gulf Coast Aquifer GAM (Chowdhury and Mace, 2007) for Red Sands GCD and Starr County GCD, and from the central portion of the Gulf Coast Aquifer GAM (Chowdhury and others, 2004) for Bee GCD, Corpus Christi ASRCD, Live Oak UWCD, San Patricio GCD, Duval County GCD, and McMullen GCD.

While these groundwater models are the best tools to evaluate regional groundwater flow, it should be noted that there is inherent uncertainty to the calculation of inflows and outflows. The models are simplified with square mile grid cells and not necessarily calibrated to the degree needed to reliably quantify surface-groundwater interaction. During the discussion at the GMA 16 board meeting, inflows and outflows were compared to the minimum and maximum modeled pumping values from the pumping scenario used to develop the proposed DFCs. Based on this review, the GMA does not anticipate the implementation of the proposed DFCs to significantly impact the hydrological conditions of the GMA during the planning horizon.

Table 4-1 Total Estimated Recoverable Storage in GMA 16 by GCD (from Jigmond and Wade, 2013)

Groundwater Conservation District	Total Storage (acre-feet)	25% of Total Storage (acre-feet)	75% of total Storage (acre-feet)
Bee	25,000,000	6,250,000	18,750,000
Brush Country	150,000,000	37,500,000	112,500,000
Corpus Christi ASRCD	6,000,000	1,500,000	4,500,000
Duval County	45,000,000	11,250,000	33,750,000
Kenedy County	360,000,000	90,000,000	270,000,000
Live Oak	35,000,000	8,750,000	26,250,000
McMullen	2,100,00	525,000	1,575,000
Red Sands	3,100,000	775,000	2,325,000
San Patricio County	51,000,000	12,750,000	38,250,000
Starr County	15,000,000	3,750,000	11,250,000
No District	310,000,000	77,500,000	232,500,000
Total	**1,002,200,000**	**250,550,000**	**751,650,000**

4.4 Other Environmental Impacts Including Spring Flow and Other Interactions Between Groundwater and Surface Water

Texas Water Code §36.108 (d)(4) requires that, during the joint-planning process, districts shall consider "other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water." In developing the proposed DFCs, GMA 16 and each of its member districts considered the following information regarding other environmental impacts within the GMA:

- The physical mechanisms whereby groundwater pumping can cause impacts to the environment such as reduced flows to springs, reduced flows to streams, and lowering the water table
- Hydrological conditions associated with sea water intrusion
- How the GMA 16 GFM simulates surface water – groundwater interaction
- How the GMA 16 GFM simulates spring – groundwater interaction
- How the GMA 16 GFM simulates ocean – groundwater interaction

On October 27, 2020, INTERA discussed the information cited above in a presentation titled "Groundwater Management Area 16 Joint Planning Cycle 2019-2022 : Other Environmental Impacts" at the public GMA 16 Board meeting. This presentation is included as **Appendix K**. The presentation provides the simulated water budgets and water levels for Pumping Scenario #2, which is the set or pumping rates to develop the adopted DFCs in Table 2-1.

As discussed previously, the purpose of the GMA 16 GAM is to evaluate regional drawdown in support of developing DFCs. It may not be suited to adequately predict groundwater-surface water interaction in a quantitative fashion. Water budgets presented previously indicate that reduced water levels may affect streams in the GMA. However, GMA 16 anticipates that the pumping rates associated with the DFC scenario will not impact environmental conditions significantly during the planning horizon and would 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.

4.5 Subsidence

TWC 36.108 (d)(5) requires that, during the joint-planning process, GCDs shall consider “the impact on subsidence.” In developing the proposed DFCs, GMA 16 and each of its member districts considered the following information regarding subsidence within the GMA:

- Options for measuring land subsidence
- Physical mechanisms that cause land subsidence In
- Historical study of subsidence along the Texas Gulf Coast in Texas Department of Water Resources Report 272 (Ratzlaff, 1982)
- TWDB report Vulnerability of Texas Aquifers to Subsidence (Furnans and others, 2017)
- TWDB report Predictive Simulation Report: Lower Rio Grande Valley Groundwater Transport Model (Hutchison, 2017)
- Analysis of areas of high drawdown in GMA 16.

On July 28, 2020, INTERA discussed the information cited above in a presentation titled “Groundwater Management Area 16 Joint Planning Cycle 2019-2022: Consideration of Land Subsidence” at the public GMA 16 Board meeting. This presentation is included as **Appendix L**.

Dewatering of clay layers can lead to compaction and ultimately observable subsidence if significant dewatering continues over time. While subsidence due to pumping in the Gulf Coast Aquifer has been well-documented in other parts of the state, particularly Houston (see Kasmarek, 2013), subsidence has not historically been identified as an issue in GMA 16. But, because the Gulf Coast Aquifer in GMA 16 is similar to the strata in the Houston area, with multiple interlayered strata of clays and sands, the potential for subsidence was considered during DFC development.

Texas Department of Water Resources Report 272 (Ratzlaff 1982) provides a study of subsidence along the Texas Gulf Coast. The report does not document any significant subsidence between 1918 and 1975 in the counties of Jim Wells, Kleberg, Nueces, and San Patricio. The maximum measured subsidence between 1918 and 1951 in the area encompassing Brooks, Cameron, Kenedy, Hidalgo, and Willacy counties was only 0.42 ft, with 90% of the subsidence occurring before 1943. The only location in GMA 16 with more than 0.5 ft of land subsidence was in Saxet Oil and Gas field near western Corpus Christi where measured subsidence between 1942 and 1975 was 5.28 ft. This subsidence is likely due to historical oil and gas production, not groundwater pumping. In addition to the available measurements of land subsidence, the INTERA presentation discuss the results of two recent TWDB reports (Furnans and others, 2017; Hutchison, 2017) that provides methods for estimating land subsidence in GMA 16.

The largest long-term groundwater drawdowns (about 200 ft since the 1930s) measured in GMA 16 have occurred in Kleberg County, near Kingsville, TX. As there is no reported evidence of land subsidence in that area, it seems unlikely that land subsidence from groundwater pumping is currently a concern for the GMA. GCDs can address land subsidence through their management plans and groundwater rules, if so desired. Based on the considerations during this joint-planning session, no district proposed a DFC for land subsidence.

4.6 Socioeconomic Impacts

TWC 36.108 (d)(6) requires that, during the joint-planning process, GCDs shall consider "socioeconomic impacts reasonably expected to occur." The TWDB prepared reports on the socioeconomic impacts of not meeting the water needs identified for each of the Regional Water Planning Groups. The socioeconomic impact reports were prepared to support the development of the draft 2021 Regional Water Plans. In developing the proposed DFCs, GMA 16 and each of its member districts considered the following information regarding socioeconomic impacts within the GMA:

- An overview of the TWDB socioeconomic impact report for Region M and N for not meeting the identified water needs in the counties in GMA 16 with respect to sales income, tax revenue, jobs, population, and school enrollment
- The socio-economic impact was grouped according to the following grouping: irrigation, livestock, manufacturing, mining, municipal, and stream electric power
- Whether or not the proposed DFCs could impede the implementation of any proposed water management strategies that depend on groundwater

On October 27, 2020, INTERA presented this information in a presentation titled "Groundwater Management Area 16 Joint Planning Cycle 2019-2022: Socioeconomic Impact Consideration" at the public GMA 16 Board meeting. This presentation is included as **Appendix M**. The GMA considered the socioeconomic impact reports in developing their DFCs. GMA 16 evaluated the development of a DFC in the context of potentially not meeting the identified needs in Regions N and M because certain recommended water management strategies may not be possible.

Based on the groundwater production that occur in Pumping Scenario #2, GMA 16 determined that the anticipated DFCs based on Pumping Scenario #2 would not restrict implementation any of the proposed water management strategies in Region M or N. In addition, the GMA 16 found that any unmet water needs are principally due to TWDB MAG calculation methodology (which do not account for pumping outside of the TWDB official aquifer boundaries) and not because GMA 16 DFCs are overly restrictive.

4.7 Impact on Private Property Rights

The requirement that districts shall consider the socioeconomic impacts before voting on the DFCs of the aquifers was added to the statues of joint planning with the passage of Senate Bill 660 in 2011. As part of their continued efforts to meet the "balance test" described in Subsection 36.108 (d-2) of the TWC, GMA 16 has considered socioeconomic impacts for this third round of joint planning.

The potential socioeconomic impacts reasonably expected to occur due to DFCs were discussed in a GMA 16 meeting on July 18, 2020. GMA 16 discuss the INTERA presentation titled "Groundwater Management Area 16 Joint Planning Cycle: 2019-2022 Consideration of Private Property Rights." This presentation is included as **Appendix N**. GMA 16 held numerous meetings during the joint planning that provided opportunities for unrestricted public comment regarding socioeconomic impacts or the potential for them to occur. In this manner, district representatives were able to obtain stakeholder input from across GMA 16's geographical boundaries from a variety of interest areas such as recreation, real estate, commerce, irrigation and agriculture, political subdivisions, environmental groups, private property, tourism, cities, groundwater developers, river authorities and others. From a qualitative perspective, GMA 16 realizes that both positive and negative socioeconomic impacts may potentially result from the implementation of the proposed DFCs. In their deliberations while creating DFCs, district representatives aimed to achieve a balance of the positive and negative impacts.

GMA 16 considered the following socioeconomic considerations that would potentially have a positive impact upon the adoption of the proposed DFCs:

- Proposed DFCs in some areas of the GMA may reduce or eliminate the costs of lowering pumps and either deepening existing wells or constructing new wells.
- Proposed DFCs may serve to sustain or enhance economic growth due to assurances provided by diversified water portfolios.
- Proposed DFCs may result in a short-term reduction in utility rates due to reduction in cost of water management strategy implementation.

Comparatively, the following socioeconomic considerations were identified as potentially having a negative impact upon the adoption of the proposed DFCs:

- Proposed DFCs may require conversion of part or all of a supply to an alternative supply or supplies, which may have increased costs associated with infrastructure, operation and maintenance.
- Proposed DFCs in some areas of the GMA may result in significant but unquantified production cost increases due to continuing to lower water levels in wells.
- Proposed DFCs may result in a reduced groundwater supply being available on a long-term basis.
- Proposed DFCs may require the lowering of well pumps and/or the deepening of existing wells or constructing new wells.

4.8 Feasibility of Achieving the DFC

TWC 36.108 (d)(8) requires that GCDs, during the joint groundwater planning process, consider the feasibility of achieving the proposed DFC(s). This requirement was added to the joint groundwater planning process with the passage of Senate Bill 660 by the 82nd Texas Legislature in 2011. This review concept can be traced back to 2007, when the TWDB adopted rules that provided guidance for petitions contesting the reasonableness of an adopted DFC. Under these 2007 rules, the TWDB required that an adopted DFC must be physically possible from a hydrological perspective.

GMA 16 has deemed that the adopted DFCs are feasible based on two considerations. One consideration that the DFCs are physically possible from a hydrogeological perspective. The GMA 16 GFM has shown that the DFCs are physically compatible by generating the DFCs by running the GMA 16 GFM with the Pumping Scenario #2. The other consideration is that the DFCs are administratively feasible. In reviewing their respective DFCs, each GCD did not identify any administrative rule or policy that would prevent the GCD from achieving their DFCs.

4.9 Other Information

TWC 36.108 (d)(9) requires that, during the joint-planning process, GCDs shall consider "any other information relevant to the specific desired future conditions." The additional information considered by the GMA was initially discussed during the second round of joint planning but continued during the third round of joint planning. The additional information related to:

1. Region M water management strategy for groundwater desalination;
2. Investment backed expectations for private groundwater development in San Patricio County GCD;
3. Groundwater development for the City of Alice, Texas municipal water supply.

5.0 DISCUSSION OF OTHER DFCS CONSIDERED

TWC 36.108(d-3)(4) requires that, during the joint groundwater planning process, GCDs shall "list other desired future condition options considered, if any, and the reasons why those options were not adopted."

There were no other DFCs that were voted on during the current round of joint groundwater planning after the adopted DFCs were proposed during the March 26, 2021 meeting. There were, however, discussions on the methodology for calculating DFCs and modeled pumping within the GMA during the joint planning process. These methodologies were discussed at the January 28, 2020 GMA 16 meeting. In one variation, DFCs and MAG were calculated to include the area outside the official TWDB boundary of the Gulf Coast Aquifer. This was in response to concerns raised by the Region M Regional Water Planning Group that the current methodology ignores pumping in the Gulf Coast Aquifer outside the official TWDB boundary. Since this methodology change had little to no effect on DFCs, the GMA did not choose to adopt this alternative methodology.

6.0 POLICY JUSTIFICATION

The adoption of DFCs by GCDs, pursuant to the requirements and procedures set forth in TWC Chapter 36, is an important policy-making function. DFCs are planning goals that state a desired condition of the groundwater resources in the future in order to promote better long-term management of those resources. GCDs are authorized to utilize different approaches in developing and adopting DFCs based on local conditions and the consideration of other statutory criteria as set forth in TWC 36.108.

GMA 16 and each of its member districts evaluated DFCs with considerations to the nine factors required by TWC 36.108(d). In addition to these nine factors, GMA 16 and the individual districts evaluated DFCs with regard to providing a balance between the highest practicable level of groundwater production and the conservation, preservation, protection and recharging, and prevention of waste of groundwater in GMA 16. While much of this process was guided by scientific analysis including GAM simulations of future pumping scnearios, the actual creation of DFCs requires a blending of both science and policy. The incorporation of policy provides the ability to account for the limitations and uncertainty inherent in GAMs, and provide guidance for and define the bounds of what these scientific tools can reasonably be expected to accomplish.

In evaluating the DFCs, GMA 16 and the individual districts recognize that: (1) the production capability of the aquifers varies significantly across GMA 16, (2) historical groundwater production is significantly different across GMA 16, and (3) the importance of groundwater production to the social-economic livelihood of an area is significantly varied among the districts. As a result of this recognition, a key GMA 16 policy decision was to allow districts to set different DFCs for the portion of an aquifer within their boundaries, as long as the different DFCs could be shown to be compatible and physically possible. The allowance of different DFCs among the districts is justified for several reasons. First, TWC 36.108(d)(1) authorizes the adoption of different DFCs for different geographic areas over the same aquifer based on the boundaries of political subdivisions. The statute expressly and specifically directs GCDs "to consider uses or conditions of an *aquifer* within the management area, including conditions that differ substantially from one geographic area to another "when developing and adopting DFCs for:

1. Each aquifer, subdivision of an aquifer, or geologic strata located in whole or in part within the boundaries of the management area; or
2. Each geographic area overlying an aquifer in whole or in part or subdivision of an aquifer within the boundaries of the management area."

The Legislature's addition of the phrase "in whole or in part" makes it clear that GCDs may establish a "different" DFC for a geographic area that does not cover the entire aquifer but only part of that aquifer. Moreover, the plain meaning of the term "geographic area" in this context would include an area defined by political boundaries, such as those of a GCD or a county.

Secondly, GMA 16 is composed of several different GCDs, each of which manages a separate portion of the aquifer. By statute, GCDs cannot regulate outside of their district boundary, and the rules that they adopt to manage groundwater only apply within their boundaries. Therefore, GMA 16 recognized that separate DFCs had to be defined for each GCD within the GMA.

The only written public comment on the proposed DFCs, which were adopted, concerned Bee County GCD. The comments were discussed in the public GMA 16 meeting on September 21, 2021 and discussed in Section 1. These public comments were considered by Bee County GCD in their evaluation of the final DFCs. The DFCs that GMA 16 considered and proposed for final adoption provided acceptable drawdown levels in the various aquifers on a county-by county basis and across the entire GMA 16 area.

7.0 REFERENCES

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APPENDIX A
AGENAS AND MINUTES
TO GMA 16 MEETING

NOTICE OF OPEN MEETING

As required by section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 16 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 16: Bee GCD, Brush Country GCD, Live Oak UWCD, McMullen GCD, Kenedy County GCD, Corpus Christi Aquifer Storage and Recovery Conservation District, San Patricio GCD, Starr GCD, Duval GCD, and Red Sands GCD will be held on **Tuesday, September 24, 2019 at 1:00PM in the Brush County GCD Office, 732 West Rice St., Falfurrias, Texas.**

Discussion and Possible Action on the following agenda items:

1. Welcome and Introductions
2. Minutes of the previous meeting
3. Treasurer’s report
4. Review Petition Expenses paid by BCGCD in August
5. Report from TWDB
6. Consultant Report
7. TCEQ Petition for Inquiry
8. District members and public members discussion
9. Set date for next meeting.
10. Future agenda items.
11. Adjournment.

Lonnie Stewart, Vice-Chairman Groundwater Management Area 16

For more information, please contact me at louwcd@yahoo.com or 361-449-7017.

GMA-16 Joint Planning Committee
Brush Country GCD Building
732 W. Rice St.
Falfurrias, TX
Sept. 24, 2019

Minutes

1. Lonnie Stewart(Live Oak) declared a quorum and called the meeting to order at 1:05 p.m. Attendees were self-introduced.

Members present: Kenedy County(Andy Garza), Brush Country(Felix Saenz, Bill Dugat, Jesse Howell), Red Sands (Armando Vela), McMullen(Lonnie Stewart), Bee(Lonnie Stewart), Reyna Guerra(Starr County) and Steve Ramos(Corpus Christi ARSCD)

Guests present: See attached sign-in sheet

2. Andy Garza moved and Steve Ramos seconded the motion to approve minutes of the March 19, 2019 meeting as presented. Motion carried.

3. Lonnie Stewart presented the Treasurer's report. The current balance is $49,575.96 which includes an outflow of $2492.54. The San Patricio GCD is paying in installments.

Armando Vela moved and Andy Garza seconded the motion to approve the Treasurer's report as presented. Motion carried.

4. Felix Saenz reported that the Brush Country GCD had paid Bill Dugat $2,952.00 for work done on the Starr County GCD petition of inquiry submitted the TCEQ by GMA-16. Saenz asked for reimbursement from GMA-16.

Andy Garza moved and Felix Saenz seconded the motion to have GMA-16 reimburse the Brush Country GCD in the amount of $2,952.00 for services provided by Bill Dugat to GMA-16. Motion carried.

5. Jean Perez, TWDB representative, reported that the TWDB has many published reports from the past that it would like to distribute to the appropriate GCDs. Perez informed the committee that Rebecca Storms is now leading the groundwater monitoring section at the TWDB.

6. Jevon Harding, hydrologist with Intera, provided the committee with an update on work that has been done for the next DFC cycle. Harding covered in detail the results of the survey conducted by Intera on issues pertinent to the DFC.

Harding asked that GMA-16 members submit their updated pumping values to her within the 30 days.

7. Bill Dugat provided an update on the Petition of Inquiry relative to the Starr County GCD that GMA-16 has filed with the TCEQ. Dugat reported that the ED of TCEQ has recommended granting the petition and that a review panel has been named. At either their Oct. 9, 2019 or the Oct. 24, 2019 meeting, the TCEQ will officially grant the petition. Dugat recommended that someone from GMA-16 should attend that meeting.

Reyna Guerra, representing the Starr County GCD, informed the committee that the Starr County GCD is making an honest effort to get back on track with its operation and participation in GMA-16. The Starr County GCD will have an opportunity to make its case before the review panel in the near future.

8. Bill Dugat reported that GMA-15 had requested an update on the Petition of Inquiry that has been filed relative to the Starr County GCD. Lonnie Stewart volunteered to attend the next meeting of GMA-15 and provide the update.

9. The next GMA-16 meeting was tentatively scheduled for January 28, 2020 in Falfurrias, TX.

10. Future agenda items should be submitted to Lonnie Stewart.

11. Andy Garza moved and Armando Vela second the motion to adjourn meeting at 3:00 PM. Motion carried.

NOTICE OF OPEN MEETING

As required by section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 16 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 16: Bee GCD, Brush Country GCD, Live Oak UWCD, McMullen GCD, Kenedy County GCD, Corpus Christi Aquifer Storage and Recovery Conservation District, San Patricio GCD, Starr GCD, Duval GCD, and Red Sands GCD will be held on **Tuesday, January 28, 2020 at 1:00PM in the Brush County GCD Office, 732 West Rice St., Falfurrias, Texas.**

Discussion and Possible Action on the following agenda items:

1. Welcome and Introductions
2. Minutes of the previous meeting
3. Treasurer's report
4. Update on Petition for Starr County GCD
5. Report from TWDB
6. Consultant Report
7. District members and public members discussion
8. Set date for next meeting.
9. Future agenda items.
10. Adjournment.

Lonnie Stewart, Vice-Chairman Groundwater Management Area 16

For more information, please contact me at louwcd@yahoo.com or 361-449-7017.

GMA-16 Joint Planning Committee
Brush Country GCD Building
732 W. Rice St.
Falfurrias, TX
January 28, 2020

Minutes

1. Scotty Bledsoe(Live Oak) declared a quorum and called the meeting to order at 1:05 p.m. Attendees were self-introduced.

Members present: Kenedy County(Andy Garza), Brush Country(Felix Saenz, Bill Dugat), Red Sands (Armando Vela), McMullen(Lonnie Stewart), Bee(Lonnie Stewart), Starr County(Reyna Guerra, Tom Koeneke), Duval County(George Gonzalez) and Corpus Christi ARSCD(Steve Ramos).

Guests present: See attached sign-in sheet

2. Andy Garza moved and Armando Vela seconded the motion to approve minutes of the Sept. 24, 2019 meeting as presented. Motion carried.

3. Lonnie Stewart presented the Treasurer's report. The current balance is $49,623.96 which includes an outflow of $5,444.54 of which $5,352.00 was to cover legal fees associated with the Petition for Inquiry on the Starr County GCD. Stewart also reported that GMA-16 had received a bill from Intera for consultant services in the amount of $8,000.00 and recommended that it be paid.

Steve Ramos moved and Lonnie Stewart seconded the motion to approve the Treasurer's report as presented and pay the bill from Intera. Motion carried.

4. Andy Garza reported that the Review Panel assigned to the Petition of Inquiry on Starr County GCD had held a meeting on January

7, 2020 in Rio Grande City , TX to gather evidence for a report that will be submitted to the TCEQ prior to February 13, 2020. Overall, Garza reported that Dirk Aaron, chairman of the Review Panel, had conducted a positive and informative meeting.

Tom Koeneke, Starr County GCD member, stated that since the Review Panel meeting was held, the Starr County GCD had made progress in various areas of district management. Koeneke also confirmed that the next meeting of the Review Panel would be held on February 13, 2020 in Austin, TX most likely.

5. Jean Perez, TWDB representative, reported that the TWDB had posted socioeconomic data pertinent to the Explanatory Report on its website. Perez suggested that GMAs should start thinking about the possibility of formulating a DFC for fresh groundwater and brackish groundwater.

John Meyer, TWDB hydrologist, reported that the TWDB was currently working on procedural rules to address the needs in HB 30 and HB 722. Meyer stated that the TWDB will be filling a position to work on brackish groundwater production permits.

6. Jevon Harding, hydrologist with Intera, reviewed, in detail, the results of the preliminary model results for the joint planning cycle 2019-2022. Harding informed the committee that the MAG excludes pumping from the Burkeville confining unit and pumping from outside the official TWDB Gulf Coast aquifer boundary, but, includes pumping includes pumping in cells that go dry. Harding also pointed out that as for the DFC, drawdown is based on pumping in wet cells only. Harding reminded the committee members that they need to submit changes to their pumping values as soon as possible.

Harding gave a presentation that covered the component of aquifer uses and conditions of the Explanatory Report.

7. Stephanie Moore, consultant with Black & Veatch, reviewed the draft MAGs and DFCs for the counties that are in GMA-16 and also in Region M.

Andy Garza and Mary Sahs, legal counsel for the Kenedy County GCD, informed the committee that the Kenedy County GCD is currently in the process to establish brackish groundwater production rules.

8. The next GMA-16 meeting was tentatively scheduled for April 28, 2020 in Falfurrias, TX.

9. Future agenda items should be submitted to Lonnie Stewart.

10. Andy Garza moved and Reyna Guerra second the motion to adjourn meeting at 3:50 PM. Motion carried.

NOTICE OF OPEN MEETING

An urgent public necessity exists requiring the Groundwater Management Area (GMA) 16 Planning Committee to alter its meeting procedures due to COVID-19 pandemic. Notice is hereby given, as required by Texas Water Code section 36.108(e), that a meeting of the GMA 16 Planning Committee, comprised of delegates (GMA delegates) from the following groundwater conservation districts located wholly or partially within GMA 16: Bee GCD, Brush Country GCD, Live Oak UWCD, McMullen GCD, Kenedy County GCD, Corpus Christi Aquifer Storage and Recovery Conservation District, San Patricio GCD, Starr GCD, Duval GCD, and Red Sands GCD will be held Tuesday, July 28, 2020 at 1:00PM in the Brush County GCD Office, 732 West Rice St., Falfurrias, Texas. A quorum of the GMA delegates may be present in person at the physical location or may participate via audio and video conference call. Likewise, members of the public may participate in person at the physical location or via audio or videoconference call. The meeting will be conducted pursuant to Texas Government Code, Sections 551.125, 551.127 and 551.131, and as modified by the Governor of Texas who ordered suspension of various provisions of the Open Meetings Act, Chapter 551, Government Code, effective March 16, 2020, in accordance with the Texas Disaster Act of 1975 (see the Governor's proclamation on March 13, 2020 as renewed, certifying that the COVID-19 pandemic poses an imminent threat of disaster and declaring a state of disaster for all counties in Texas). The audio and videoconference information for the GMA delegates and public to participate in the meeting described below follows the Governor's guidance for conducting a public meeting and ensures public accessibility. The GMA delegates and members of the public not attending in person may call in or participate via videoconference as follows:

GMA 16 July 28,2020
Tue, Jul 28, 2020 1:00 PM - 4:00 PM (CDT)

Please join my meeting from your computer, tablet or smartphone.

https://global.gotomeeting.com/join/243461901

You can also dial in using your phone.
(For supported devices, tap a one-touch number below to join instantly.)

United States: +1 (408) 650-3123
- One-touch: tel:+14086503123,,243461901# Access Code: 243-461-901

This meeting will be recorded and the recording will be available on the Brush Country Groundwater Conservation District's website www.brushcountrygcd.com after the meeting. A copy of the agenda packet for this meeting will be available on the Brush Country Groundwater Conservation District's website www.brushcountrygcd.com at the time of the meeting.

Discussion and Possible Action on the following agenda items:

1. Welcome and Introductions
2. Minutes of the previous meeting
3. Treasurer's report
4. Report from TWDB
5. Consultant Report
6. Update from Starr County GCD on petition
7. District members and public members discussion
8. Set date for next meeting.
9. Future agenda items.
10. Adjournment.

Lonnie Stewart, Vice-Chairman Groundwater Management Area 16

Lonnie Stewart

For more information, please contact me at louwcd@yahoo.com or 361-449-7017.

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GMA-16 Joint Planning Committee
Brush Country GCD Building
732 W. Rice St.
Falfurrias, TX
July 28, 2020

Minutes

1. Scotty Bledsoe(Live Oak) declared a quorum and called the meeting to order at 1:05 p.m. Attendees attended in person or via virtual conference.

Members present: Kenedy County(Andy Garza), Brush Country(Felix Saenz, Louie Pena), McMullen(Lonnie Stewart), Bee(Lonnie Stewart), San Patricio County(Lonnie Stewart), Starr County(Reyna Guerra), Duval County(George Gonzalez) and Corpus Christi ARSCD(Steve Ramos).

Guests present: See attached sign-in sheet

2. Andy Garza moved and Felix Saenz seconded the motion to approve minutes of the January 28, 2020 meeting as presented. Motion carried.

3. Lonnie Stewart presented the Treasurer's report and stated that the current balance is $37,590.92. Stewart also reported that GMA-16 had received a bill from Intera for consultant services in the amount of $5,365.00 and recommended that it be paid.

Lonnie Stewart moved and Felix Sarnz seconded the motion to approve the Treasurer's report as presented and pay the bill from Intera in the amount of $5,365.00. Motion carried.

4. Jean Perez, TWDB representative, reported that the TWDB had been compiling a checklist for Desired Future Condition packets that will be submitted by the GMA regions between now and May, 2021.

Kathleen Jackson, TWDB board member, reported that the TWDB was doing as much as can be done despite the pandemic.

5. Consultant Report: Consideration of factors for Explanatory Report

Jevon Harding, hydrologist with Intera, described, in detail, the hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows and discharge. In another report, Harding described the water supply needs and water management strategies included in the state water plan as they apply to each GCD in GMA-16.

Steve Young, hydrologist with Intera, reviewed the causes of land subsidence, measurement of land subsidence, factors affecting land subsidence, aquifer compressibility, simplified equations for predicting land subsidence, TWDB reports on land subsidence predictions and evidence of land subsidence in GMA-16. In another report, Young reviewed chapters 36.002 and 36.108 of the Texas Water Code as they relate to ownership of groundwater and private property rights.

6. Reyna Guerra gave a report on the status of Starr County GCD as it relates to the petition that was approved by the TCEQ. Due to technical difficulties, it was hard to understand everything that was reported.

7. There was nothing to report under this item.

8. The next meeting tentatively will be held on October 27, 2020.

9. Future agenda items should be submitted to Lonnie Stewart.

10. Andy Garza moved and Lonnie Stewart second the motion to adjourn meeting at 3:00 PM. Motion carried.

GMA-16 Joint Planning Committee
Brush Country GCD Building
732 W. Rice St.
Falfurrias, TX
October 27, 2020

Minutes

1. Scotty Bledsoe (Live Oak) declared a quorum and called the meeting to order at 1:05 p.m. Attendees attended in person or via virtual conference.

Members present: Kenedy County (Andy Garza), Brush Country (Felix Saenz, Louie Pena), McMullen (Lonnie Stewart), Bee (Lonnie Stewart), San Patricio County (Charles Ring), Starr County (Tom Koeneke), Duval County (George Gonzalez) and Red Sands GCD (Armando Vela).

Guests present: See attached sign-in sheet

2. Lonnie Stewart moved and Andy Garza seconded the motion to approve minutes of the July 28, 2020 meeting as presented. Motion carried.

3. Lonnie Stewart presented the Treasurer's report and stated that the current balance is $32,225.92 and does not include the latest bill from Intera which is $10,122.30. Stewart recommended that the bill from Intera be paid today.

Lonnie Stewart moved and Felix Saenz seconded the motion to approve the Treasurer's report as presented and pay the bill from Intera in the amount of $10,122.30. Motion carried.

4. Jean Perez, TWDB representative, reported that Andy Weinberg had replaced Chuck Crawford for the position that maintains well recorders. Perez stated that spring flow measurements will start in early 2021.

Kathleen Jackson, TWDB board member, reported that the TWDB had completed the initial flood plan for Texas and thanked all joint planning committee members for their efforts

5. Consultant Report: Consideration of factors for Explanatory Report

Steve Young, hydrologist with Intera, made a powerpoint presentation on Environmental Impacts which covered interactions between groundwater and streams, springs and oceans. Young also reviewed the water budgets for most of the member districts.

Young then proceeded with a powerpoint presentation on Socioeconomic Impacts that covered the social and economic impacts of not meeting identified water needs in the GMA and the socioeconomic impacts reasonably expected to occur due to DFC adoption.

Young informed the committee that Intera would have a draft copy of the Explanatory Report available at the next meeting.

6. Dr. Venki Uddameri, consultant with the Kenedy County GCD, made a presentation on the conceptual model of the groundwater availability model (GMA) that is being developed by the TWDB. Uddemeri discussed the strengths and weaknesses of the proposed GAM and will be providing comments to the TWDB on behalf of the Kenedy County GCD.

7. Tom Koeneke, Starr County GCD director, reported on the quarterly reports that his GCD has been submitting to the TCEQ to comply with the orders issued as a result of the petition of inquiry that was completed in early 2020. Koeneke also stated that the Starr County GCD had entered in an MOU with Starr County that will provide financial assistance through 2021.

8. There was nothing to report.

9. The next meeting was tentatively set for January 26, 2021.

10. Lonnie Stewart moved and Felix Saenz second the motion to adjourn meeting at 3:00 PM. Motion carried.

NOTICE OF OPEN MEETING

An urgent public necessity exists requiring the Groundwater Management Area (GMA) 16 Planning Committee to alter its meeting procedures due to COVID-19 pandemic. Notice is hereby given, as required by Texas Water Code section 36.108(e), that a meeting of the GMA 16 Planning Committee, comprised of delegates (GMA delegates) from the following groundwater conservation districts located wholly or partially within GMA 16: Bee GCD, Brush Country GCD, Live Oak UWCD, McMullen GCD, Kenedy County GCD, Corpus Christi Aquifer Storage and Recovery Conservation District, San Patricio GCD, Starr GCD, Duval GCD, and Red Sands GCD will be held **Tuesday, October 27, 2020 at 1:00PM** in the Brush County GCD Office, 732 West Rice St., Falfurrias, Texas. A quorum of the GMA delegates may be present in person at the physical location or may participate via audio and video conference call. Likewise, members of the public may participate in person at the physical location or via audio or videoconference call. The meeting will be conducted pursuant to Texas Government Code, Sections 551.125, 551.127 and 551.131, and as modified by the Governor of Texas who ordered suspension of various provisions of the Open Meetings Act, Chapter 551, Government Code, effective March 16, 2020, in accordance with the Texas Disaster Act of 1975 (see the Governor's proclamation on March 13, 2020 as renewed, certifying that the COVID-19 pandemic poses an imminent threat of disaster and declaring a state of disaster for all counties in Texas). The audio and videoconference information for the GMA delegates and public to participate in the meeting described below follows the Governor's guidance for conducting a public meeting and ensures public accessibility. The GMA delegates and members of the public not attending in person may call in or participate via videoconference as follows:

GMA 16 October 27, 2020
Tue, October 27, 2020 1:00 PM - 4:00 PM (CDT)

Please join my meeting from your computer, tablet or smartphone.

https://global.gotomeeting.com/join/509172069

You can also dial in using your phone.
(For supported devices, tap a one-touch number below to join instantly.)

United States: +1 (571) 317-3122
- One-touch: tel:+15713173122,,509172069#

Access Code: 509-172-069

This meeting will be recorded and the recording will be available on the Brush Country Groundwater Conservation District's website www.brushcountrygcd.com after the meeting. A copy of the agenda packet for this meeting will be available on the Brush Country Groundwater Conservation District's website www.brushcountrygcd.com at the time of the meeting.

Discussion and Possible Action on the following agenda items:

1. Welcome and Introductions
2. Minutes of the previous meeting
3. Treasurer's report
4. Report from TWDB
5. Consultant/ Explanatory Report
6. GAM Model for GMA 15 and 16
7. Update from Starr County GCD on compliance with TCEQ order
8. District members and public members discussion
9. Set date for next meeting.
10. Future agenda items.
11. Adjournment.

Lonnie Stewart, Vice-Chairman Groundwater Management Area 16

Lonnie Stewart

For more information, please contact me at louwcd@yahoo.com or 361-449-7017.

NOTICE OF OPEN MEETING

An urgent public necessity exists requiring the Groundwater Management Area (GMA) 16 Planning Committee to alter its meeting procedures due to COVID-19 pandemic. Notice is hereby given, as required by Texas Water Code section 36.108(e), that a meeting of the GMA 16 Planning Committee, comprised of delegates (GMA delegates) from the following groundwater conservation districts located wholly or partially within GMA 16: Bee GCD, Brush Country GCD, Live Oak UWCD, McMullen GCD, Kenedy County GCD, Corpus Christi Aquifer Storage and Recovery Conservation District, San Patricio GCD, Starr GCD, Duval GCD, and Red Sands GCD will be held **Thursday, January 28, 2021 at 1:00PM** in the Brush County GCD Office, 732 West Rice St., Falfurrias, Texas. A quorum of the GMA delegates may be present in person at the physical location or may participate via audio and video conference call. Likewise, members of the public may participate in person at the physical location or via audio or videoconference call. The meeting will be conducted pursuant to Texas Government Code, Sections 551.125, 551.127 and 551.131, and as modified by the Governor of Texas who ordered suspension of various provisions of the Open Meetings Act, Chapter 551, Government Code, effective March 16, 2020, in accordance with the Texas Disaster Act of 1975 (see the Governor's proclamation on March 13, 2020 as renewed, certifying that the COVID-19 pandemic poses an imminent threat of disaster and declaring a state of disaster for all counties in Texas). The audio and videoconference information for the GMA delegates and public to participate in the meeting described below follows the Governor's guidance for conducting a public meeting and ensures public accessibility. The GMA delegates and members of the public not attending in person may call in or participate via videoconference as follows:

GMA 16 Thursday January 28, 2021
Thursday January 28, 2021 1:00 PM - 4:00 PM (CDT)

Please join my meeting from your computer, tablet or smartphone.

https://global.gotomeeting.com/join/823969469

You can also dial in using your phone.
(For supported devices, tap a one-touch number below to join instantly.)

United States: +1 (872) 240-3212
- One-touch: tel:+18722403212,,823969469#

Access Code: 823-969-469

This meeting will be recorded and the recording will be available on the Brush Country Groundwater Conservation District's website www.brushcountrygcd.com after the meeting. A copy of the agenda packet for this meeting will be available on the Brush Country Groundwater Conservation District's website www.brushcountrygcd.com at the time of the meeting.

Discussion and Possible Action on the following agenda items:

1. Welcome and Introductions
2. Minutes of the previous meeting
3. Treasurer's report
4. Report from TWDB
5. Consultant/ Explanatory Report
6. Update from Starr County GCD on compliance with TCEQ order
7. District members and public members discussion
8. Set date for next meeting.
9. Future agenda items.
10. Adjournment.

Lonnie Stewart, Vice-Chairman Groundwater Management Area 16

Lonnie Stewart

For more information, please contact me at louwcd@yahoo.com or 361-449-7017.

GMA-16 Joint Planning Committee
Brush Country GCD Building
732 W. Rice St.
Falfurrias, TX
January 28, 2021

Minutes

1. Scotty Bledsoe (Live Oak) declared a quorum and called the meeting to order at 1:05 p.m. Attendees attended in person or via virtual conference.

Members present: Kenedy County (Andy Garza), Brush Country (Louie Pena, Bill Dugat), McMullen (Lonnie Stewart), Bee (Lonnie Stewart), San Patricio County (Charles Ring), Starr County (Reyna Guerra), Duval County (George Gonzalez), Red Sands GCD (Armando Vela) and Steve Ramos(Corpus Christi ASRD)

Guests present: See attached sign-in sheet

2. Lonnie Stewart moved and Andy Garza seconded the motion to approve minutes of the October 27, 2020 meeting as presented. Motion carried.

3. Lonnie Stewart presented the Treasurer's report that showed a current balance of $22,103.62 for GMA-16 with no pending bills.

Andy Garza moved and Louie Pena seconded the motion to approve the Treasurer's report as presented. Motion carried.

4. Jean Perez, TWDB representative, reported on the following: 1) all regional water plans have been approved, 2) TWDB will allow amending designated brackish groundwater production zones, 3) ASR study had been completed and 4) applications for agriculture grants are due on February 10, 2021.

5. Consultant Report/ Explanatory Report

Steve Young, hydrologist with Intera, reviewed the following with his powerpoint presentation: 1) DFC model simulations with pumping scenarios #1 and #2, 2) average drawdowns for pumping scenario #2, 3) joint planning requirements, 4) flowchart of DFC and MAG process and 5) explanatory report progress.

6. Reyna Guerra, Starr County GCD board member, reported that the Starr County GCD was current with the orders issued by TCEQ relative to the petition for inquiry.

7. Reyna Guerra stated that the Starr County GCD will be receiving training from the Texas Water Development Board. Training is being coordinated by Steve Allen.

8. The next meeting was tentatively set for March 23, 2021.

9. Scotty Bledsoe reminded members to submit agenda items for the next meeting to Lonnie Stewart or Andy Garza.

10. Louie Pena moved and George Gonzalez second the motion to adjourn meeting at 1:40 PM. Motion carried.

NOTICE OF OPEN MEETING

An urgent public necessity exists requiring the Groundwater Management Area (GMA) 16 Planning Committee to alter its meeting procedures due to COVID-19 pandemic. Notice is hereby given, as required by Texas Water Code section 36.108(e), that a meeting of the GMA 16 Planning Committee, comprised of delegates (GMA delegates) from the following groundwater conservation districts located wholly or partially within GMA 16: Bee GCD, Brush Country GCD, Live Oak UWCD, McMullen GCD, Kenedy County GCD, Corpus Christi Aquifer Storage and Recovery Conservation District, San Patricio GCD, Starr GCD, Duval GCD, and Red Sands GCD will be held **Tuesday, March 23, 2021 at 1:00PM** in the Brush County GCD Office, 732 West Rice St., Falfurrias, Texas. A quorum of the GMA delegates may be present in person at the physical location or may participate via audio and video conference call. Likewise, members of the public may participate in person at the physical location or via audio or videoconference call. The meeting will be conducted pursuant to Texas Government Code, Sections 551.125, 551.127 and 551.131, and as modified by the Governor of Texas who ordered suspension of various provisions of the Open Meetings Act, Chapter 551, Government Code, effective March 16, 2020, in accordance with the Texas Disaster Act of 1975 (see the Governor's proclamation on March 13, 2020 as renewed, certifying that the COVID-19 pandemic poses an imminent threat of disaster and declaring a state of disaster for all counties in Texas). The audio and videoconference information for the GMA delegates and public to participate in the meeting described below follows the Governor's guidance for conducting a public meeting and ensures public accessibility. The GMA delegates and members of the public not attending in person may call in or participate via videoconference as follows:

GMA 16 Planning Committee
Tue, Mar 23, 2021 1:00 PM - 4:00 PM (CDT)

Please join my meeting from your computer, tablet or smartphone.

https://global.gotomeeting.com/join/191628533

You can also dial in using your phone.
(For supported devices, tap a one-touch number below to join instantly.)

United States: +1 (872) 240-3212
- One-touch: tel:+18722403212,,191628533#

Access Code: 191-628-533

This meeting will be recorded and the recording will be available on the Brush Country Groundwater Conservation District's website www.brushcountrygcd.com after the meeting. A copy of the agenda packet for this meeting will be available on the Brush Country Groundwater Conservation District's website www.brushcountrygcd.com at the time of the meeting.

Discussion and Possible Action on the following agenda items:

1. Welcome and Introductions
2. Minutes of the previous meeting
3. Treasurer's report
4. Report from TWDB
5. Consultant/ Explanatory Report
6. Adopt Proposed Desired Future Condition
7. Update from Starr County GCD on compliance with TCEQ order
8. District members and public members discussion
9. Set date for next meeting.
10. Future agenda items.
11. Adjournment.

Lonnie Stewart, Vice-Chairman Groundwater Management Area 16

Lonnie Stewart

For more information, please contact me at louwcd@yahoo.com or 361-449-7017.

GMA-16 Joint Planning Committee
Brush Country GCD Building
732 W. Rice St.
Falfurrias, TX
March 23, 2021

Minutes

1. **Scotty Bledsoe (Live Oak) declared a quorum and called the meeting to order at 1:05 p.m. Attendees attended in person or via virtual conference.**

Members present: Kenedy County (Andy Garza), Brush Country (Louie Pena, Bill Dugat), McMullen (Lonnie Stewart), Bee (Lonnie Stewart), San Patricio County (Charles Ring), Starr County (Reyna Guerra), Duval County (George Gonzalez) and Red Sands GCD (Armando Vela).

Guests present: See attached sign-in sheet

2. **Andy Garza moved and Lonnie Stewart seconded the motion to approve minutes of the January 28, 2021 meeting as presented. Motion carried.**

3. **Lonnie Stewart presented the Treasurer's report that showed a current balance of $17,743.62 for GMA-16 with no pending bills.**

Louie Pena moved and George Gonzalez seconded the motion to approve the Treasurer's report as presented. Motion carried.

4. **There was no one from the TWDB to give a report.**

5. **Consultant Report/ Explanatory Report**

Steve Young, hydrologist with Intera, reviewed the flowchart of the Desired Future Conditions to Modeled Available Groundwater process as dictated by the TWDB. According to Young, the proposed DFCs

must be adopted by May 1, 2021 and finally adopted by January 5, 2022.

Young proceeded to review the average drawdowns from pumping scenario #2 for each of the GCDs in GMA-16. The Brush Country GCD and the Bee GCD informed Steve Young that average drawdowns for non-district areas in their GCDs were not shown. Young responded that those discrepancies would be noted and corrected.

6. Scotty Bledsoe moved and Andy Garza seconded the motion; the motion passed unanimously to adopt the proposed Desired Future Conditions as presented by Steve Young with the corrections requested by the Brush Country and Bee GCDs

7. Reyna Guerra, Starr County GCD director, reported that the Starr County GCD is in compliance with all orders from TCEQ and that its management plan has been revised and submitted the TWBD. Guerra indicated that the directors of the Starr County GCD will be receiving individual online training from the TWDB.

8. Bill Dugat, legal counsel for the Brush Country GCD, informed the committee that the required 90 day comment period begins when the GCD receives the proposed DFC. Lonnie Stewart stated that he would be mailing the proposed DFCs within the next few days.

9. The next meeting was tentatively set for September 28, 2021.

10. Scotty Bledsoe reminded members to submit agenda items for the next meeting to Lonnie Stewart or Andy Garza.

11. Andy Garza moved and George Gonzalez second the motion to adjourn meeting at 1:40 PM. Motion carried.

GMA-16 Joint Planning Committee
Brush Country GCD Building
732 W. Rice St.
Falfurrias, TX
Sept. 21, 2021

Minutes

1. Scotty Bledsoe (Live Oak) declared a quorum and called the meeting to order at 1:05 p.m. Attendees attended in person or via virtual conference.

Members present: Kenedy County (Andy Garza), Brush Country (Louie Pena), McMullen (Lonnie Stewart), Bee (Lonnie Stewart), Starr County (Reyna Guerra, Tom Koeneke) and Duval County (David Towler).

Guests present: See attached sign-in sheet

2. Andy Garza moved and Lonnie Stewart seconded the motion to approve minutes of the March 23, 2021 meeting with one correction. Motion carried.

3. Lonnie Stewart presented the Treasurer's report that showed a current balance of $17,743.62 for GMA-16 with no pending bills.

Tom Koeneke moved and Lonnie Stewart seconded the motion to approve the Treasurer's report as presented. Motion carried.

4. Jean Perez, TWDB coordinator, reported on the following: a. explanatory report should be submitted in hard drive format, b. 2022 state water plan has been posted on TWDB's website, c. process to develop rules to amend brackish groundwater production zone boundaries is about to begin and d. Water for Texas conference will be held in January, 2022.

5. Consultant Report/ Explanatory Report

Steve Young, Intera hydrologist, reported that the Explanatory Report was 70% complete and should be fully completed in about 5 weeks. Young stated that if he needed additional information, he would coordinate requests through Lonnie Stewart.

6. Scotty Bledsoe asked for comments on proposed DFCs received from public hearings. Both the Bee and Kenedy County GCDs will submit comments received on proposed DFCs to Steve Young for inclusion in the Explanatory Report.

David Towler, Duval County GCD legal counsel, reported that a uranium mining project, which could increase the need for groundwater, is in the works in northern Duval County.

7. Scotty Bledsoe informed the committee that the proposed DFCs needed to be adopted for inclusion in the Explanatory Report.

Lonnie Stewart moved and Andy Garza seconded the motion for final adoption of the DFCs as presented. Motion carried.

8. Scotty Bledsoe stated that GMA-16 needed to appoint and/or reappoint representatives to Regions M and N.

Louie Pena moved and Reyna Guerra seconded the motion to reappoint Armando Vela to Region M and Andy Garza to Region N. Motion carried.

9. Tom Koeneke and Reyna Guerra reported that the Starr County GCD, in complying with TCEQ orders, has an approved management plan and adopted rules. They further stated that they are currently registering wells and have established committees to address various facets of the GCD's operation. Mr. Koeneke and Mrs. Guerra thanked Andy Garza for his assistance to the Starr County GCD. GMA-16 will no longer be requesting updates from the Starr County GCD at every meeting.

10. John Marez introduced himself as the new administrator of the South Texas Water Authority. Mr. Marez stated that he is looking forward to working with GMA-16 and Region N.

11. The next meeting was tentatively set for November 23, 2021.

12. Scotty Bledsoe reminded members to submit agenda items for the next meeting to Lonnie Stewart or Andy Garza.

13. Lonnie Stewart moved and Reyna Guerra second the motion to adjourn meeting at 1:50 PM. Motion carried.

NOTICE OF OPEN MEETING

NOTICE OF OPEN MEETING

As required by section 36.108(e), Texas Water Code, a meeting of the Groundwater Management Area 16 Planning Committee, comprised of delegates from the following groundwater conservation districts located wholly or partially within Groundwater Management Area 16: Bee GCD, Brush Country GCD, Live Oak UWCD, McMullen GCD, Kenedy County GCD, Corpus Christi Aquifer Storage and Recovery Conservation District, San Patricio GCD, Starr GCD, Duval GCD, and Red Sands GCD will be held on **Tuesday, November 23, 2021 at 1:00PM in the Brush County GCD Office, 732 West Rice St., Falfurrias, Texas.**

Discussion and Possible Action on the following agenda items:

1. Welcome and Introductions
2. Minutes of the previous meeting
3. Treasurer’s report
4. Report from TWDB
5. Consultant/ Explanatory Report
6. Approve Resolution for the Desired Future Condition
7. Declaring some aquifers as non-relevant
8. Review Explanatory report
9. District members and public members discussion
10. Set date for next meeting.
11. Future agenda items.
12. Adjournment.

Lonnie Stewart, Vice-Chairman Groundwater Management Area 16

Lonnie Stewart

For more information, please contact me at louwcd@yahoo.com or 361-449-7017.

APPENDIX B
WRITTEN PUBLIC COMMENT RECEIVED DURING THE 90-DAY COMMENT PERIOD FOR THE PROPOSED DFCS

Bee County Groundwater Conservation District
PO Box 682
Beeville, TX 78104-0682

July 26, 2021

Neighbors Against Destroying Aquifers
9116 FM 743
Kenedy, Texas 78119

RE: NADA's Public Comments on Proposed Desired Future Conditions for GMA-15 and GMA-16

Dear Chairman and Directors:

Neighbors Against Destroying Aquifers (NADA) is a nonprofit group concerned with preventing the depletion of critical shared groundwater resources in our member area. Our members own property in Bee County as well as other counties within GMA-15 and GMA-16.

NADA is concerned with the feasibility of Bee County Groundwater Conservation District's (BGCD) achieving the proposed Desired Future Conditions (DFC) for the Gulf Coast Aquifer System (GCAS) of 7 feet drawdown between 2000 and 2080 for GMA-15, and 93 feet of drawdown between 2010 and 2070 for GMA-16. On average this is 0.0875 ft of drawdown per year for BGCD relative to GMA-15, and 1.329 ft of drawdown per year relative to GMA-16. It is not tenable for the BGCD to have such widely divergent DFCs. According to BGCD data, the proposed DFCs are not feasible to achieve or have a detrimental socio-economic impact. The data shows that the drawdown within BGCD's boundaries will far exceed the proposed GMA-15 DFC and will be under the proposed GMA-16 DFC. NADA is not proposing that our quantification and analysis of BGCD data is the only method to quantify and analyze it. Using any method of rational analysis of the data, it is not achievable, feasible, or reasonable to have such widely divergent DFCs.

<u>Figure 1</u> is a graph of BGCD data from 2010 through 2021. The blue dots are the BGCD water levels for each monitor well. Only wells that had recorded data for most of the years between 2010 and 2021 were used in this analysis.[1] For State Well Number 7934409 only the first reading for each year was used to prevent its daily readings from biasing the results. All other wells had yearly readings. The red line is the line generated by using the slope form of linear regression analysis[2]. R^2 (R-squared) is the coefficient of determination. It is a statistical measure in a regression model that determines the proportion of variance in the dependent variable that can be explained by the independent variable. In this case the independent variable is the number of years that elapse, and the dependent variable is the water level of the wells measured. According to this

[1] Wells used in this analysis are State Well Numbers 7944103, 7917801, 7935101, 7935305, 7925303, 7925608, 7934202, 7943903, and 7934409. Four are in GMA-15. Five are in GMA-16.

[2] Linear regression analysis is the most widely used of all statistical techniques: it is the study of linear, additive relationships between variables.

analysis, 85 percent of the variance in water level can be explained by time elapsing. The results of this analysis are that the water levels in Bee County were being drawn down by 0.657 feet per year between 2010 and 2021. This is a significant and concerning drawdown.

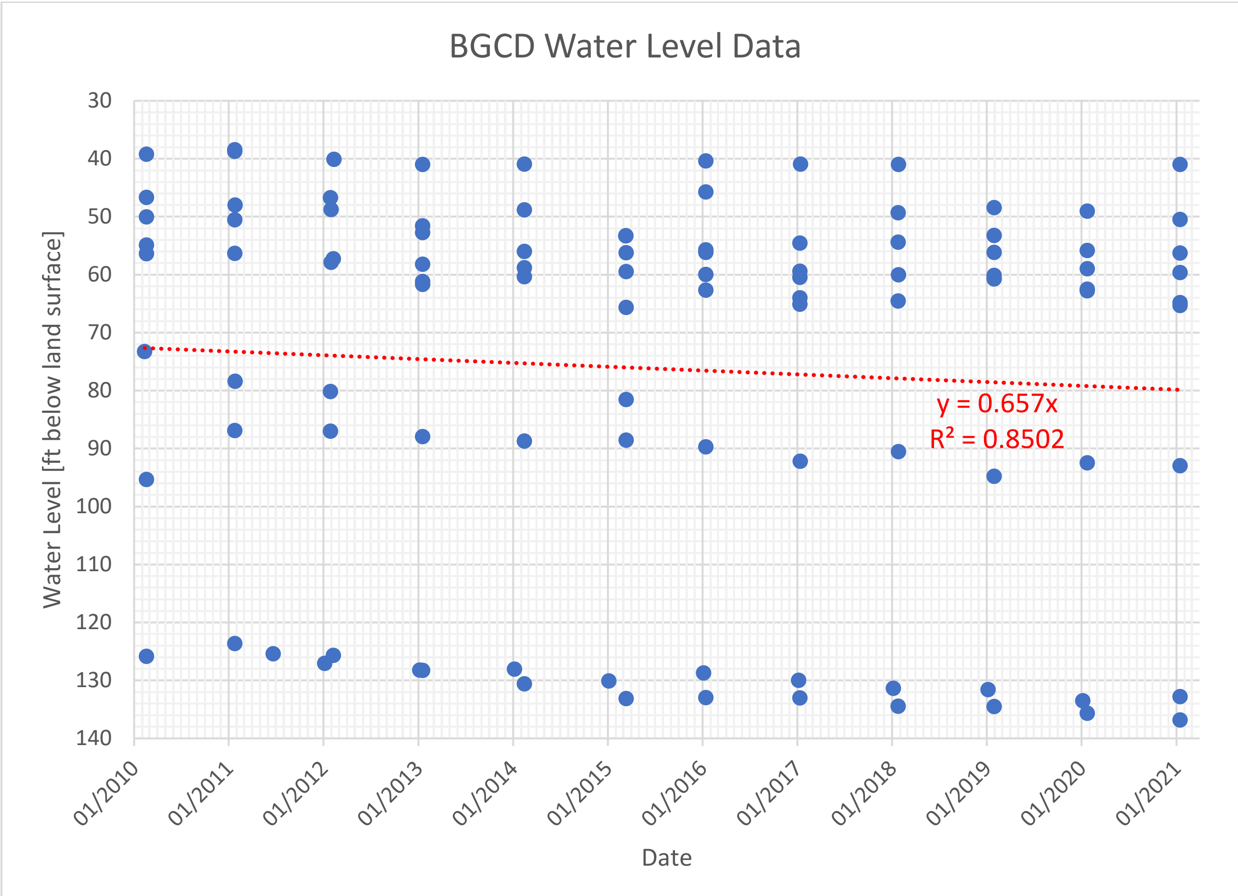

Figure 1

Figure 2 below is the yearly average[3] and median[4] water levels for the same monitor wells used above. Looking at the averages, the average water level in 2010 was 67.71 feet. In 2021 the average water level was 77.79 feet. This is 10.08 feet of drawdown divided by 12 years is 0.84 feet per year on average from 2010 to 2021. Looking at the medians, the median water level in 2010 was 55.65 feet. The median water level in 2021 was 64.84 feet. The median water level has drawn down 9.19 feet. Dividing this by twelve years is a drawdown of the median water level of 0.766 feet per year. Just looking at the averages and medians without doing any complex math, the water level drawdown is significant and concerning.

[3] The average of a set of number expresses the central or typical value in a set of data. The sum of all the data points divided by the number of data points.

[4] The median is the value separating the higher half of a data sample, a population, or a probability distribution, from the lower half. In simple terms, it may be thought of as the "middle" value of a data set.

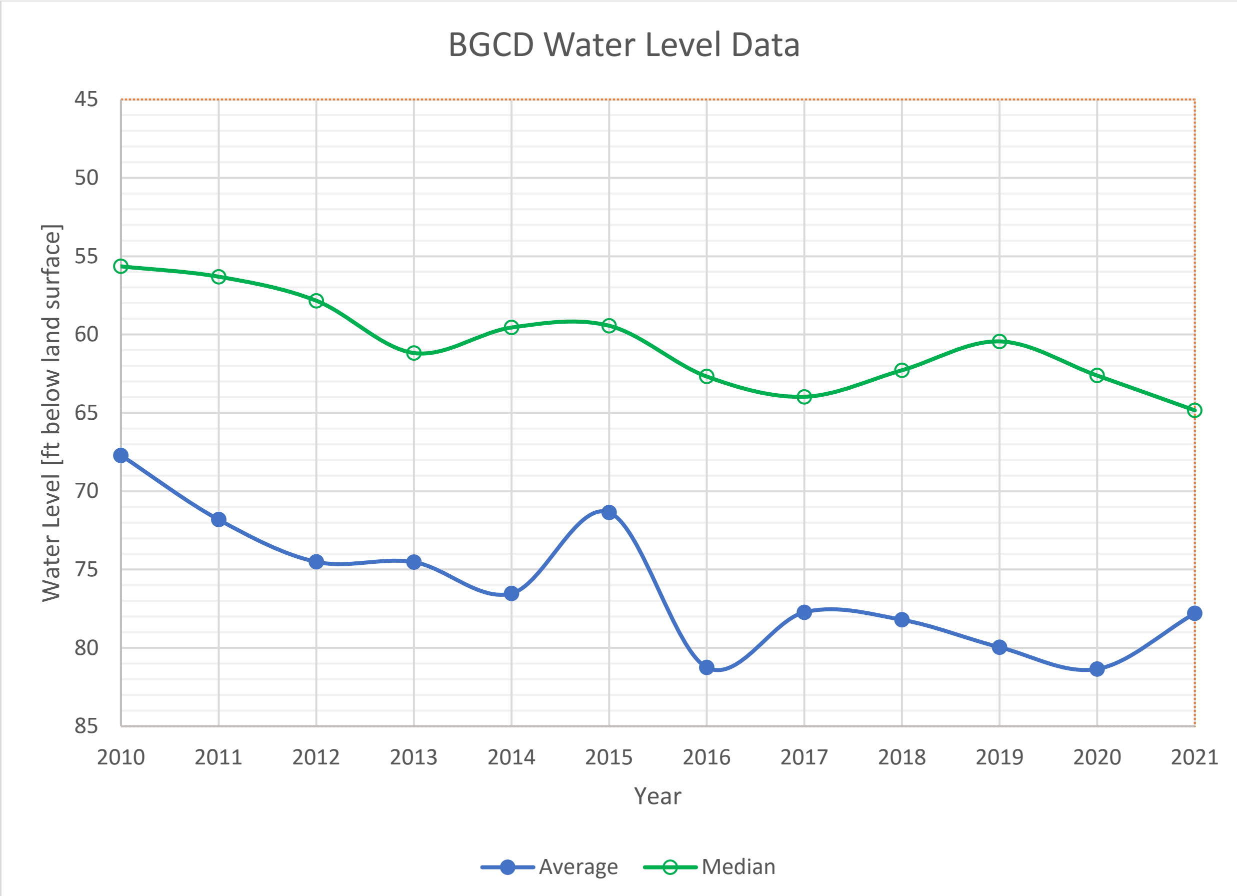

Figure 2

Figure 3 is the same as **Figure 2** except the linear regression trend from **Figure 1**, the proposed DFCs for GMA-15 and GMA-16 DFC have been superimposed on the median water level starting at 2010. The black dash-dot line representing the proposed GMA-15 DFC for BGCD has clearly been exceeded by 2021. There is not any indication that the rate of drawdown in water level will decrease. Therefore, it is not feasible for BGCD have a drawdown that is less than or equal to 7 feet in 2080. The orange dashed line representing the proposed GMA-16 DFC for BGCD is feasible. It is feasible that there will be less than or equal to 93 feet of drawdown by 2080. The concern is the socio-economic impact 93 feet water level drawdown will have on Bee County and our members' property. From looking at the water level monitor well data, many if not all wells in Bee County would need to be replaced with new wells. The shallower water sands would be depleted if they have not already been. The cost of pumps and equipment, and the energy costs to run pumps would increase due to pumping water 93 feet further to the surface. Water quality would likely suffer. Increased filtering and treatment costs would be likely. The red dotted line, the linear regression trend, although representing a large drawdown fits the existing data better. It represents the best of both worlds between a water level drawdown that is feasible to achieve (that has not already been exceeded) and minimizing detrimental socio-economic impacts.

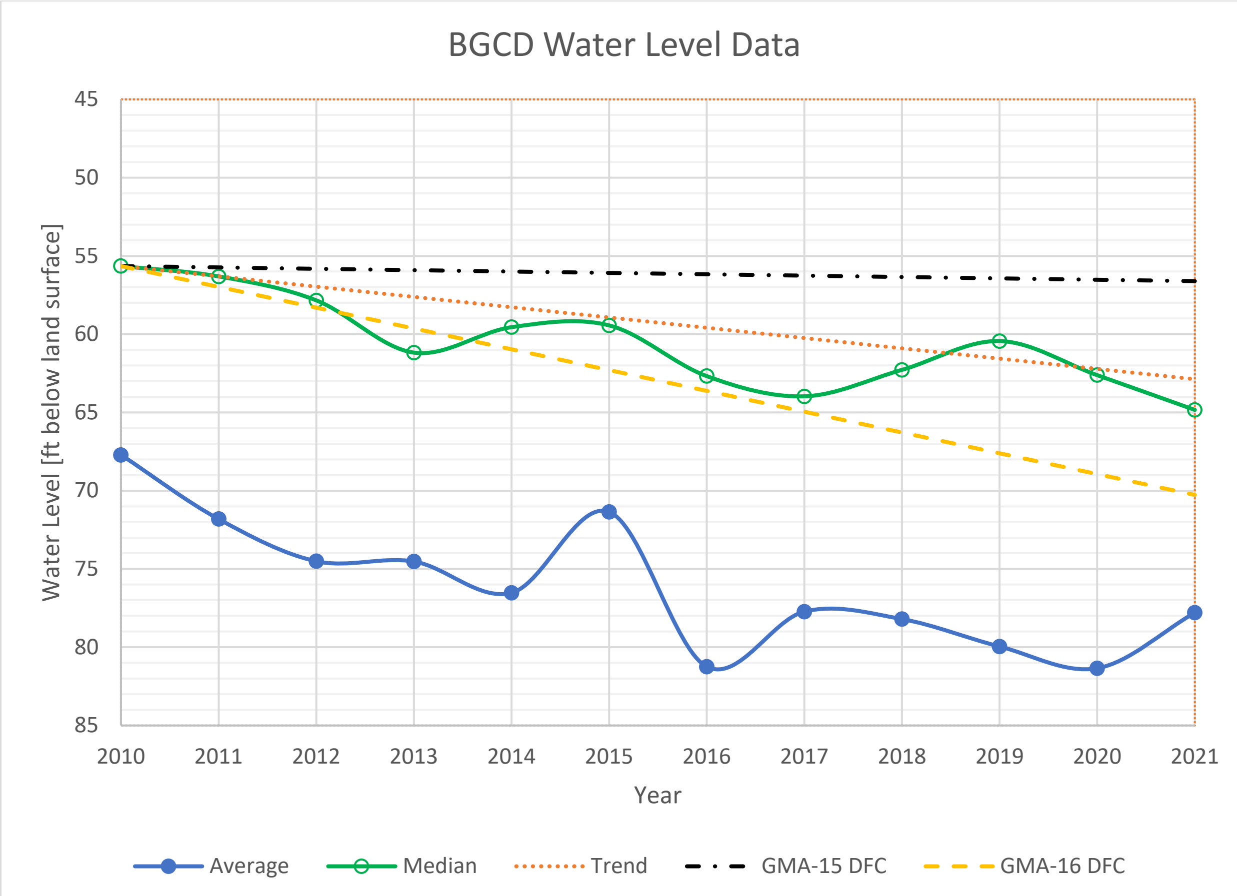

Figure 3

To check the results of our analysis, further analysis was done. See **Figure 4**. State well number 7934409 is a dedicated water level monitor well (i.e., it is not pumped). It is located centrally in Bee County. It appears to have been completed in the Evangeline aquifer. It has been monitored 24 hours a day, 7 days a week from June 2011 to the present. The blue dots are the water levels recorded. There are a few gaps presumably due to equipment malfunctions. Just looking at the data plotted in the graph, there is a significant water level drawdown occurring. In 2011 the water level was 125.42 feet. The most recent water level was 132.82 feet. This is a drawdown of 7.5 feet in 10 ½ years, or 0.714 feet per year. This is on par with the drawdown discussed above for Bee County. Linear regression analysis of the data was performed for this water level monitor well. The equation, R-squared and trend line in red is for the slope form of linear regression analysis. The slope indicates a drawdown of 1.132 feet per year. The equation, R-squared, and trend line in green are the slope-intercept form of linear regression analysis. This slope indicates the drawdown of 0.730 feet per year. The R-squared for either form of linear regression analysis in **Figure 4** is high. With either form most of the variability in water level is explained by the elapse of time. At 1.132 feet per year the slope form comes very near the GMA-16 model at a drawdown of 1.329 feet per year. The slope-intercept form of linear regression analysis below of 0.730 feet per year is closer to the multiple water level monitor well analysis above with results of 0.657 feet per year of drawdown in Bee County. This illustrates the R-squared is not the only statistic that counts. The green slope-intercept form appears to fit the data better even though the R-squared value is lower.

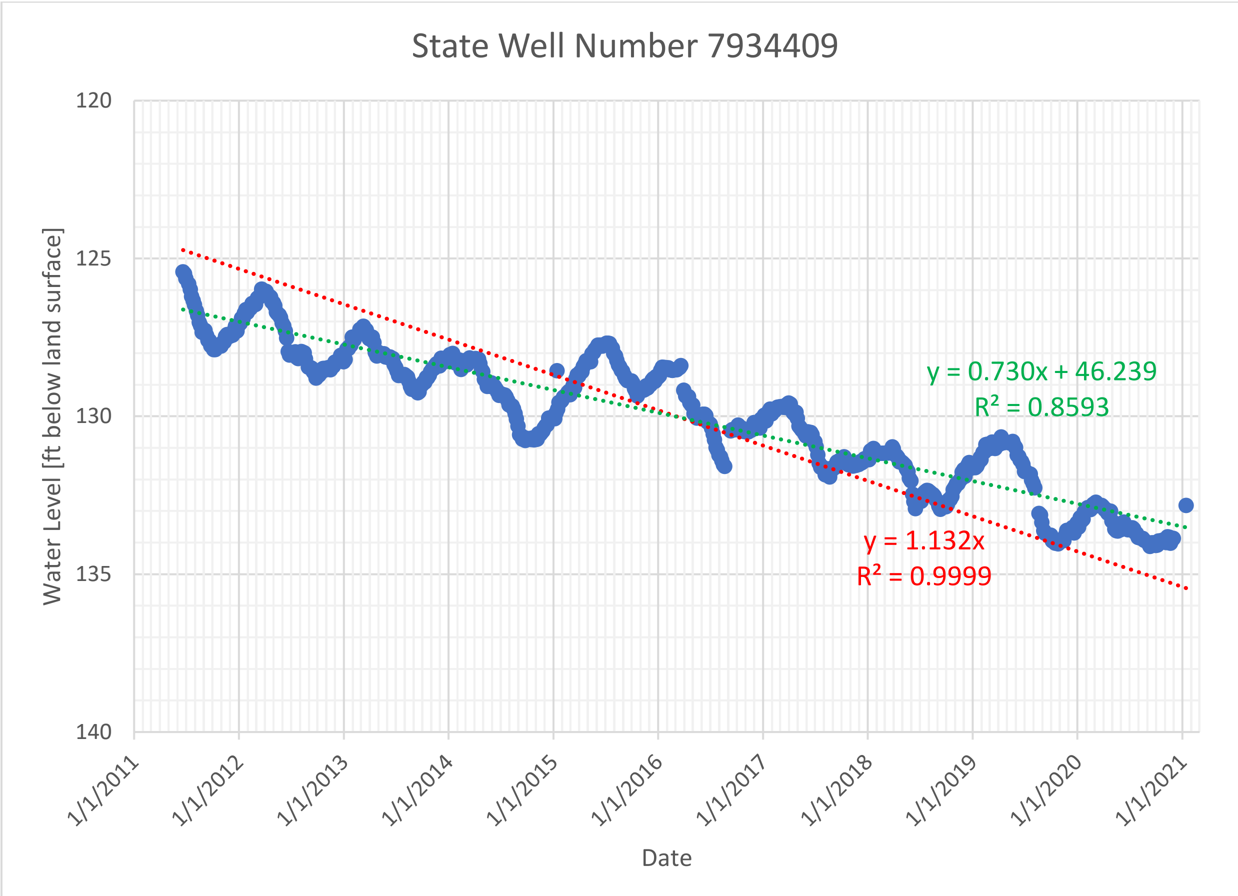

Figure 4

Rather than manage the Gulf Coast Aquifer System (GCAS) as a whole, it is more accurate to manage its individual components: the Chicot aquifer, the Evangeline aquifer, the Burkeville aquifer, and the Jasper aquifer individually. **Table 1** is an excerpt from Appendix 5.16 of the draft GMA-15 Explanatory Report. It is not accurate and should be updated with the latest modeling results (i.e., 7 feet of drawdown for GCAS in Bee County rather than the 10 feet shown in **Table 1**). This serves as another example of how far off the data is from the models. For the GCAS the GMA-15 model uncertainty analysis indicates that drawdown for the GCAS could be from 2 to 18 feet. Neither comes close to fitting BGCD data. For the Chicot aquifer predicted drawdown could be from 0 to 16 feet. 0 feet of drawdown completely ignores the depletion of shallow aquifers that has likely occurred. For the Jasper aquifer water levels could either recover 10 feet or be drawn down 19 feet. This is a widely divergent result. The Jasper aquifer either has the largest recovery or near largest drawdown. This illustrates the need to monitor GCAS components separately in order to make necessary changes in rules by aquifer component and provide an early warning system for all components of the GCAS. We could not find an uncertainty analysis for the GMA-16 GAM. It would be helpful if an uncertainty analysis was added to the GMA-16 explanatory report. Uncertainty analysis is a standard component of modeling and statistics.

RANGE OF AVERAGE DRAWDOWN

County	Chicot	Evangeline	Burkeville	Jasper	GCAS
Aransas	0 (-2 to 2)	6 (3 to 8)	—	—	0 (-2 to 2)
Bee*	8 (0 to 16)	16 (12 to 21)	11 (3 to 19)	5 (-10 to 19)	10 (2 to 18)
Calhoun	-1 (-15 to 12)	10 (-3 to 23)	3 (-10 to 16)	—	3 (-11 to 16)
Colorado	12 (1 to 24)	26 (-8 to 60)	24 (-16 to 63)	28 (-64 to 121)	23 (-17 to 63)
De Witt	0 (-56 to 56)	5 (-2 to 11)	19 (-37 to 75)	34 (-26 to 95)	21 (-35 to 77)
Fayette	—	11 (-60 to 83)	43 (-28 to 114)	53 (-18 to 124)	44 (-27 to 116)
Goliad	-4 (-19 to 10)	-2 (-67 to 64)	4 (-59 to 68)	8 (-39 to 55)	3 (-60 to 66)
Jackson	15 (-44 to 75)	20 (-36 to 76)	14 (-43 to 71)	22 (-35 to 79)	18 (-40 to 75)
Karnes	—	-1 (-19 to 17)	22 (3 to 40)	25 (7 to 43)	22 (3 to 40)
Lavaca	7 (-21 to 35)	7 (-16 to 30)	17 (-5 to 39)	32 (-96 to 161)	18 (-66 to 102)
Matagorda	5 (-55 to 64)	17 (-42 to 76)	16 (-43 to 75)	—	10 (-49 to 69)
Refugio	0 (-7 to 6)	7 (-3 to 17)	3 (-5 to 10)	—	3 (-4 to 10)
Victoria	-4 (-35 to 27)	6 (-38 to 50)	5 (-34 to 43)	8 (-30 to 47)	3 (-35 to 42)
Wharton	15 (-34 to 63)	12 (-37 to 61)	24 (-25 to 73)	27 (-21 to 76)	19 (-29 to 68)
GMA 15	**6 (-40 to 52)**	**12 (-39 to 62)**	**16 (-6 to 38)**	**24 (-72 to 121)**	**14 (-42 to 71)**

*Average drawdown is for all of Bee County, not just the portion in GMA 15

Table 1

Table 2 below is an excerpt from the draft explanatory report for the GMA-16 GAM. For BGCD a 126 feet drawdown for the Chicot aquifer is predicted for the period 2010 to 2080. This is a concerning drawdown with no guarantee or evidence that this amount of easily obtainable good quality groundwater water exists in the Chicot aquifer. The drawdowns predicted for other aquifers are no less concerning. Including the 93 feet drawdown predicted for the GCAS. This further highlights the need to manage the Chicot, Evangeline, Burkeville, and Jasper aquifers individually.

Average Drawdowns From Pumping Scenario #2

GCD or Region	Simulated Averaged Drawdown (ft) 2010-2080*				
	Chicot	Evangeline	Burkeville	Jasper	Gulf Coast Aquifer
Bee GCD	126	102	90	75	93
Brush County GCD	60	101	88	89	89
Duval County GCD	99	183	121	109	137
Kenedy County GCD	18	56	18	18	27
Live Oak UWCD	100	83	79	25	45
McMullen GCD	0	0	0	12	12
Red Sands GCD	48	62	61	60	60
San Patricio County GCD	114	84	39	39	69
Starr County GCD	0	112	100	76	94
Non-district Cameron	125	196	78	78	119
Non-district Hidalgo	153	170	119	117	138
Non-district Kleberg	15	46	11	11	21
Non-district Nueces	33	40	15	15	26
Non-district Webb	0	226	0	91	161
Non-district Willacy	47	85	23	23	44
GMA 16 TOTAL	61	110	67	65	78

*1/1/2010 to 1/1/2080

Revised from 3/23

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Table 2

Figure 5 is an excerpt for the draft GMA-16 explanatory report. It shows that water demand (from both surface water and ground water supplies), current or future, cannot be met without water management strategies. Currently the deficit between water demand and supply is around 2,400 acre-feet per year and increasing.

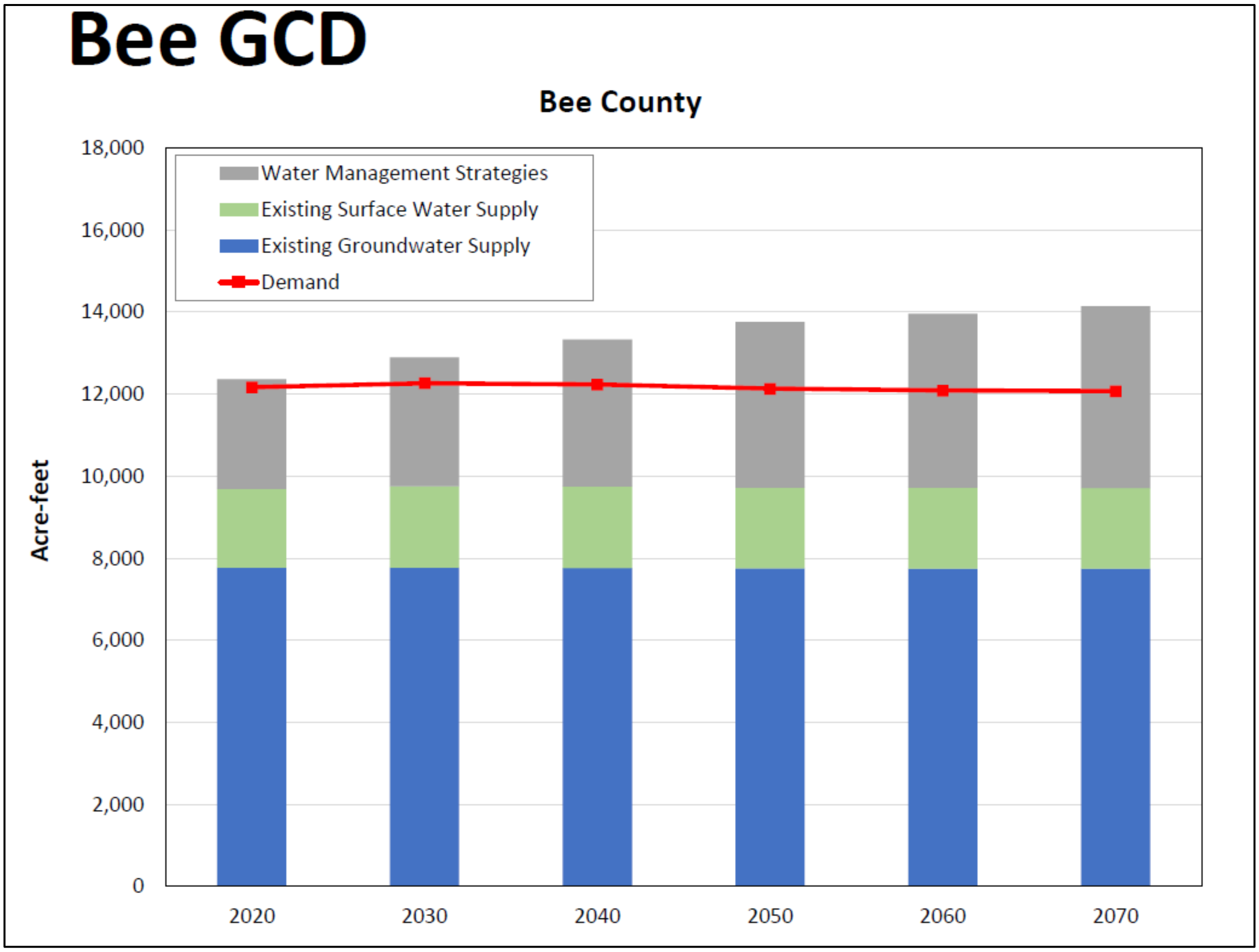

Figure 5

Figure 6 is an excerpt for the GMA-16 draft explanatory report explaining what water management strategies are. None of these water management strategies are currently being considered in Bee County. Water re-use from the City of Beeville's sewage treatment plant is a laudable goal. There is a lot to consider regarding how this could be accomplished. Currently, millions of gallons of treated sewage discharged from the City of Beeville's sewage treatment plant are discharged into a creek without potential for reuse. A reservoir on the Aransas River is worth considering. There is not any indication that it is currently being considered. Without any realistic water management strategies for achieving water demand for Bee County, the burden rests upon BGCD to protect groundwater supplies.

Example of Regional Water Plan Accounting by County

Water Management Strategies can include:

- Conservation
- Demand Reduction
- Water Re-use
- Additional Infrastructure
    - Groundwater wells
    - Desalination plants
    - Reservoirs or pipelines

Figure 6

For the reasons given above, GMA-15 and by extension BGCD may fail to fully consider the feasibility of achieving the proposed DFC for Bee County. BGCD water level monitor well data clearly shows that the model used by GMA-15 does not predict the actual condition of the GCAS or its components in Bee County. Stating it plainly, given all available data it is not feasible that BGCD could achieve a drawdown of not greater than 7 feet of the GCAS between 2000 and 2080. **7 feet of drawdown has already been exceeded between 2000 and 2021.**

For the reasons given above, GMA-16 and by extension BGCD may fail to fully consider the detrimental socioeconomic impacts that could occur if the drawdown represented by the proposed DFC for Bee County occurs. BGCD water level monitor well data shows that the model used by GMA-16 does not predict the actual condition of the GCAS or its components in Bee County. Stating it plainly, given all available data and consideration, the socio-economic impact of BGCD achieving a drawdown of GCAS of not greater than 93 feet between 2010 and 2080 could be catastrophic. 93 feet of groundwater drawdown of good quality easily attainable groundwater may not even exist. We have not seen any data proving otherwise.

It is difficult to understand how either GMA-15 and/or the GMA-16 and by extension BGCD are considering hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge. Given the wide disparity between proposed DFCs, these statutorily required factors could not have been reasonably and scientifically considered.

It is difficult to understand how either GMA-15 and/or the GMA-16 and by extension BGCD could be considering other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water. Given the wide disparity between proposed DFCs this statutorily required factor could not have been reasonably and scientifically considered.

Due to the wide disparity of proposed DFCs between the GMA-15 GAM and the GMA-16 GAM, Modeled Available Groundwater (MAG), the amount of groundwater pumping necessary to achieve the proposed DFC, could not be accurate. Modeled Available Groundwater is a misnomer. It is defined as the amount of pumping required to achieve the Desired Future Condition. It has nothing to do with available groundwater as the name falsely leads one to believe. The GMA-15 GAM grossly understates the MAG. This could hinder economic development of Bee County. The GMA-16 GAM grossly overstates the MAG. We are doubtful that good quality groundwater exists to achieve the proposed GMA-16 DFC for Bee County.

NADA's sole purpose in this process is to ensure that there is sufficient good quality groundwater available to meet the needs for all as required by statute and equity. By carefully planning ahead, equitable groundwater rights could be maintained for all. Because of excessive groundwater withdrawals, the little guy will be forced to carry the burden (i.e., poor groundwater quality, having to set pumps deeper and associated higher energy costs of lifting water further to the surface, or drilling new wells to accommodate excessive groundwater withdrawals).

Given the discussion and considerations above, NADA makes the following recommendations:

1. NADA recommends that BGCD set its DFC at not greater than 47 feet of drawdown between 2010 to 2080 in accordance with the analysis in **Figure 1**.
2. NADA recommends that BGCD revise its rules allowing withdrawal of 1 acre-foot of groundwater per acre to ½ acre-foot of groundwater per acre or less. This would not decrease current groundwater withdrawal levels but would reduce future increases of groundwater withdrawal.
3. NADA recommends that BGCD adopt rules that limit pump capacity by depth of well. For instance, wells with a depth of 100 feet would be allowed to produce much less than wells with a depth of 300 feet. This would serve to protect shallow groundwater for individuals and landowners that use less groundwater such as domestic and livestock users. This could potentially reverse the trend of depletion of shallower aquifers.
4. NADA recommends that BGCD manage the Chicot, Burkeville, Evangeline, and Jasper aquifers (Gulf Coast Aquifer System components) separately. It is a more accurate and conservative practice than managing the Gulf Coast Aquifer System. **Figure 1** illustrates problems with trying to look at individual aquifers at the same time. In **Figure 1** there are separate aquifers being looked at the same time. This could lead to errors. Looking at the individual aquifers could provide an early warning of potential problems and make the necessary changes in a timely manner.
5. NADA recommends that BGCD set a DFC that the average Total Dissolved Solids (TDS) of its water quality monitor wells shall not increase by more than 50 mg/L in any given year from the year before. This provides a warning system that what quality is decreasing.

6. NADA recommends that BGCD locate or drill more dedicated water level monitor wells that are not pumped. This would provide more accurate water level data.
7. NADA recommends that BGCD begin educational programs to inform constituents of the depletion of groundwater that is occurring and the need to conserve water.

The 2022 budgeting and tax computation cycles for BGCD are soon to begin. All necessary factors, costs, and expenses should be considered in the process.

We look forward to working cooperatively with BGCD and anyone else to move forward productively to protect our shared groundwater. Members of NADA and nonmembers alike would be hard pressed to make do without easily available quality groundwater.

Best Regards,

/s/ David Morgan	/s/ Tina Shearman
President	Secretary

APPENDIX C
GMA 16 RESOLUTION TO ADOPTION DESIRED FUTURE CONDITIONS

RESOLUTION TO ADOPT DESIRED FUTURE CONDITIONS FOR GROUNDWATER MANAGEMENT AREA 16 AQUIFERS

STATE OF TEXAS RESOLUTION # 2022-01

GROUNDWATER MANAGEMENT AREA 16

WHEREAS, Texas Water Code 36.108 requires the Groundwater Conservation Districts located whole or in part in a Groundwater Management Area ("GMA") designated by the Texas Water Development Board to adopt desired future conditions for the relevant aquifers located within the management area;

WHEREAS, the Groundwater Conservation Districts located wholly or partially within Groundwater Management Area 16 ("GMA 16"), as designated by the Texas Water Development Board, as of the date of this resolution are as follows: Bee Groundwater Conservation District, Kenedy County Groundwater Conservation District, Brush Country Groundwater Conservation District, Duval County Groundwater Conservation District, Starr County Groundwater Conservation District, Corpus Christi Aquifer Storage and Recovery Conservation District, Live Oak Underground Water Conservation District, Red Sands Groundwater Conservation District, McMullen Groundwater Conservation District, and San Patricio County Groundwater Conservation District (collectively referred to as "Member Districts");

WHEREAS, the Board Presidents or their Designated Representatives of districts in GMA 16 have met at various meetings and conducted joint planning in accordance with Chapter 36.108, Texas Water Code since 2015 and;

WHEREAS, Section 36.108 of the Texas Water Code requires the Member Districts in GMA 16 to consider groundwater availability models and other data or information for the management area and vote on a proposal for adoption of DFC's for each relevant aquifer within GMA 16 by January 5, 2022, which GMA Member Districts accomplished on September 21, 2021, and;

WHEREAS, GMA 16, having given proper and timely notice, held an open meeting of the GMA 16 Member Districts on September 21, 2021 and;

WHEREAS, GMA 16 has solicited and considered public comment at specially called Public Meeting, including the meeting on September 21, 2021 and;

WHEREAS, the GMA 16 Member Districts received and considered technical advice regarding local aquifers, hydrology, geology, recharge characteristics, local groundwater demands and usage, population projections, ground and surface water inter-relationships, and other considerations that affect groundwater conditions and;

WHEREAS, in developing the proposed DFC's for the relevant aquifers within GMA 16, the Member Districts considered the nine statutory factors set forth in Section 36.108 (d) of the Texas Water Code and ;

WHEREAS, pursuant to Section 36.108(d-2) of the Texas Water Code the Member Districts also considered in the development of the proposed DFC's 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 GMA 16 and;

WHEREAS, following public discussion and due consideration of the current and future needs and conditions of the aquifers in question, the current and projected groundwater demands, and the potential effects on springs, surface water, habitat, and water dependent species through the year 2080, GMA 16 Member Districts have analyzed drawdown estimations from numerous pumping scenarios using the Lower Gulf Coast Groundwater Availability Model and have voted on a motion made and seconded to adopt a Desired Future Condition (DFC) stated as follows:

> Groundwater Management Area 16 adopts Desired Future Conditions for each county within the groundwater management area (county-specific DFC's) and adopts a Desired Future Condition for the counties in the groundwater management area (gma-specific DFC's). The Desired Future Condition for the counties in the groundwater management area shall not exceed an average drawdown of 78 feet for the Gulf Coast Aquifer System at December 2080. Desired Future Conditions for each county within the groundwater management area (county-specific DFC's) shall not exceed the values specified in Scenario 2 at December 2080.
>
> Table A-1: Desired Future Conditions for GMA 16 expressed as an Average Drawdown between January 2010 and December 2079.
>
> Bee GCD: 93 feet of drawdown of the Gulf Coast Aquifer System;
>
> Live Oak UWCD: 45 feet of drawdown of the Gulf Coast Aquifer System;
>
> McMullen GCD: 12 feet of drawdown of the Gulf Coast Aquifer System;
>
> Red Sands GCD: 60 feet of drawdown of the Gulf Coast Aquifer System;
>
> Kenedy County GCD: 27 feet of drawdown of the Gulf Coast Aquifer System;

Brush Country GCD: 89 feet of drawdown of the Gulf Coast Aquifer System;

Duval County GCD: 137 feet of drawdown of the Gulf Coast Aquifer System;

San Patricio County GCD: 69 feet of drawdown of the Gulf Coast Aquifer System;

Starr County GCD: 94 feet of drawdown of the Gulf Coast Aquifer System;

Cameron: 119 feet of drawdown of the Gulf Coast Aquifer System;

Hidalgo: 138 feet of drawdown of the Gulf Coast Aquifer System;

Kleberg: 21 feet of drawdown of the Gulf Coast Aquifer System;

Nueces: 26 feet of drawdown of the Gulf Coast Aquifer System;

Webb: 161 feet of drawdown of the Gulf Coast Aquifer System;

Willacy: 44 feet of drawdown of the Gulf Coast Aquifer System.

WHEREAS, the GMA 16 Member Districts evaluated and determined that the Yegua-Jackson Aquifer in Jim Hogg, Duval, Live Oak, and Starr Counties and the Carrizo-Wilcox Aquifer in Bee, Live Oak, and McMullen Counties are not relevant for planning purposes within GMA 16 and no DFC is required.

NOW THEREFORE BE IT RESOLVED, that the Groundwater Management Area 16 Member Districts do hereby document, record and confirm a Desired Future Condition stated above was adopted by all member districts present.

AND IT IS SO ORDERD.

PASSED AND ADOPTED on this 28th day of June 2022.

ATTEST:

Lonnie Stewart

Bee Groundwater Conservation District

Scott Bledsoe, III

Live Oak Underground Water Conservation District

McMullen Groundwater Conservation District

Red Sands Groundwater Conservation District

Kenedy County Groundwater Conservation District

Corpus Christi Aquifer Storage and Recovery Conservation District

Brush Country Groundwater Conservation District

Duval County Groundwater Conservation District

San Patricio County Groundwater Conservation District

Starr County Groundwater Conservation District

APPENDIX D
TECHNICAL MEMO DECLARING THE CARRIZO-WILCOX AS A NON-RELEVANT AQUIFER

GMA 16 TECHNICAL MEMORANDUM DECLARING THAT THE PORTION OF THE CARRIZO-WILCOX AQUIFER IN BEE, LIVE OAK, AND McMULLEN COUNTIES BE DECLARED AS NON-RELEVANT FOR THE PURPOSE OF JOINT PLANNING

1.0 INTRODUCTION

The Texas Water Development Board, in its May 2020 document, Explanatory Report for Submittal of Desired Future Conditions to the Texas Water Development Board, offers the following guidance regarding documentation for aquifers that are to be classified not relevant for purposes of joint planning:

Districts in a groundwater management area may, as part of the process for adopting and submitting desired future conditions, propose classification of a portion or portions of a relevant aquifer as non-relevant (31 Texas Administrative Code 356.31 (b)). This proposed classification of an aquifer may be made if the districts determine that aquifer characteristics, groundwater demands, and current groundwater uses do not warrant adoption of a desired future condition. The districts must submit to the TWDB the following documentation for the portion of the aquifer proposed to be classified as non-relevant:

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

This technical memorandum provides the required documentation to classify the portion of the Carrizo-Wilcox Aquifer in Bee, Live Oak, and McMullen counties as not relevant for purposes of joint planning.

2.0 AQUIFER DESCRIPTION AND LOCATION

Figure 1 shows the portion of the Carrizo-Wilcox aquifer that exists in GMA 16 based on aquifers boundaries determined by the TWDB (George and others, 2011). A portion of the Carrizo-Wilcox Aquifer exists in three counties in GMA 16: Bee County, Live Oak County, and McMullen County. Table 1 associates each county with its respective groundwater conservation district and provides the total number of square miles of the Carrizo-Wilcox aquifer that exists in each county. The description of the Carrizo-Aquifer is described by George and others (2011) as:

The Carrizo-Wilcox Aquifer *is a major aquifer extending from the Louisiana border to the border of Mexico in a wide band adjacent to and northwest of the Gulf Coast Aquifer. It consists of the Wilcox Group and the overlying Carrizo Formation of the Claiborne Group. The aquifer is primarily composed of sand locally interbedded with gravel, silt, clay, and lignite. Although the Carrizo-Wilcox Aquifer reaches 3,000 feet in thickness, the freshwater saturated thickness of the sands averages 670 feet. The groundwater, although hard, is generally fresh and typically contains less than 500 milligrams per liter of total dissolved solids in the outcrop, whereas softer groundwater with total dissolved solids of more than 1,000 milligrams per liter occurs in the subsurface. High iron and manganese content in excess of secondary drinking water standards is characteristic of the deeper subsurface portions of the aquifer. Parts of the aquifer in the Winter Garden area are slightly to moderately saline, with total dissolved solids* *ranging from 1,000 to 7,000 milligrams per liter. Irrigation pumping accounts for slightly more than half the water pumped, and pumping for municipal supply accounts for another 40 percent. Water levels have declined in the Winter Garden area because of irrigation pumping and in the northeastern part of the aquifer because of municipal pumping. The regional water planning groups, in their 2006 Regional Water Plans, recommended several water management strategies that use the Carrizo-Wilcox Aquifer, including developing new wells and well fields, withdrawing additional water from existing wells, desalinating brackish water, using surface water and groundwater conjunctively, reallocating supplies, and transporting water over long distances.*

Table 1 Occurrence of the Carrizo-Wilcox Aquifer in GMA 16

Groundwater Conservation District	County	Area (sq miles)
Bee Groundwater Groundwater Conservation District	Bee	13
Live Oak Underground Water Conservation District	Live Oak	279
McMullen Groundwater Conservation District	McMullen	33

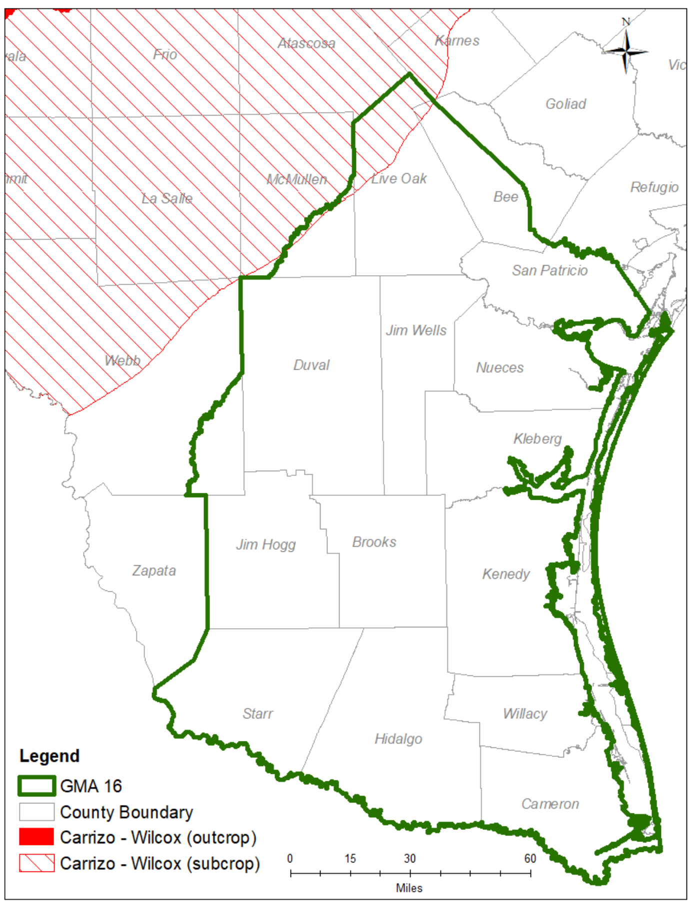

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Figure 1 Location of Carrizo-Wilcox Aquifer in GMA 16

3.0 AQUIFER CHARACTERISTICS, GROUNDWATER PUMPING, AND TOTAL ESTIMATED STORAGE

The portion of the Carrizo Wilcox Aquifer (including the Carrizo, Calvert Bluff, Simsboro, and Hooper) that occurs below the Bee, Live Oak, and McMullen counites in GMA 16 is expected to be moderately saline to very saline and occurs below depths of 5,500 feet. Table 2 provides the historical pumping for 2018 and 2019 (which are the most recent years reported by the TWDB). Both Bee and Live Oak counties have no reported pumping for both years. For McMullen County, the pumping amount for the entire county is reported. The General Manager for the three GCDs listed in Table 1 reported to INTERA that for the Carrizo-Wilcox Aquifer: (1) Bee County does not have any registered well; (2) McMullen County does not have any registered well; and, (3) Live Oak County has less than 20 registered wells and they are all used for oil and gas exploration.

Table 2 provides the Total Estimated Recoverable Storage (TERS) for the Carrizo-Wilcox that lies within each county and within GMA 16. Additional information on the TERS is available from Jigmond and Wade (2013).

Table 2 Aquifer Characteristics for the Carrizo-Wilcox Aquifer in GMA 16 for Bee, Live Oak, and McMullen Counties

Groundwater Conservation District (GCD) or Conservation District (CD)	County	Total Estimated Recoverable Storage (acre-feet)	Historical Pumping (acre-feet/year)		Approximate Range of Depths (ft)	
			2018	2019	Top of Carrizo	Bottom of Hooper
Bee GCD	Bee	4,700,000	NR	NR	5,500 – 6,400	9,200 – 10,200
Live Oak Underground CD	Live Oak	89,000,000	NR	NR	4,200 – 6,300	7,900 – 9,700
McMullen GCD	McMullen	11,000,000			5,600 – 6,100	9,300 – 9,000

Notes: TERS values obtained from Jigmond and Wade (2013)

Historical Pumping TWDB website: www.twdb.texas.gov/waterplanning/index.asp

NR = none reported

*Pumping in McMullen is for the entire county

4.0 EXPLANATION OF NON-RELEVANCE

The portion of the Carrizo-Wilcox Aquifer in Bee Live Oak and McMullen is deep and is characterized by poor water quality. The aquifer currently has very low use and is its future use in the near future is anticipated to remain low. The three counties are part of the Coastal Bend Regional Water Planning Area (Region N). Region N (CBRWPA, 2020) has no water management strategies listed for the Carrizo-Wilcox Aquifer for the next 20 years. In addition to having no having little to no production in GMA 16, the Carrizo-Wilcox Aquifer is isolated from the Gulf Coast Aquifer System, which is the only aquifer system that GMA 16 consider non relevant. Between the Jasper aquifer, which is the deepest portion of the Gulf Coast Aquifer System, and the Carrizo-Aquifer System are thick clay-rich confining units of the Cook Mountain and the lower Catahoula formations.

Due to its extreme depth, poor water quality, its very low use and anticipated use in the future, and it being hydrologically isolated from the Gulf Coast Aquifer System, the portion of the Carrizo-Wilcox Aquifer in Bee, Live Oak, and McMullen counites is classified as not relevant for purposes of joint planning in GMA 16. GMA 16 will re-evaluate the status of the non-relevant classification every joint planning cycle.

5.0 REFERENCES

CBRWPA (Coastal Bend Regional Water Planning Area), 2020. Coastal Bend Regional Planning Area, Region N. Prepared for the Texas Water Development Board. Prepared by: Rio Grande Regional Water Planning Group with technical assistance from HDR Engineering, March 2020.

George, P.G., Mace, R.E., and Petrossian, R., 2011. Aquifers of Texas. Texas Water Development Board Report 380, July 2011, 182p.

Jigmond, M., and Wade, S., 2013. GAM Run 12-025: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 16. Texas Water Development Board. Groundwater Resource Division. March 28, 2013.

APPENDIX E
TECHNICAL MEMO DECLARING THE YEGUA-JACKSON AS A NON-RELEVANT AQUIFER

GMA 16 TECHNICAL MEMORANDUM DECLARING THAT THE PORTION OF THE YEGUA-JACKSON AQUIFER IN DUVAL, BRUSH COUNTRY, LIVE OAK, AND STARR COUNTIES BE DECLARED AS NON-RELEVANT FOR THE PURPOSE OF JOINT PLANNING

INTRODUCTION

The Texas Water Development Board, in its May 2020 document, Explanatory Report for Submittal of Desired Future Conditions to the Texas Water Development Board, offers the following guidance regarding documentation for aquifers that are to be classified not relevant for purposes of joint planning:

> *Districts in a groundwater management area may, as part of the process for adopting and submitting desired future conditions, propose classification of a portion or portions of a relevant aquifer as non-relevant (31 Texas Administrative Code 356.31 (b)). This proposed classification of an aquifer may be made if the districts determine that aquifer characteristics, groundwater demands, and current groundwater uses do not warrant adoption of a desired future condition. The districts must submit to the TWDB the following documentation for the portion of the aquifer proposed to be classified as non-relevant:*
>
> 1. *A description, location, and/or map of the aquifer or portion of the aquifer;*
> 2. *A summary of aquifer characteristics, groundwater demands, and current groundwater uses, including the total estimated recoverable storage as provided by the TWDB, that support the conclusion that desired future conditions in adjacent or hydraulically connected relevant aquifer(s) will not be affected; and*
> 3. *An explanation of why the aquifer or portion of the aquifer is nonrelevant for joint planning purposes.*

This technical memorandum provides the required documentation to classify the portion of the Carrizo-Wilcox Aquifer in Bee, Live Oak, and McMullen counties as not relevant for purposes of joint planning.

I. AQUIFER DESCRIPTION AND LOCATION

Figure 1 shows the portion of the Yegua-Jackson aquifer that exists in GMA 16 based on aquifers boundaries determined by the TWDB (George and others, 2011). A portion of the Yegua-Jackson Aquifer exists in four counties in GMA 16: Duval County, Brush County, Live Oak and Starr County. Table 1 associates each county with its respective groundwater conservation district and provides the total number of square miles of the Yegua aquifer that exists in each county. The description of the Yegua-Jackson is described by George and others (2011) as:

> **The Yegua-Jackson Aquifer** is a minor aquifer stretching across the southeast part of the state. It includes water-bearing parts of the Yegua Formation (part of the upper Claiborne Group) and the Jackson Group (comprising the Whitsett, Manning, Wellborn, and Caddell formations). These geologic units consist of interbedded sand, silt, and clay layers originally deposited as fluvial and deltaic sediments. Freshwater saturated thickness averages about 170 feet. Water quality varies greatly owing to sediment composition in the aquifer formations, and in all areas the aquifer becomes highly mineralized with depth. Most groundwater is produced from the sand units of the aquifer, where the water is fresh and ranges from less than 50 to 1,000 milligrams per liter of total dissolved solids. Some slightly to moderately saline water, with

concentrations of total dissolved solids ranging from 1,000 to 10,000 milligrams per liter, also occurs in the aquifer. No significant water level declines have occurred in wells measured by the TWDB. Groundwater for domestic and livestock purposes is available from shallow wells over most of the aquifer's extent. Water is also used for some municipal, industrial, and irrigation purposes. The regional water planning groups, in their 2006 Regional Water Plans, recommended several water management strategies that use the Yegua-Jackson Aquifer, including drilling more wells and desalinating the water.

Table 1. Occurrence of the Yegua-Jackson Aquifer in GMA 16

Groundwater Conservation District	County	Area (sq miles)
Duval County GCD	Duval	29
Brush Country GCD	Jim Hogg	12
Live Oak Underground CD	Live Oak	56
Starr County GCD	Starr	273

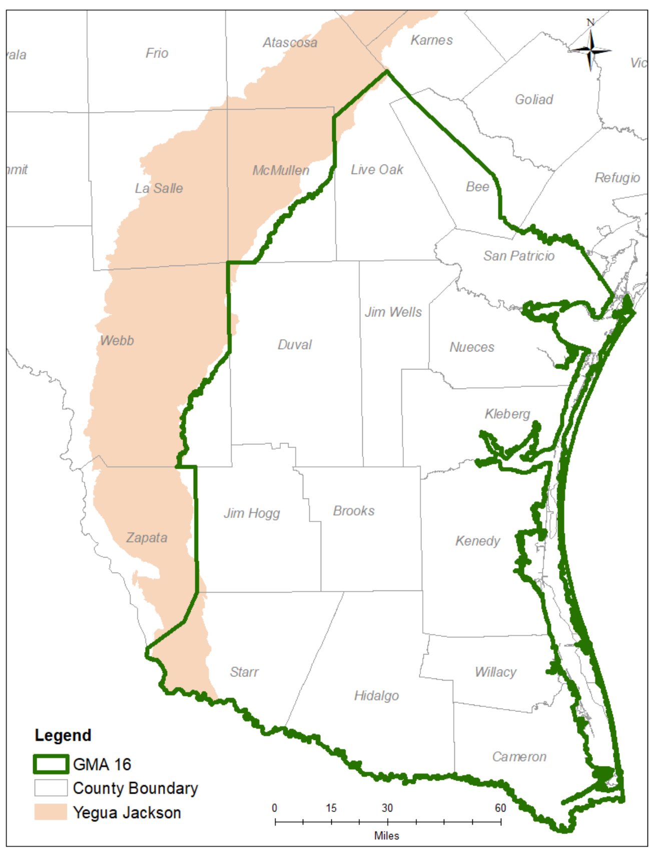

Figure 1. Location of Yegua-Jackson Aquifer in GMA 16

II. AQUIFER CHARACTERISTICS, GROUNDWATER PUMPING, AND TOTAL ESTIMATED STORAGE

The Yegua Jackson Aquifer occurs long the western edge of Duval, Jim Hogg, and Live Oak counties. The GCDs for these three counties do not have any permitted wells in the Yegua-Jackson Aquifer. The Yegua Jackson Aquifers covers the southwest portion of Starr County. The GCD for Starr County does not have any permitted wells in the Yegua-Jackson Aquifer but has about 40 registered exempted wells. Table 1 provides the estimated pumping in the four counties in 2018 and 2019. Table 1 also provides the estimated range of depths for the Yegua-Jackson in all four counties.

In western Starr County, McCoy (1990) the that Eocene-age strata of the Yegua Jackson provide small quantities of slightly to moderately saline water to rural wells, mostly for domestic and livestock use (Table 1). Water quality in these strata differs considerably across the area Bind there does not seem to be any pattern or uniformity to the distribution. In Duval County, Schafer (1774) reports that the Jackson group consists of an estimated 1,000-1,600 feet of brown to buff sandy shale, fossiliferous sandstone, and beds of volcanic ash. The unit is reported to yield small quantities of moderately saline water to a few wells in the northwestern part of the county. In Live Oak County, Anders and Baker (1961) report that the Jackson group yield very small to small amounts of slightly to moderately saline water and some thin strata that contain highly saline water.

Table 2 provides the Total Estimated Recoverable Storage (TERS) for the Carrizo-Wilcox that lies within each county and within GMA 16. Additional information on the TERS is available from Jigmond and Wade (2013).

Table 2. Aquifer Characteristics for the Yegua-Jackson Aquifer in GMA 16 for Duval, Jim Hogg, Live Oak, and Starr Counties in GMA 16

Groundwater Conservation District (GCD) or Conservation District (CD)	County	Total Estimated Recoverable Storage (acre-feet)	Historical Pumping (acre-feet/yr)		Approximate Range of Depths (ft)	
			2018	2019	Top of Yegua-Jackson	Bottom of Yegua Jackson
Duval County GCD	Duval	7,200,000	1	1	0	3500
Brush Country GCD	Jim Hogg	3,000,000	NR	NR	0	2600
Live Oak Underground CD	Live Oak	11,000,000	26	26	300	2000
Starr County GCD	Starr	46,000,000	170	164	0	3800
Notes: TERS values obtained from TWDB (2013)						
Historical Pumping obtained from TWDB web site: http://www.twdb.texas.gov/waterplanning/index.asp						
NR = none reported						

III. EXPLANATION OF NON-RELEVANCE

The portion of the Yegua-Jackson Aquifer in Duval, Live Oak, and Jim Hogg counties currently has low pumping and there is no notable anticipated increase in pumping in the next 20 years. In Starr County, moderate amount of pumping occurs in the Yegua-Jackson but the pumping remains sufficiently low for pumping impacts to no warrant a DFCs at this time. Region N

(CBRWPA, 2020) has no water management strategies that involve pumping the Yegua-Jackson. Region M (Black & Veatch, 2020) has no water management strategies that involve pumping the Yegua Jackson in GMA 16 but has two water management strategies identified for two counties near GMA 16. Region N water management strategies of 350 AFY/year from additional pumping of fresh water in Webb County and of 1,120 AFY/year from new pumping in Zapata Counties. A potential concern of any drawdown in the Yegua-Jackson in GMA 16 is an impact on water levels in the Gulf Coast Aquifer System. As a result of clay rich zone in the Catahoula that occurs between the Jasper Aquifer and the Yegua-Jackson aquifer, the hydraulic connection between the Yegua-Jackson Aquifer and the Gulf Coast Aquifer System will be low. In the area where the most up dip region of the Jasper overlies the Yegua-Jackson Aquifer in GMA 16, the GMA 16 GAM has a vertical conductivity of 0.0034 ft/day, which suggest that the Yegua-Jackson aquifer has a poor hydraulic connection to the Gulf Coast Aquifer System. As a result of its generally low yield, its low use and anticipated use in the future, the portion of the Yegua-Jackson Aquifer in Duval, Live Oak, Jim Hogg, and Star counites is classified as not relevant for purposes of joint planning in GMA 16. GMA 16 will re-evaluate the status of the non-relevant classification every joint planning cycle.

IV. REFERENCES

Anders, R. B. and Baker, E. T., 1961. Groundwater Geology of Live Oak Texas. Report 6105. Texas Water Development Board, Austin, TX.

Black & Veatch, 2020. Rio Grande Regional Water Plan: 2021 Update. Prepared by: Rio Grande Regional Water Planning Group with administration by: Lower Rio Grande Valley Development Council, March 3, 2020.

CBRWPA (Coastal Bend Regional Water Planning Area), 2020. Coastal Bend Regional Planning Area, Region N. Prepared for the Texas Water Development Board. Prepared by: Rio Grande Regional Water Planning Group with technical assistance from HDR Engineering, March 2020.

George, P.G., Mace, R.E., and Petrossian, R., 2011. Aquifers of Texas. Texas Water Development Board Report 380, July 2011, 182p.

McCoy, W., 1990. Evaluation of Ground-water Resources in the Lower Rio Grande Valley, Report 316. Texas. Texas Water Development Board. Austin Texas.

Shafter, G. H., 1994. Ground Water Resources of Duval County. Report 181. Texas Water Development Board. Austin, TX.

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APPENDIX F
PRESENTATION ON PRELIMINARY GROUNDWATER MODELING RESULTS

Groundwater Management Area 16 Joint Planning Cycle 2019-2022: Preliminary Model Results

Falfurrias, TX
January 28, 2020

Jevon Harding, P.G.
Steve Young, Ph.D., P.G., P.E.

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Meeting Objectives

- ***Review Model from Previous Joint Planning Cycle***
- District responses for updated pumping values
- Implementation of updated pumping values
- Discuss options for calculating DFC & MAG values

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Previous Model

Modeled Available Groundwater (MAG)

GCD	2010	2020	2030	2040	2050	2060	INTERA Check
Bee GCD	7,689	8,971	10,396	11,061	11,392	11,584	11,584
Brush Country GCD*	14,182	18,672	19,037	19,365	19,730	20,022	20,022
Duval County GCD	18,973	20,571	22,169	23,764	25,363	26,963	26,983
Kenedy County GCD	13,989	23,314	32,637	41,964	51,289	51,289	51,287
Live Oak UWCD	6,556	8,338	9,343	8,564	8,441	8,441	8,441
McMullen GCD	510	510	510	510	510	510	510
Red Sands GCD	1,368	1,667	1,966	2,265	2,563	2,863	2,863
San Patricio County GCD	14,201	43,611	45,016	46,422	47,828	49,234	49,234
Starr County GCD	2,742	3,722	4,701	5,681	6,659	7,639	7,639

** The published MAG report (Goswami, 2017) has a typo – these are the corrected values from TWDB website*

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3

Previous Model

Desired Future Conditions (DFC)

GCD	2060	INTERA Check
Bee GCD	76	76
Brush Country GCD	69	69
Duval County GCD	104	107
Kenedy County GCD	40	39
Live Oak UWCD	34	34
McMullen GCD	9	9
Red Sands GCD	40	40
San Patricio County GCD	48	49
Starr County GCD	69	69

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Key MAG assumptions

- ***Excludes pumping in Layer 3 (Burkeville Confining Unit)***
- Excludes pumping outside of the official TWDB Gulf Coast Aquifer boundary
- Includes pumping in cells that go dry

5

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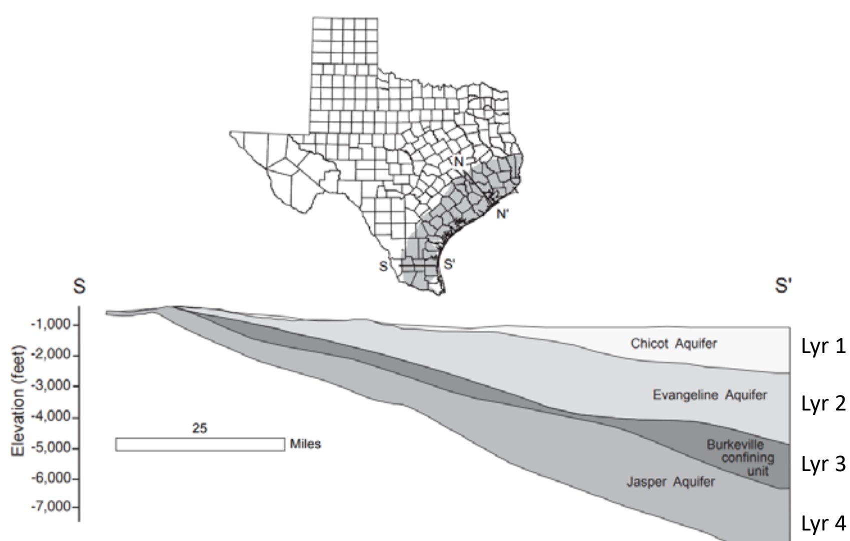
Key MAG assumptions



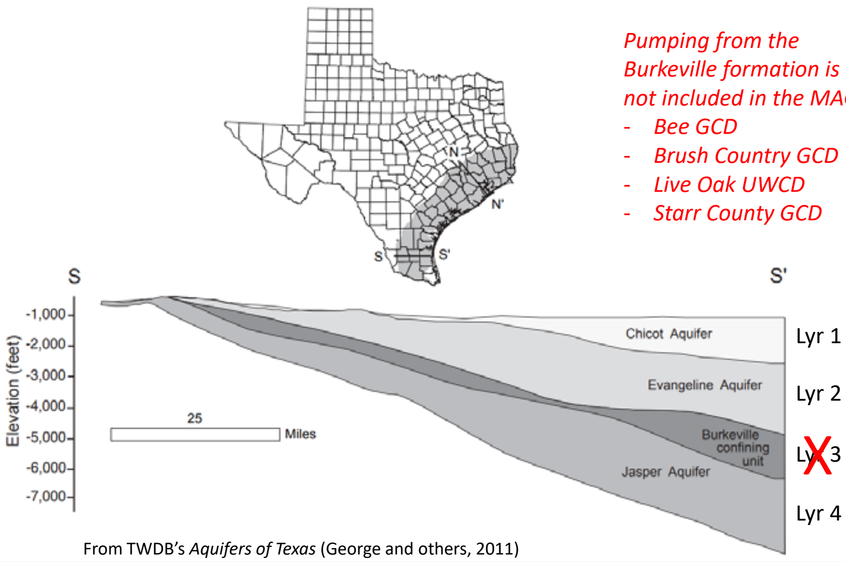
From TWDB's *Aquifers of Texas* (George and others, 2011)

6

7

Key MAG assumptions

Pumping from the Burkeville formation is not included in the MAG
- *Bee GCD*
- *Brush Country GCD*
- *Live Oak UWCD*
- *Starr County GCD*



From TWDB's *Aquifers of Texas* (George and others, 2011)

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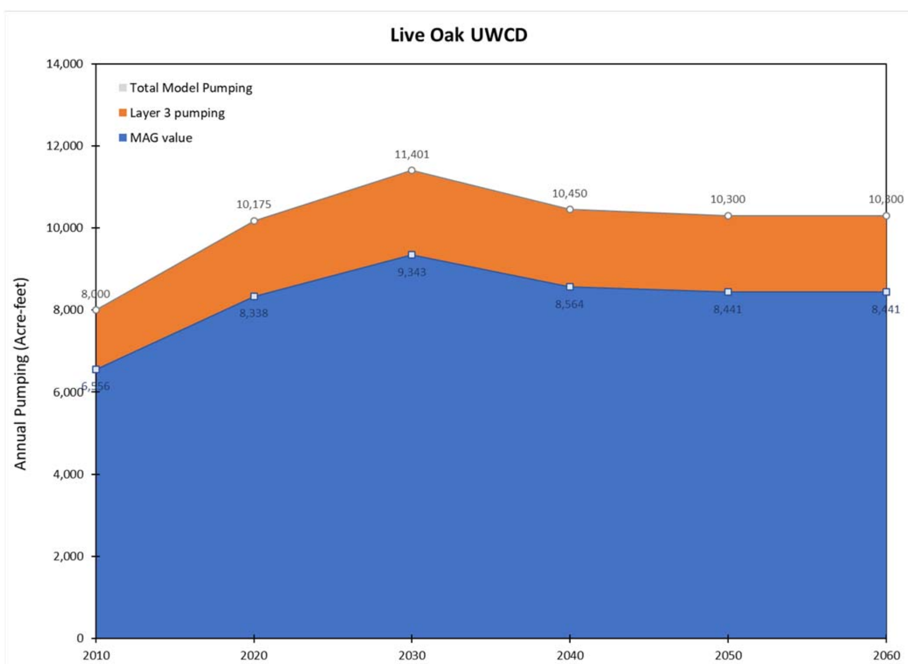

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Key MAG assumptions

Pumping in Burkeville (Layer 3)

	2010	2020	2030	2040	2050	2060
Bee GCD	405	472	547	582	599	609
Brush County GCD	7	7	7	7	7	7
Duval County GCD	0	0	0	0	0	0
Kenedy County GCD	0	0	0	0	0	0
Live Oak UWCD	1,439	1,831	2,051	1,880	1,853	1,853
McMullen GCD	0	0	0	0	0	0
Red Sands GCD	0	0	0	0	0	0
San Patricio GCD	0	0	0	0	0	0
Starr County GCD	56	76	96	116	135	156

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Key MAG assumptions

- Excludes pumping in Layer 3 (Burkeville Confining Unit)

- ***Excludes pumping outside of the official TWDB Gulf Coast Aquifer boundary***

- Includes pumping in cells that go dry

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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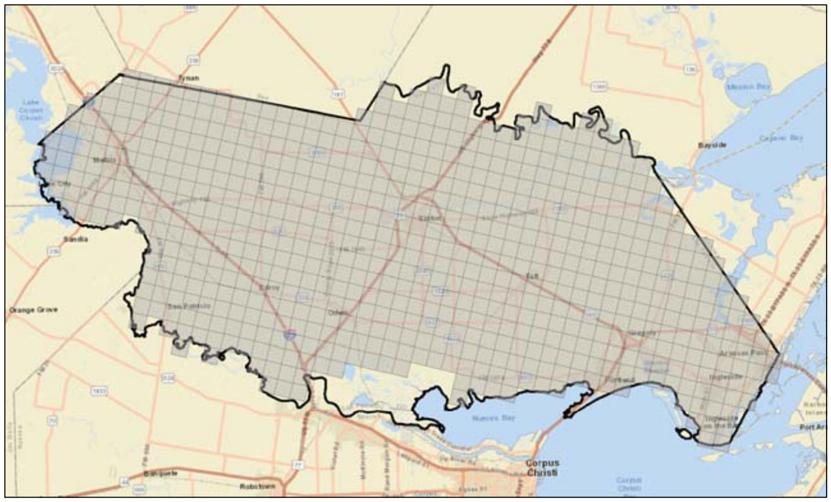
Key MAG assumptions



Active Model Cells

Model Grid   San Patricio County

0 3.5 7 14 Miles

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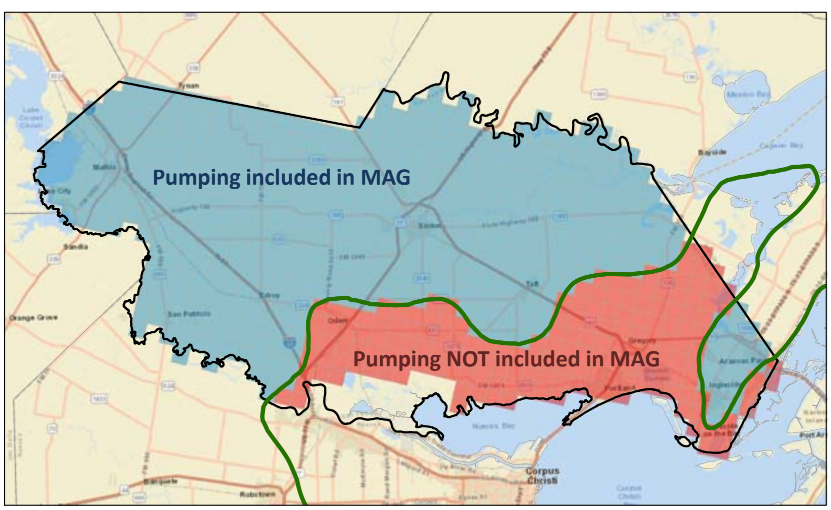
Key MAG assumptions



Active Model Cells

Inside TWDB boundary   San Patricio County

Outside TWDB boundary   TWDB Gulf Coast Aquifer boundary

0 3.5 7 14 Miles

12

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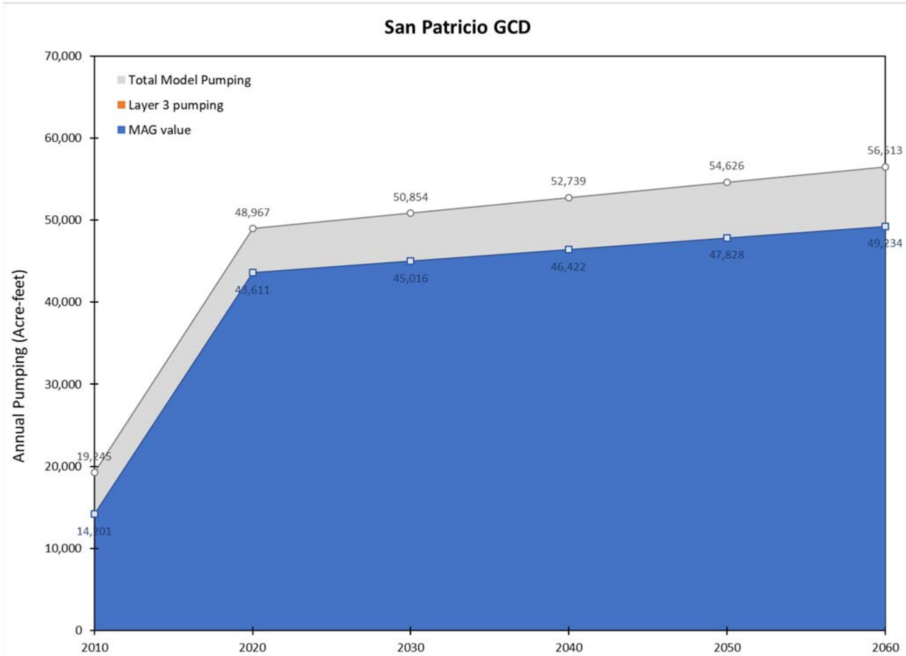

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Key MAG assumptions

Pumping outside TWDB official Gulf Coast Aquifer boundary

	2010	2020	2030	2040	2050	2060
Bee GCD	0	0	0	0	0	0
Brush County GCD	0	0	0	0	0	0
Duval County GCD	0	0	0	0	0	0
Kenedy County GCD	1,010	1,684	2,358	3,031	3,705	3,705
Live Oak UWCD	0	0	0	0	0	0
McMullen GCD	0	0	0	0	0	0
Red Sands GCD	0	0	0	0	0	0
San Patricio GCD	4,846	5,326	5,806	6,285	6,765	7,245
Starr County GCD	0	0	0	0	0	0

Affects GCDs along the Coast

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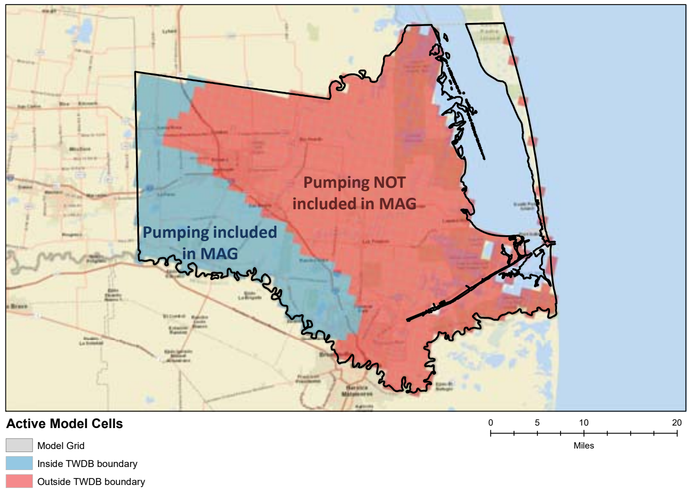
Non-District Cameron County



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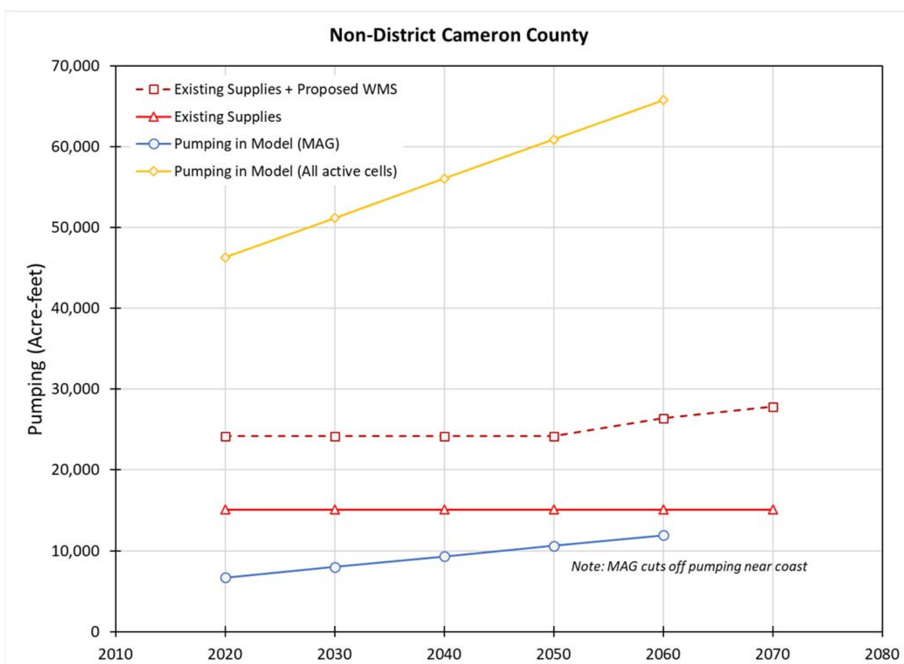

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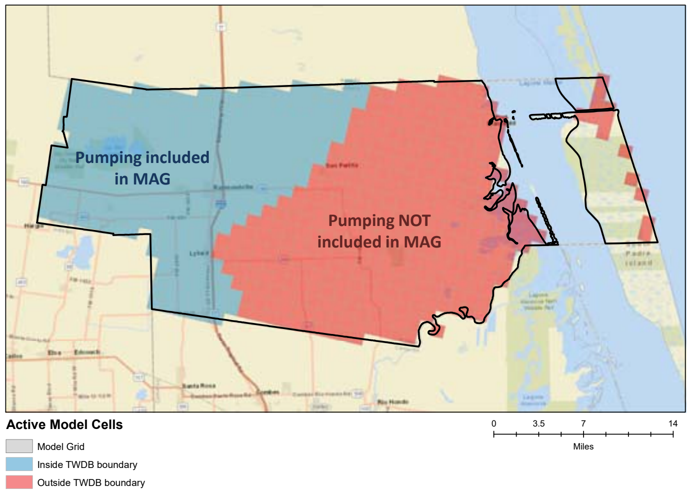
Non-District Willacy County



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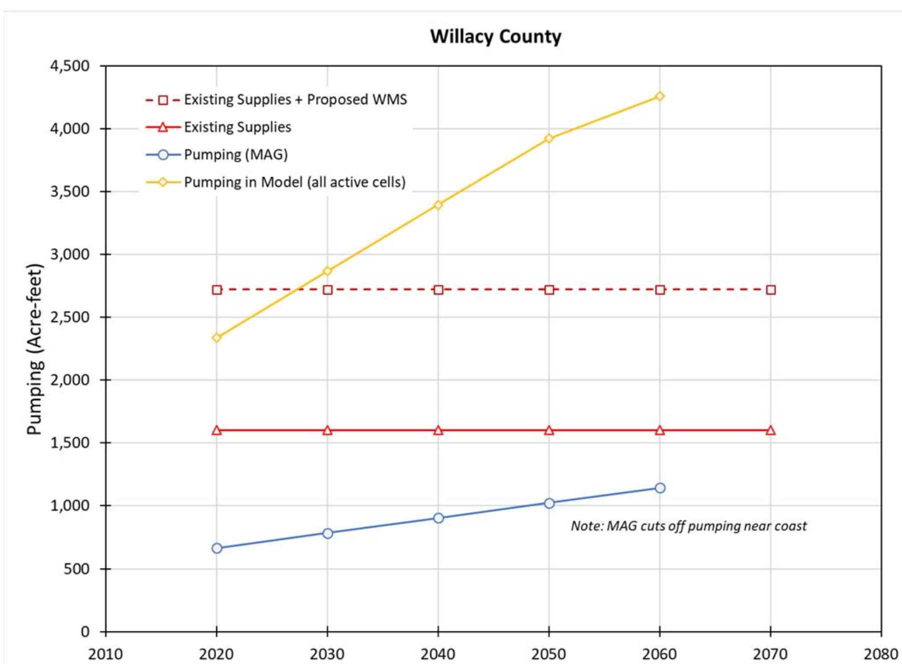

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Key MAG assumptions

- Excludes pumping in Layer 3 (Burkeville Confining Unit)
- Excludes pumping outside of the official TWDB Gulf Coast Aquifer boundary
- ***Includes pumping in cells that go dry***

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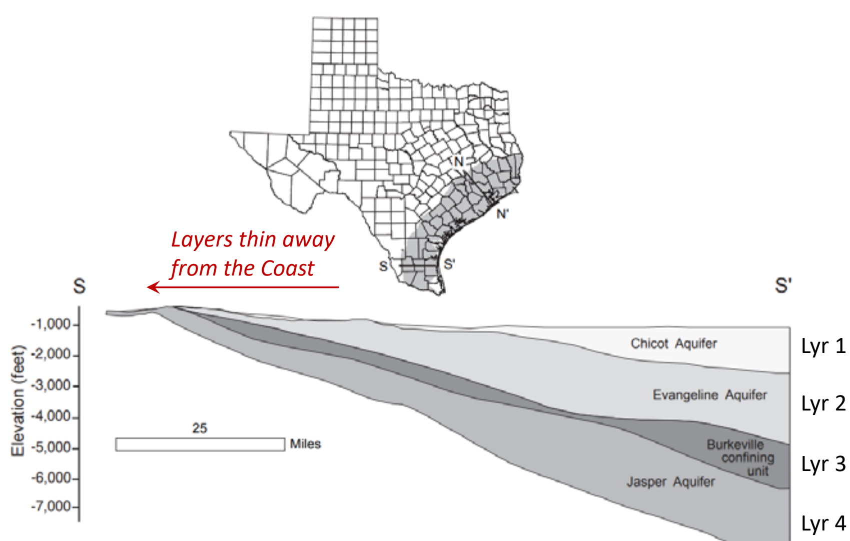
Key MAG assumptions



From TWDB's *Aquifers of Texas* (George and others, 2011)

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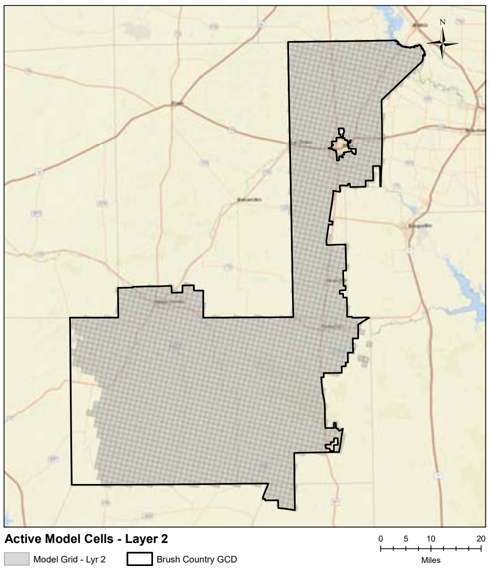
Key MAG assumptions



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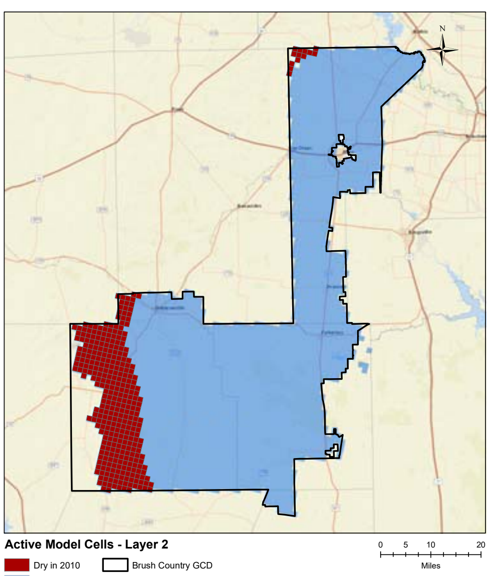
Key MAG assumptions



MAG:
Pumping in wet cells +
Pumping in dry cells

***DFC** :*
Drawdown in wet cells only

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Key MAG assumptions

Pumping within dry cells

	2000	2010	2020	2030	2040	2050	2060
Bee GCD	1,895	2,214	2,797	3,519	3,988	4,189	4,345
Brush County GCD	3,489	3,897	4,256	4,618	4,840	5,039	5,276
Duval County GCD	5,630	6,510	7,539	8,475	9,506	10,406	11,443
Kenedy County GCD	5	10	24	53	83	140	163
Live Oak UWCD	814	946	1,239	1,501	1,452	1,464	1,561
McMullen GCD	115	119	120	124	126	128	128
Red Sands GCD	92	114	168	247	388	479	578
San Patricio County GCD	754	990	1,399	1,977	2,476	2,929	3,489
Starr County GCD	367	427	624	865	1,146	1,436	1,767

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Key MAG assumptions

Pumping within dry cells (as % of total GMA 16 pumping)

	2000	2010	2020	2030	2040	2050	2060
Bee GCD	23%	27%	30%	32%	34%	35%	36%
Brush County GCD	25%	27%	23%	24%	25%	26%	26%
Duval County GCD	30%	34%	37%	38%	40%	41%	42%
Kenedy County GCD	0.0%	0.1%	0.1%	0.2%	0.2%	0.3%	0.3%
Live Oak UWCD	10%	12%	12%	13%	14%	14%	15%
McMullen GCD	23%	23%	24%	24%	25%	25%	25%
Red Sands GCD	7%	8%	10%	13%	17%	19%	20%
San Patricio County GCD	4%	5%	3%	4%	5%	5%	6%
Starr County GCD	13%	15%	16%	18%	20%	21%	23%

Affects GCDs away from the coast (closer to the outcrop)

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Meeting Objectives

- Review Model from Previous Joint Planning Cycle
- ***District responses for updated pumping values***
- Implementation of updated pumping values
- Discuss options for calculating DFC & MAG values

INTERA
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Survey Results

Changes Requested:

- Bee GCD - move 1,000 AF from GMA 16 --> GMA 15
- Brush Country GCD – update pumping timeline
- Kenedy County GCD – update pumping timeline
- San Patricio GCD – update old model values, if necessary

Requested NO change:

- Duval County GCD
- Red Sands GCD
- Live Oak UWCD
- McMullen GCD

Excluded (assumed no change):

- Corpus Christi ASRCD
- Starr County GCD

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Meeting Objectives

- Review Model from Previous Joint Planning Cycle
- District responses for updated pumping values
- ***Implementation of updated pumping values***
- Discuss options for calculating DFC & MAG values

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Groundwater Availability Model Runs

- Extended to 2080 to be consistent with the next regional water planning cycle
- Performed two Model Runs:
  - Original model extended to 2080
    - assumed 2080 pumping = 2060 pumping
  - Updated pumping values extended to 2080
    - For GCDs/counties with no change, assumed 2080 pumping = 2060 pumping
    - For GCDs with updated pumping, assumed 2080 pumping = 2070 pumping

INTERA
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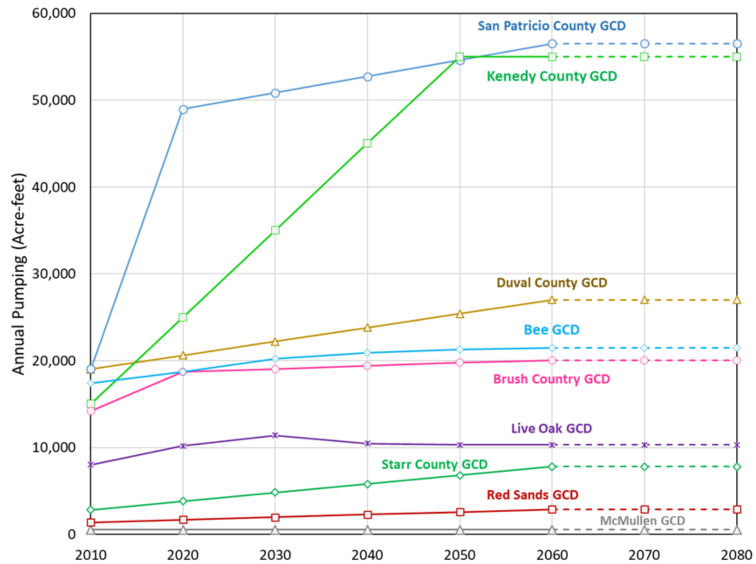
Groundwater Availability Model Run #1

Unchanged Pumping Extended to 2080:



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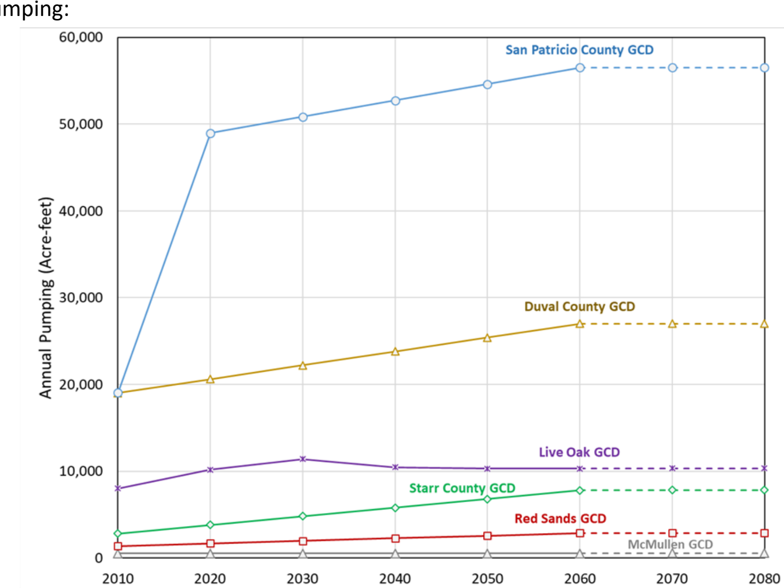
Groundwater Availability Model Run #2

Unchanged Pumping:



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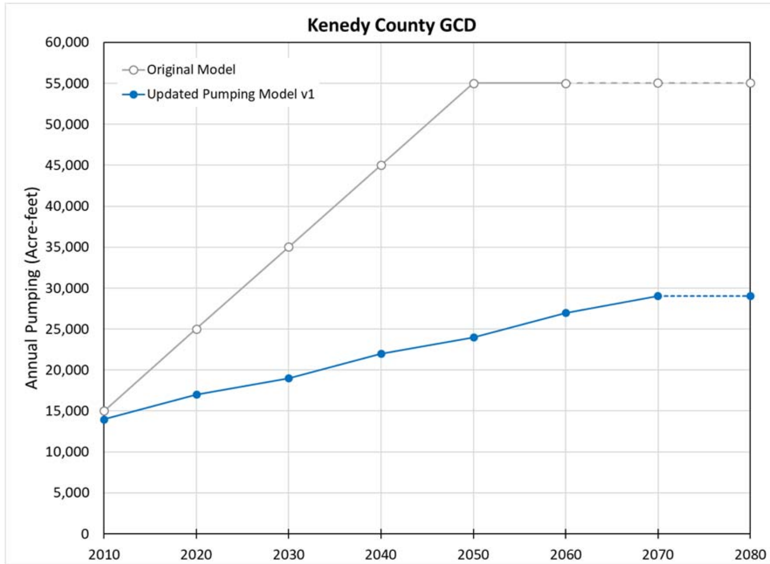
Groundwater Availability Model Run #2

Requested Changes to Pumping:



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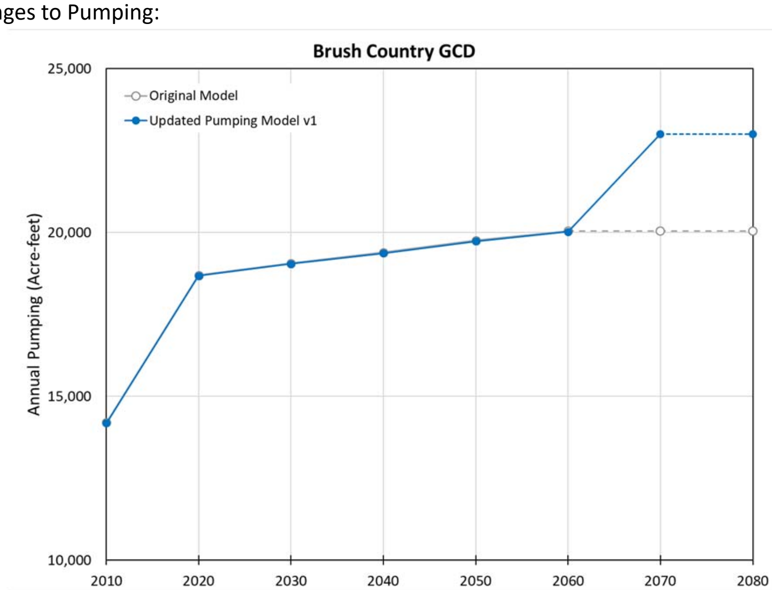
Groundwater Availability Model Run #2

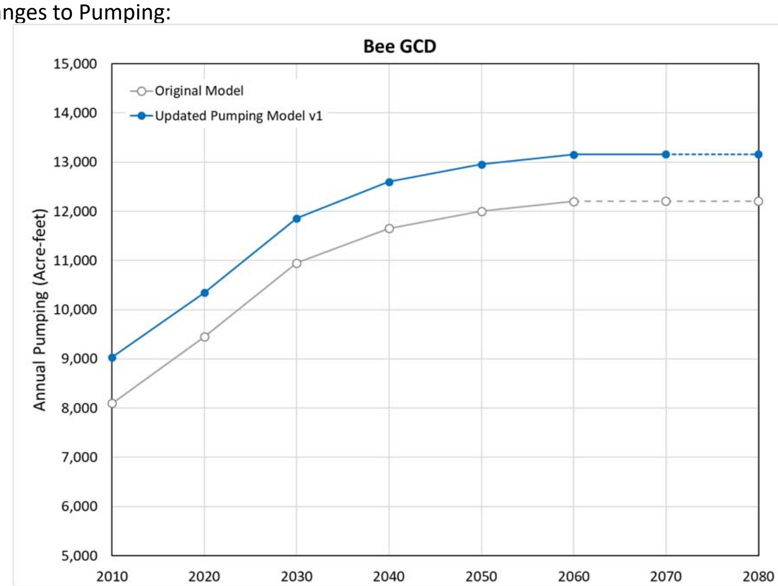
Requested Changes to Pumping:



32

Groundwater Availability Model Run #2

Requested Changes to Pumping:



33

Meeting Objectives

- Review Model from Previous Joint Planning Cycle
- District responses for updated pumping values
- Implementation of updated pumping values
- ***Discuss options for calculating DFC & MAG values***

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Preliminary Model Results

DFC

	Original Model Pumping extended to 2080		Updated Model Pumping extended to 2080	
	Inside TWDB boundary only 2080	Include area outside TWDB boundary 2080	Inside TWDB boundary only 2080	Include area outside TWDB boundary 2080
Bee GCD	91	91	91	91
Brush County GCD	91	91	90	90
Duval County	136	136	136	136
Kenedy County GCD	51	49	28	26
Live Oak UWCD	44	44	44	44
McMullen GCD	12	12	12	12
Red Sands GCD	65	65	61	61
San Patricio County GCD	69	61	69	61
Starr County GCD	94	94	94	94

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Preliminary Model Results

MAG

	Original Model			Updated Model		
	Inside TWDB boundary only 2080	Include area outside TWDB boundary 2080	Include area outside & exclude Dry cells 2080	Inside TWDB boundary only 2080	Include area outside TWDB boundary 2080	Include area outside & exclude Dry cells 2080
Bee GCD	12,201	12,201	7,856	13,154	13,154	8,809
Brush County GCD	20,043	20,043	14,767	23,000	23,000	17,723
Duval County GCD	27,001	27,001	15,558	27,001	27,001	15,558
Kenedy County GCD	51,322	55,027	54,864	27,048	29,000	28,837
Live Oak UWCD	10,300	10,300	8,739	10,300	10,300	8,739
McMullen GCD	510	510	382	510	510	382
Red Sands GCD	2,865	2,865	2,287	2,865	2,865	2,287
San Patricio GCD	49,268	56,513	53,024	49,268	56,513	53,024
Starr County GCD	7,800	7,800	6,033	7,800	7,800	6,033

Highlight = GCDs along Coast

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Preliminary Model Results

MAG

	Original Model			Updated Model		
	Inside TWDB boundary only 2080	Include area outside TWDB boundary 2080	Include area outside & exclude Dry cells 2080	Inside TWDB boundary only 2080	Include area outside TWDB boundary 2080	Include area outside & exclude Dry cells 2080
Bee GCD	12,201	12,201	7,856	13,154	13,154	8,809
Brush County GCD	20,043	20,043	14,767	23,000	23,000	17,723
Duval County GCD	27,001	27,001	15,558	27,001	27,001	15,558
Kenedy County GCD	51,322	55,027	54,864	27,048	29,000	28,837
Live Oak UWCD	10,300	10,300	8,739	10,300	10,300	8,739
McMullen GCD	510	510	382	510	510	382
Red Sands GCD	2,865	2,865	2,287	2,865	2,865	2,287
San Patricio GCD	49,268	56,513	53,024	49,268	56,513	53,024
Starr County GCD	7,800	7,800	6,033	7,800	7,800	6,033

Highlight = GCDs with high % dry cell pumping

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Questions?

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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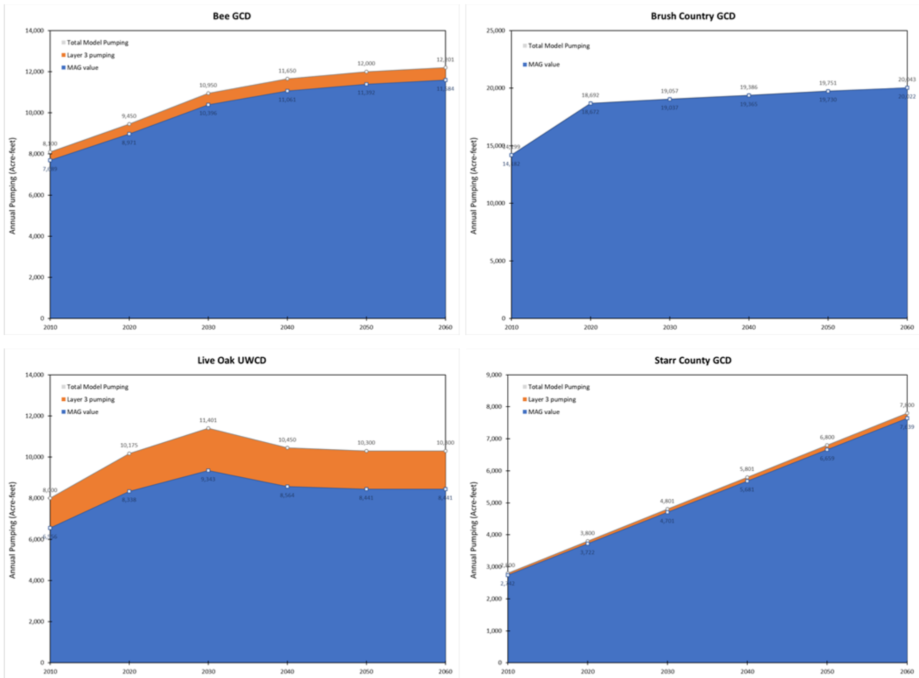
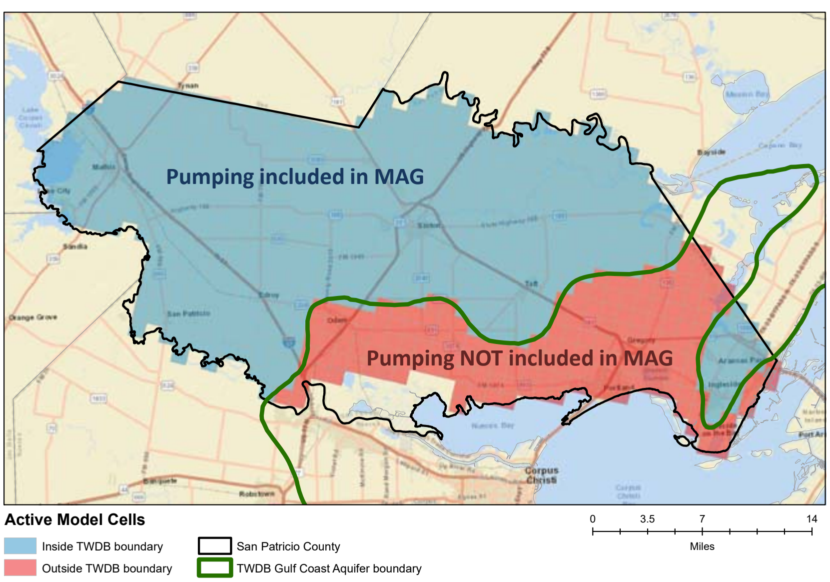
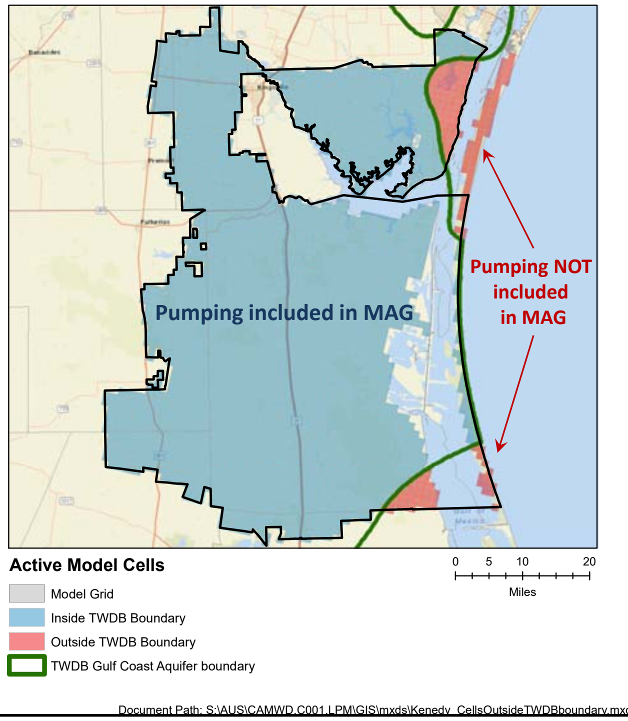

Bee GCD
Total Model Pumping
Layer 3 pumping
MAG value
Annual Pumping (Acre-feet)
9,450
8,971
10,950
10,396
11,650
11,061
12,000
11,392
Brush Country GCD
Total Model Pumping
MAG value
Annual Pumping (Acre-feet)
18,692
18,672
19,057
19,037
19,386
19,365
19,751
19,730
Live Oak UWCD
Total Model Pumping
Layer 3 pumping
MAG value
Annual Pumping (Acre-feet)
10,175
8,338
11,401
9,343
10,450
8,564
10,300
8,441
Starr County GCD
Total Model Pumping
Layer 3 pumping
MAG value
Annual Pumping (Acre-feet)
3,800
3,722
4,801
4,701
5,801
5,681
6,800
6,659
2010
2020
2030
2040
2050
2060

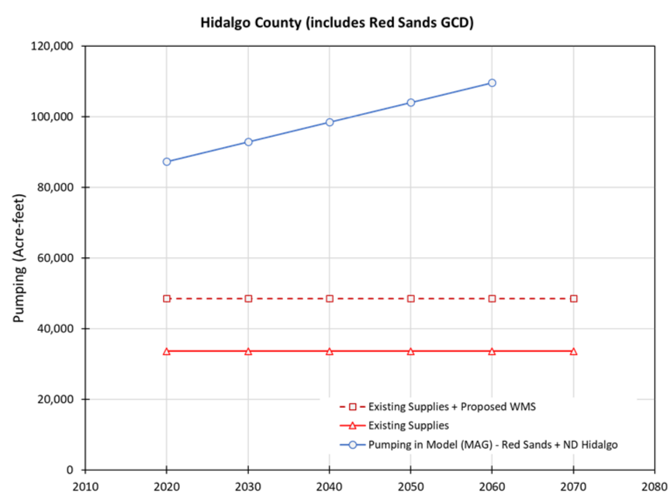
39


Pumping included in MAG
Pumping NOT included in MAG
Corpus Christi
Active Model Cells
Inside TWDB boundary
Outside TWDB boundary
San Patricio County
TWDB Gulf Coast Aquifer boundary
0
3.5
7
14
Miles

40


Pumping included in MAG
Pumping NOT included in MAG
Active Model Cells
0 5 10 20
Miles
Model Grid
Inside TWDB Boundary
Outside TWDB Boundary
TWDB Gulf Coast Aquifer boundary
Document Path: S:\AUS\CAMWD.C001.LPM\GIS\mxds\Kenedy_CellsOutsideTWDBboundary.mxd

41


Hidalgo County (includes Red Sands GCD)
Pumping (Acre-feet)
120,000
100,000
80,000
60,000
40,000
20,000
0
2010 2020 2030 2040 2050 2060 2070 2080
Existing Supplies + Proposed WMS
Existing Supplies
Pumping in Model (MAG) - Red Sands + ND Hidalgo

42


Starr County
Existing Supplies + Proposed WMS
Existing Supplies
Pumping in Model (MAG)
Pumping (Acre-feet)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2010
2020
2030
2040
2050
2060
2070
2080

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APPENDIX G
PRESENTATION ON AQUIFER USES AND CONDITIONS

Groundwater Management Area 16 Joint Planning Cycle: 2019-2022 Aquifer Uses & Conditions

Falfurrias, TX
January 28, 2020
Jevon Harding, P.G.
Steve Young, Ph.D., P.G., P.E.

1

Joint Planning Requirements

- Balancing Test
  - 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*"

2

Joint Planning Requirements

- Consideration of 9 "factors" (paraphrased)
  - ***Aquifer uses or conditions***
  - Water supply needs and management strategies
  - Hydrological conditions
  - Other environmental impacts
  - Impact on subsidence
  - Socioeconomic impacts
  - Impact on private property rights
  - Feasibility of achieving the DFC
  - Any other relevant information

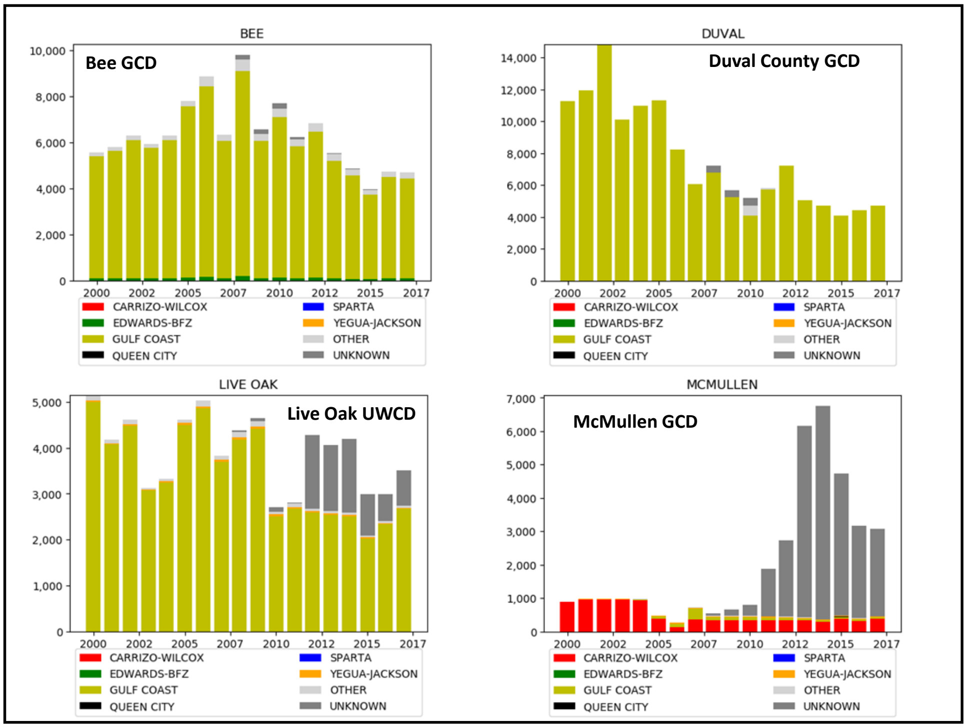
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

3

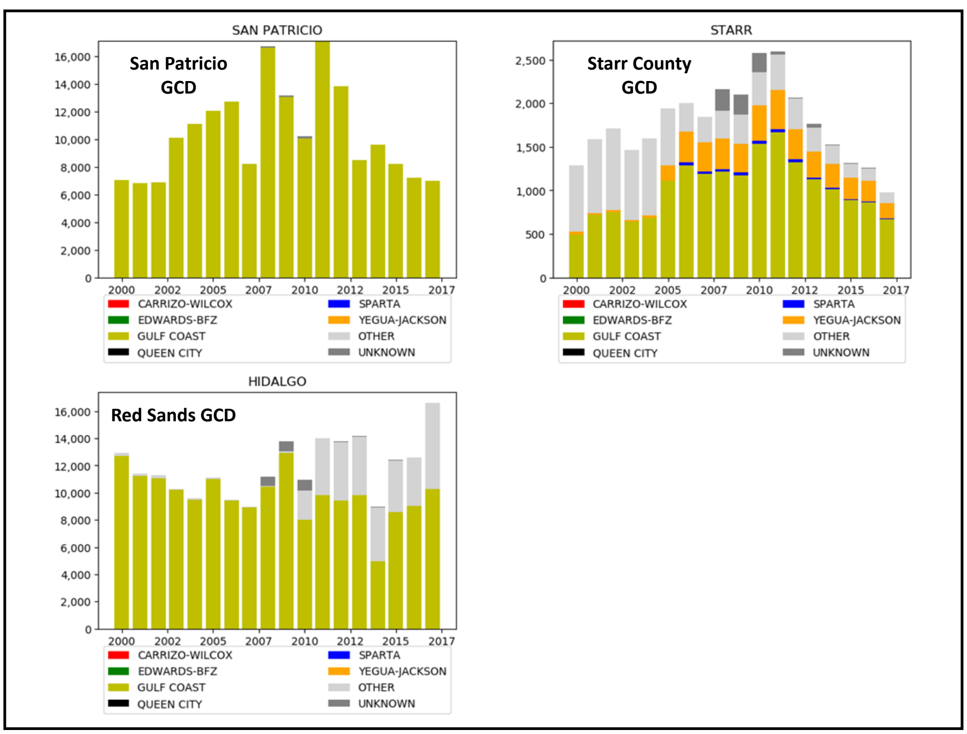
TWDB Historical Groundwater Pumping

- TWDB Historical Groundwater Pumpage Estimates are specific to the location where groundwater is pumped from the aquifer
- Downloaded from https://www3.twdb.texas.gov/apps/reports/WU/SumFinal_CountyPumpage
- Pumpage estimates do *NOT* include Rural Domestic Pumping values
- Compiled on County-level *NOT* on GCD-level
- Uncertainty due to Survey response rate

4

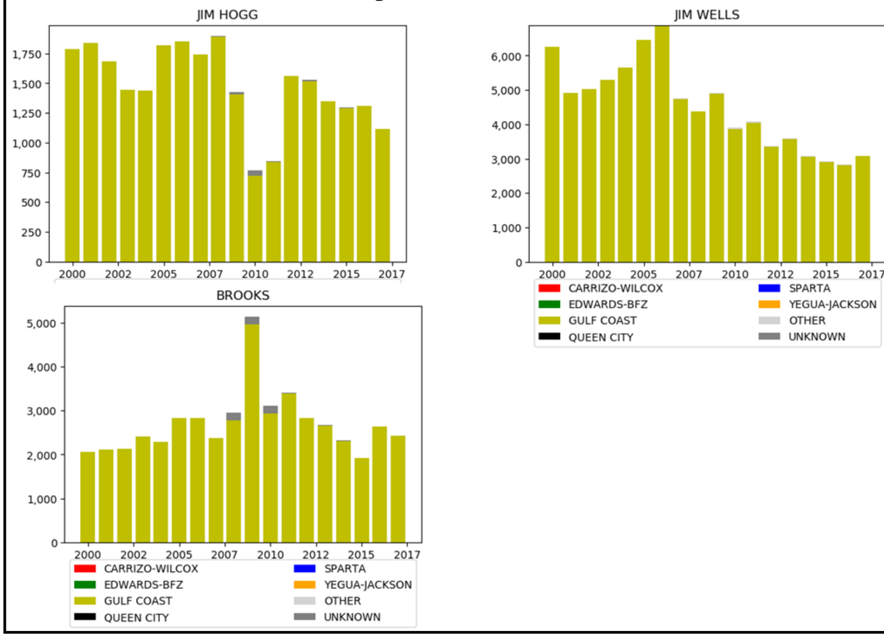

BEE
Bee GCD
DUVAL
Duval County GCD
LIVE OAK
Live Oak UWCD
MCMULLEN
McMullen GCD
CARRIZO-WILCOX
SPARTA
EDWARDS-BFZ
YEGUA-JACKSON
GULF COAST
OTHER
QUEEN CITY
UNKNOWN

5


SAN PATRICIO
San Patricio GCD
STARR
Starr County GCD
HIDALGO
Red Sands GCD
CARRIZO-WILCOX
SPARTA
EDWARDS-BFZ
YEGUA-JACKSON
GULF COAST
OTHER
QUEEN CITY
UNKNOWN

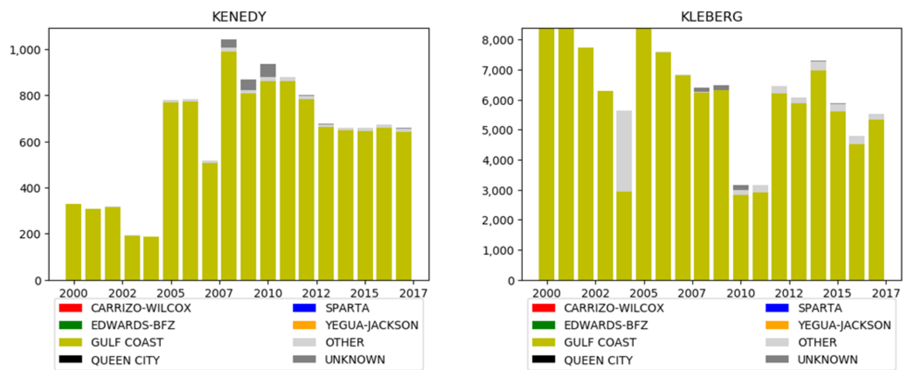
6

Brush Country GCD



7

Kenedy County GCD



8

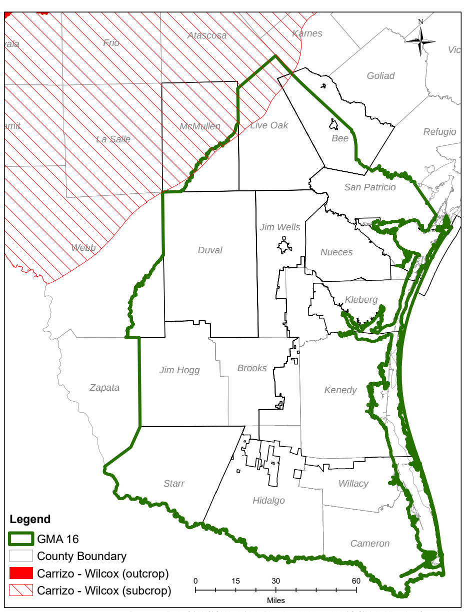
Non-Relevant Aquifers

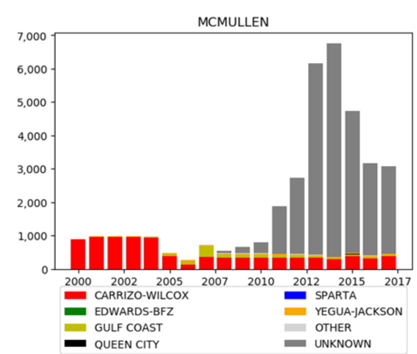
The Texas Water Development Board, in its July 2013 document, Explanatory Report for Submittal of Desired Future Conditions to the Texas Water Development Board, offers the following guidance regarding documentation for aquifers that are to be classified not relevant for purposes of joint planning:

> *Districts in a groundwater management area may, as part of the process for adopting and submitting desired future conditions, propose classification of a portion or portions of a relevant aquifer as non-relevant (31 Texas Administrative Code 356.31 (b)). This proposed classification of an aquifer may be made if the districts determine that aquifer characteristics, groundwater demands, and current groundwater uses do not warrant adoption of a desired future condition.*
>
> *The districts must submit to the TWDB the following documentation for the portion of the aquifer proposed to be classified as non-relevant:*
>
> 1. *A description, location, and/or map of the aquifer or portion of the aquifer;*
> 2. *A summary of aquifer characteristics, groundwater demands, and current groundwater uses, including the total estimated recoverable storage as provided by the TWDB, that support the conclusion that desired future conditions in adjacent or hydraulically connected relevant aquifer(s) will not be affected; and*
> 3. *An explanation of why the aquifer or portion of the aquifer is non-relevant for joint planning purposes.*

9

Non-Relevant Aquifers

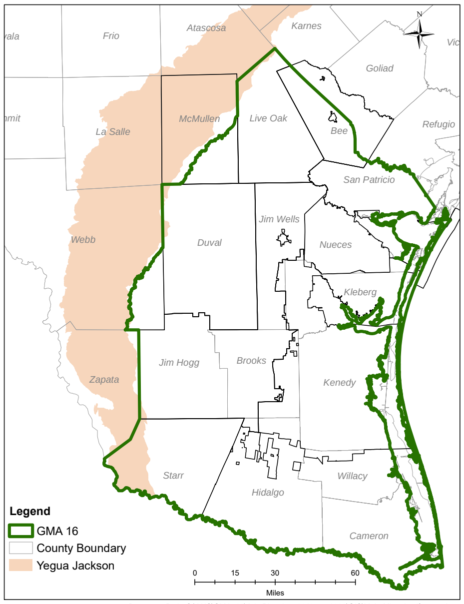


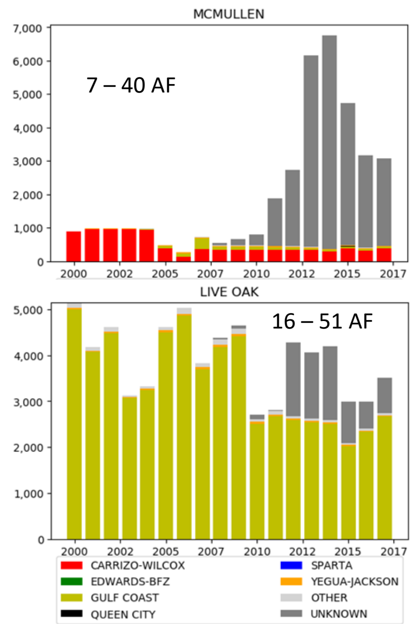


10

Non-Relevant Aquifers

11

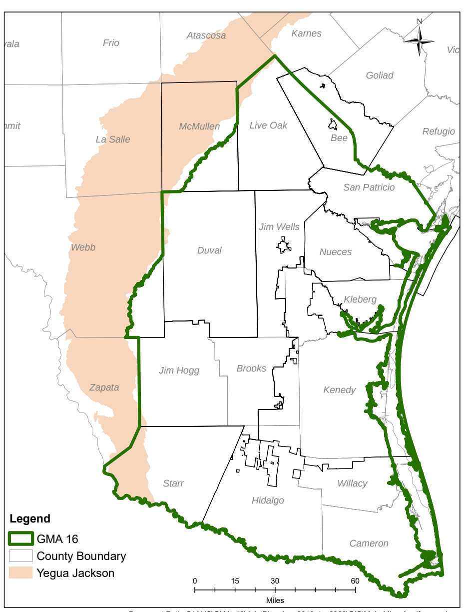


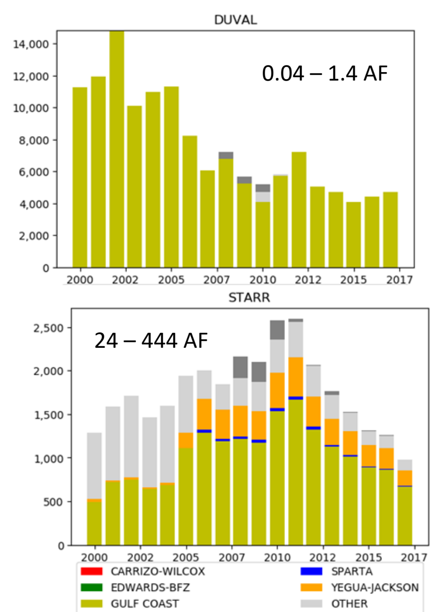


11

Non-Relevant Aquifers

12

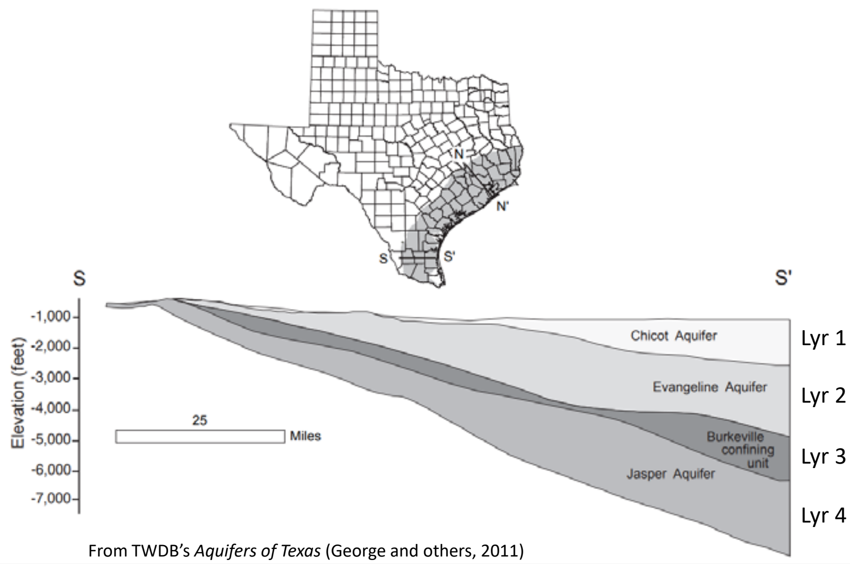




12

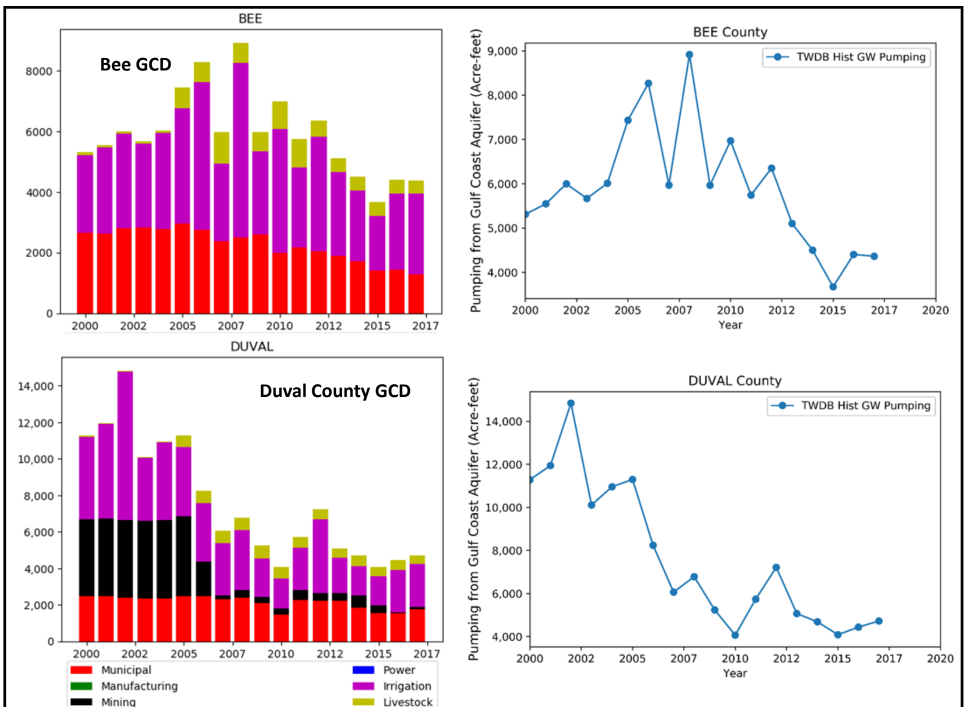
13

Gulf Coast Aquifer

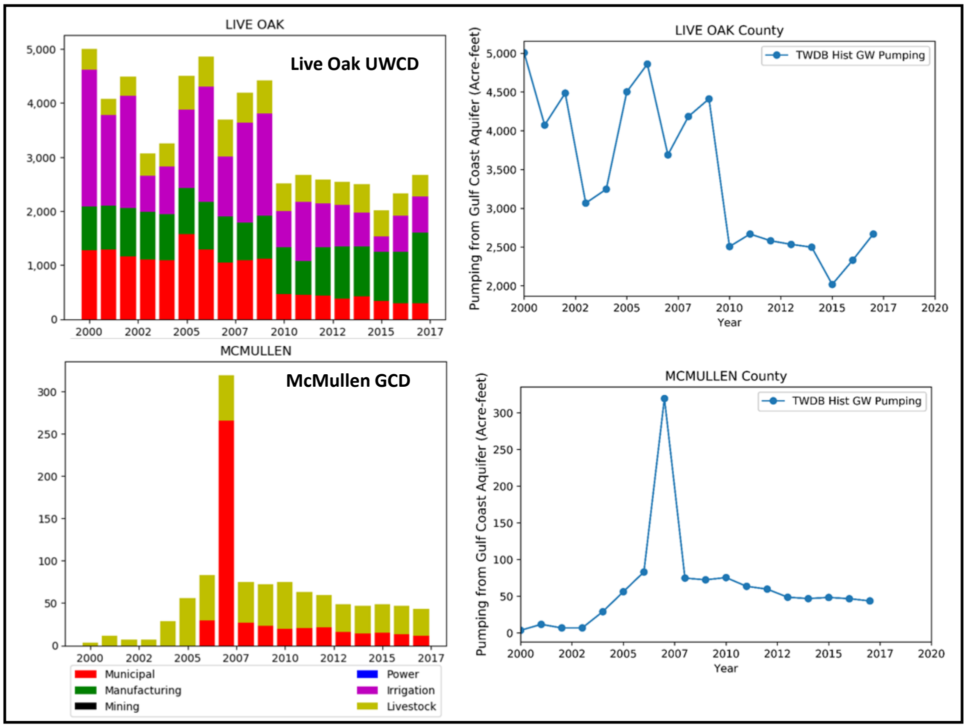


From TWDB's *Aquifers of Texas* (George and others, 2011)

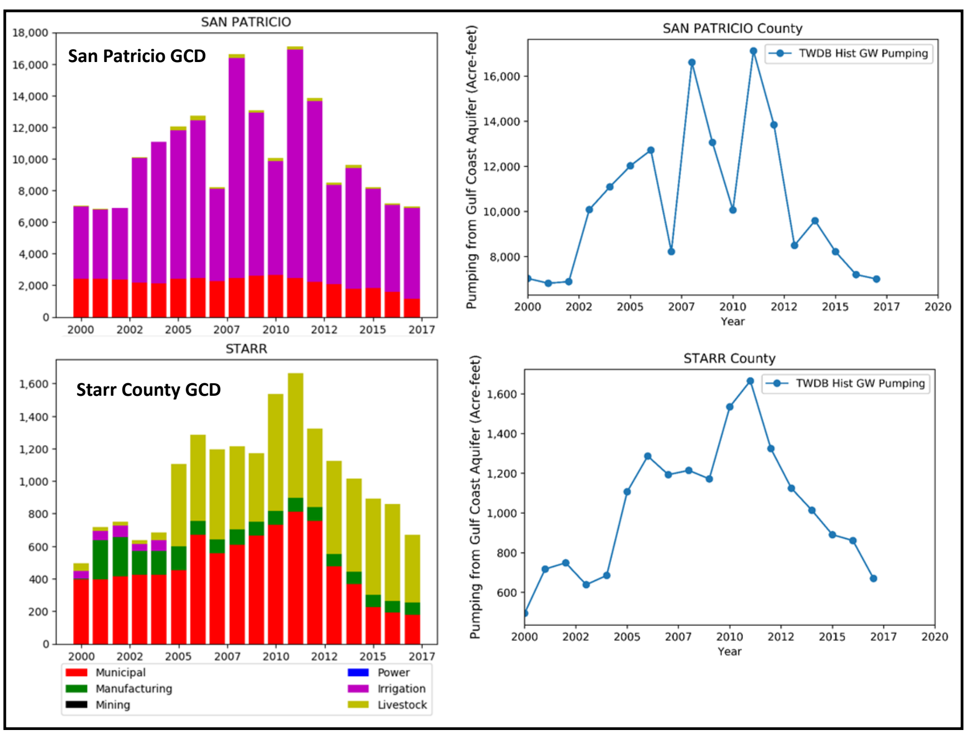
13



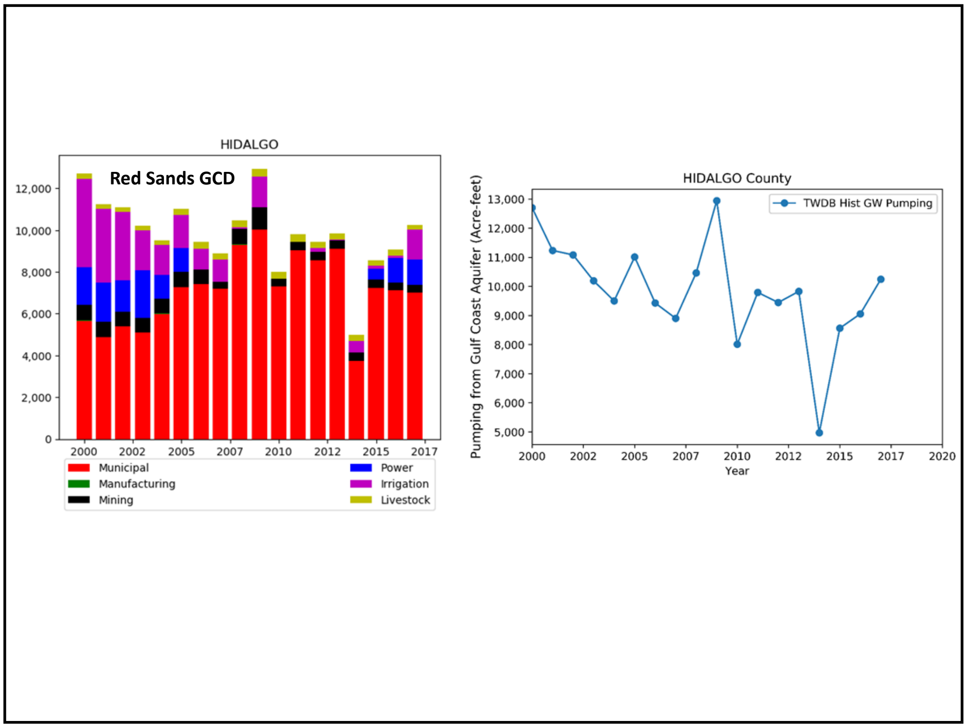
14


LIVE OAK
Live Oak UWCD
LIVE OAK County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year
MCMULLEN
McMullen GCD
MCMULLEN County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year
Municipal
Manufacturing
Mining
Power
Irrigation
Livestock

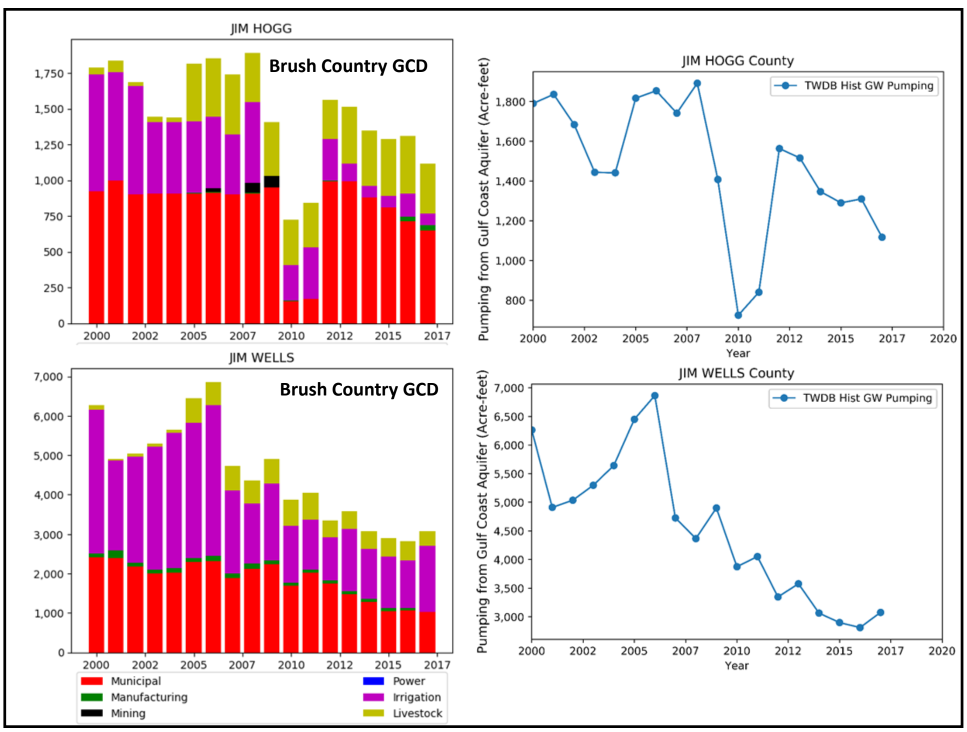
15


SAN PATRICIO
San Patricio GCD
SAN PATRICIO County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year
STARR
Starr County GCD
STARR County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year
Municipal
Manufacturing
Mining
Power
Irrigation
Livestock

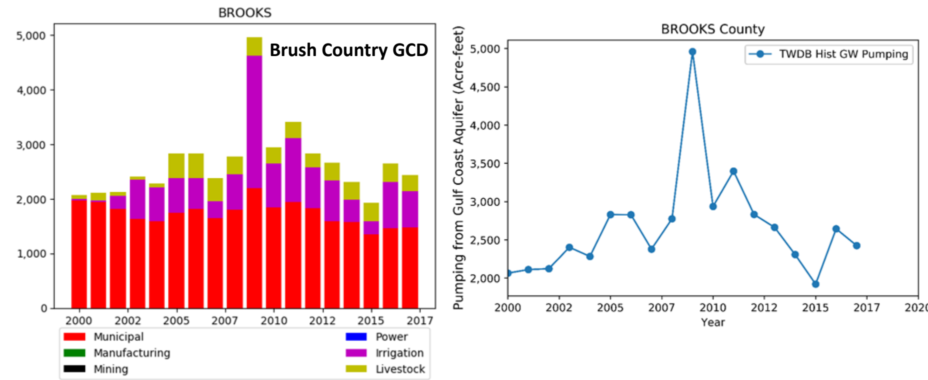
16


HIDALGO
Red Sands GCD
Municipal
Manufacturing
Mining
Power
Irrigation
Livestock
HIDALGO County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year

17


JIM HOGG
Brush Country GCD
JIM HOGG County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year
JIM WELLS
Brush Country GCD
JIM WELLS County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year
Municipal
Manufacturing
Mining
Power
Irrigation
Livestock

18


BROOKS
Brush Country GCD
Municipal
Manufacturing
Mining
Power
Irrigation
Livestock
BROOKS County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year

19

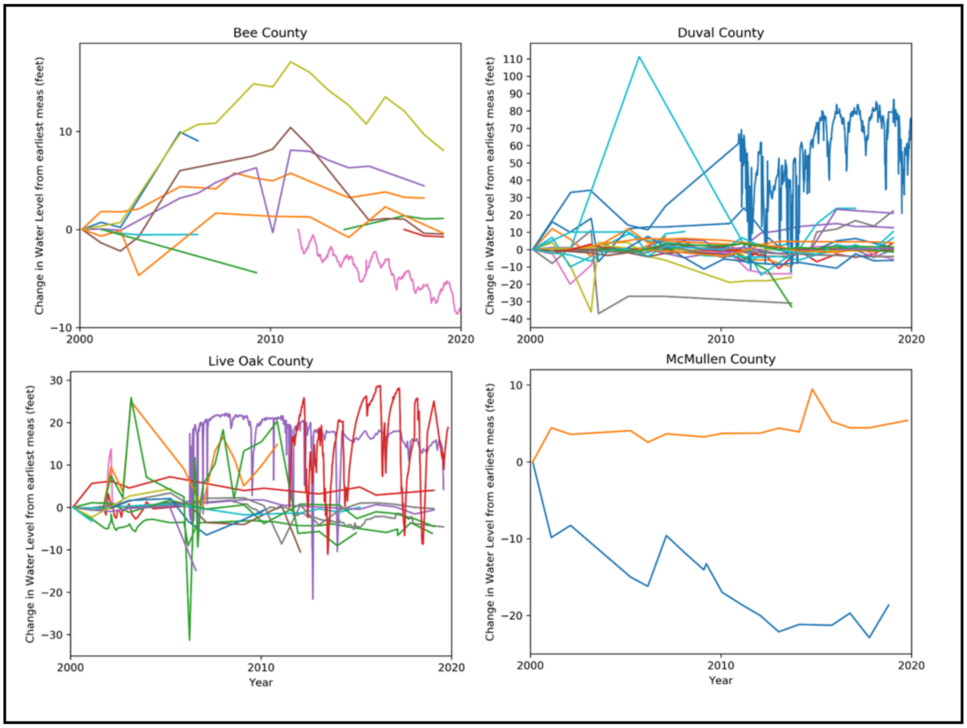

KENEDY
Kenedy County GCD
KENEDY County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year
KLEBERG
Kenedy County GCD
KLEBERG County
TWDB Hist GW Pumping
Pumping from Gulf Coast Aquifer (Acre-feet)
Year
Municipal
Manufacturing
Mining
Power
Irrigation
Livestock

20

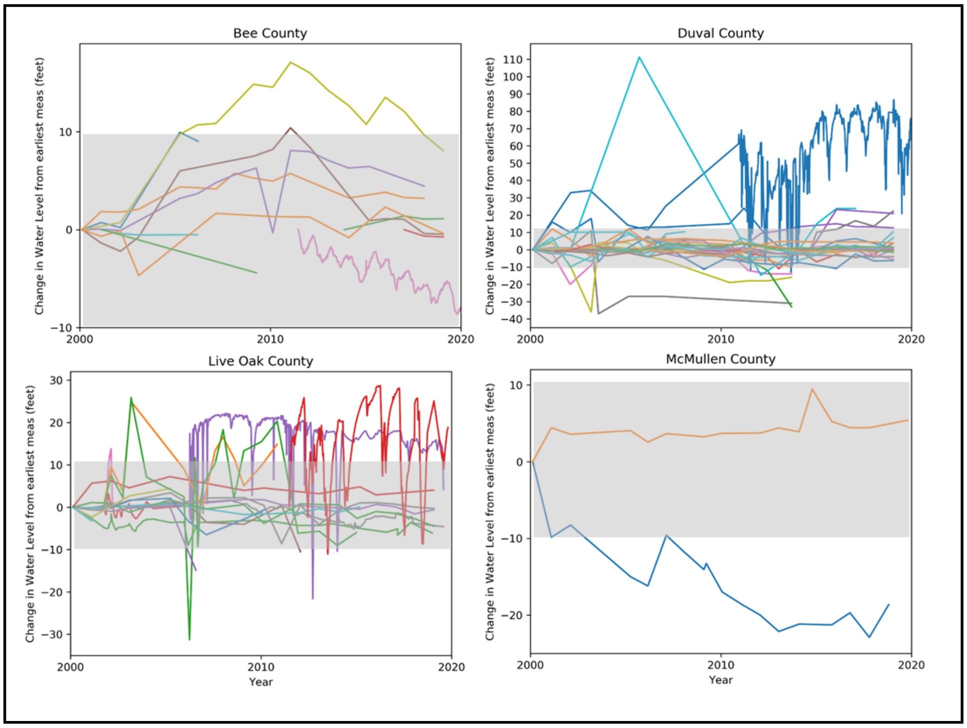
TWDB Groundwater Levels

- TWDB Groundwater database
- Downloaded from http://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp
- Compiled on County-level *NOT* on GCD-level
- Designated as Gulf Coast Aquifer, not as component formations
- Drawdown from 2000 (or earliest measurement)
- Most water levels stable <u>+</u> 10 ft

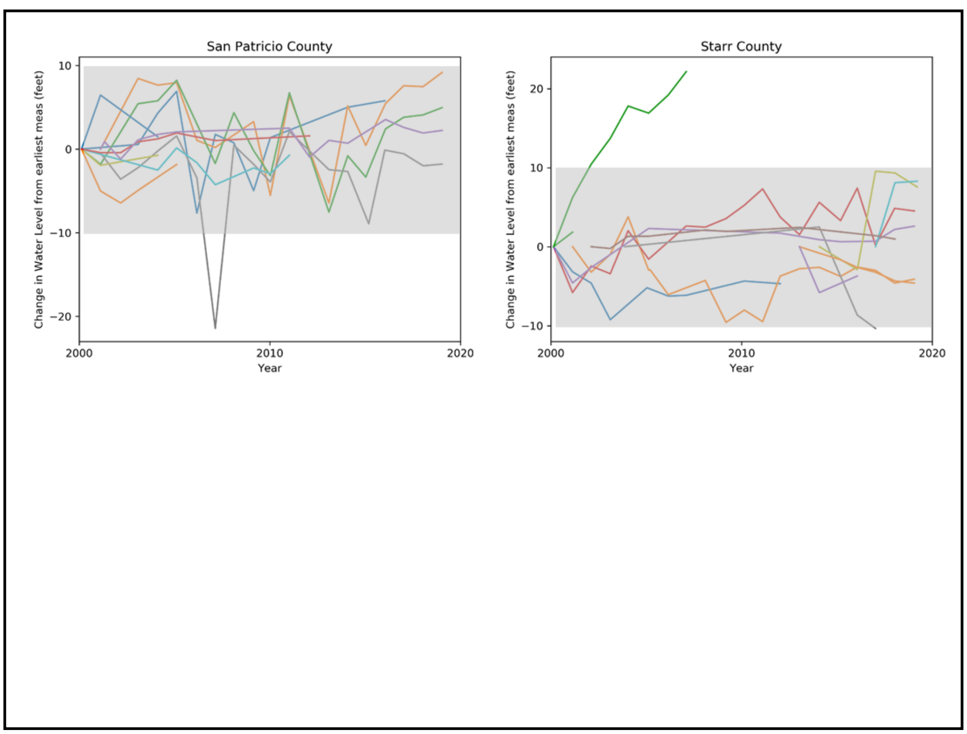
21



22

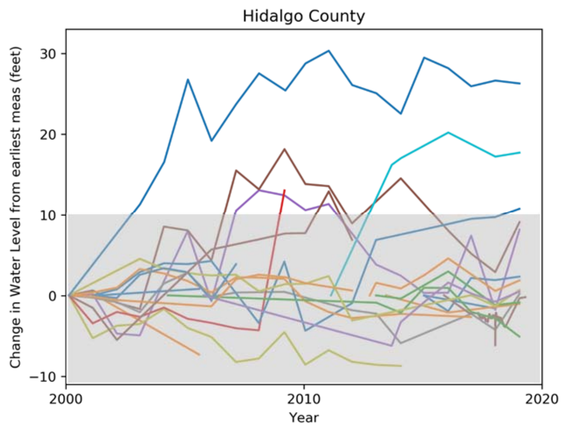

Bee County
Duval County
Live Oak County
McMullen County
Change in Water Level from earliest meas (feet)
Year

23

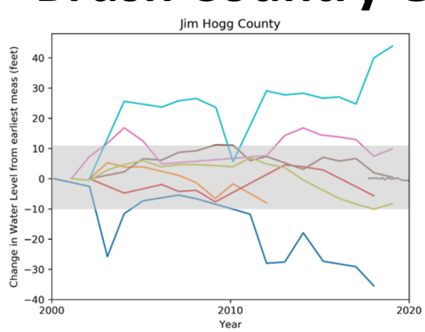

San Patricio County
Starr County
Change in Water Level from earliest meas (feet)
Year

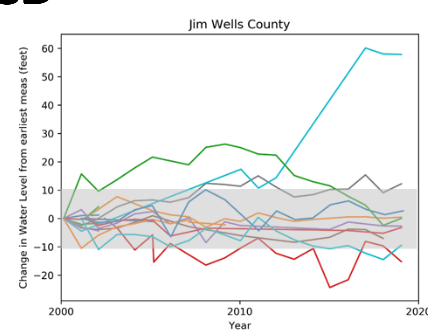
24

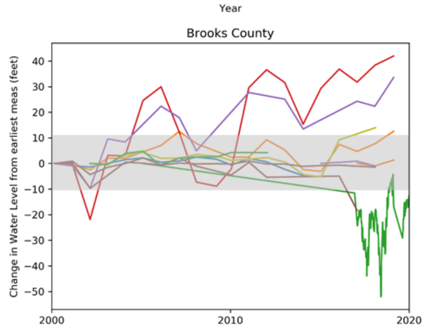
Red Sands GCD



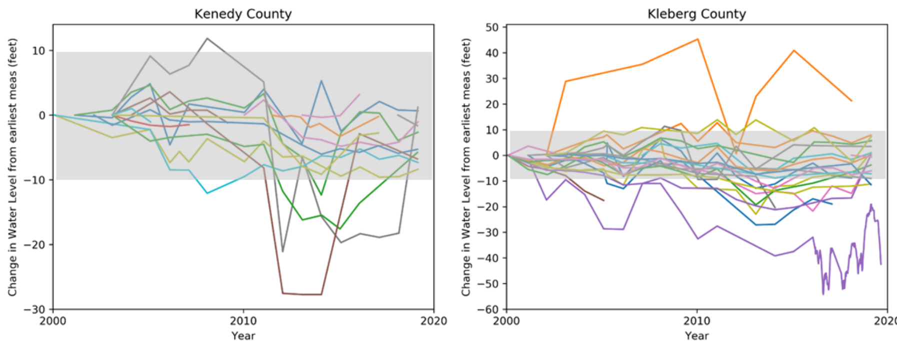
Brush Country GCD







Kenedy County GCD



27

Questions?

28

APPENDIX H
PRESENTATION ON WATER SUPPLY NEEDS & MANAGEMENT STRATEGIES

Groundwater Management Area 16 Joint Planning Cycle: 2019-2022
Water Supply Needs & Management Strategies

Falfurrias, TX
July 28, 2020

Jevon Harding, P.G.
Steve Young, Ph.D., P.G., P.E.
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

1

2

Joint Planning Requirements

- Balancing Test
  - 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*"

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

2

Joint Planning Requirements

- Consideration of 9 "factors" (paraphrased)
  - Aquifer uses or conditions
  - ***Water supply needs and management strategies***
  - Hydrological conditions
  - Other environmental impacts
  - Impact on subsidence
  - Socioeconomic impacts
  - Impact on private property rights
  - Feasibility of achieving the DFC
  - Any other relevant information

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

3

Consideration of Water Supply Needs & Management Strategies

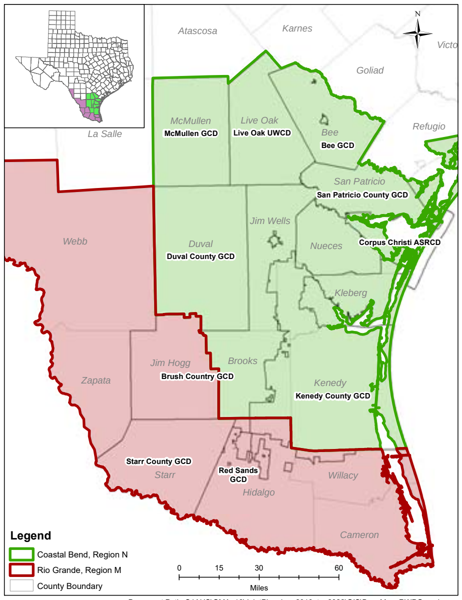
- Describe the water supply needs and water management strategies included in the state water plan

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

4

5

Regional Water Planning Areas



- Texas State Water Plan is compilation of Regional Water Plans
- GMA 16 falls into 2 Regional Water Planning Areas:
  - Region N (Coastal Bend)
  - Region M (Rio Grande)

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

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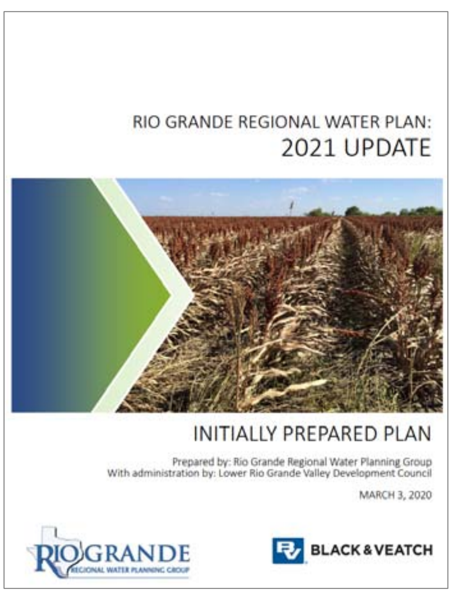
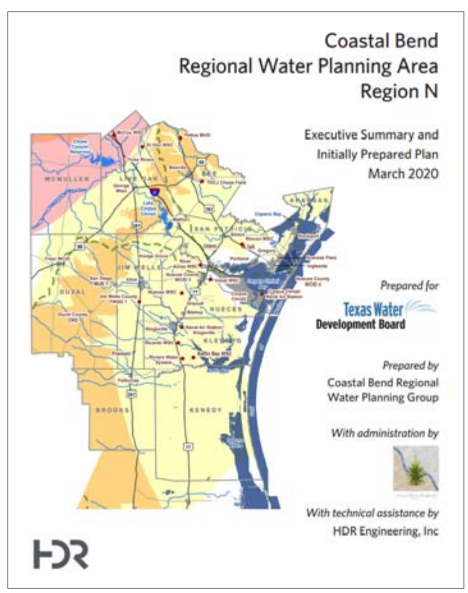
Regional Water Planning Areas

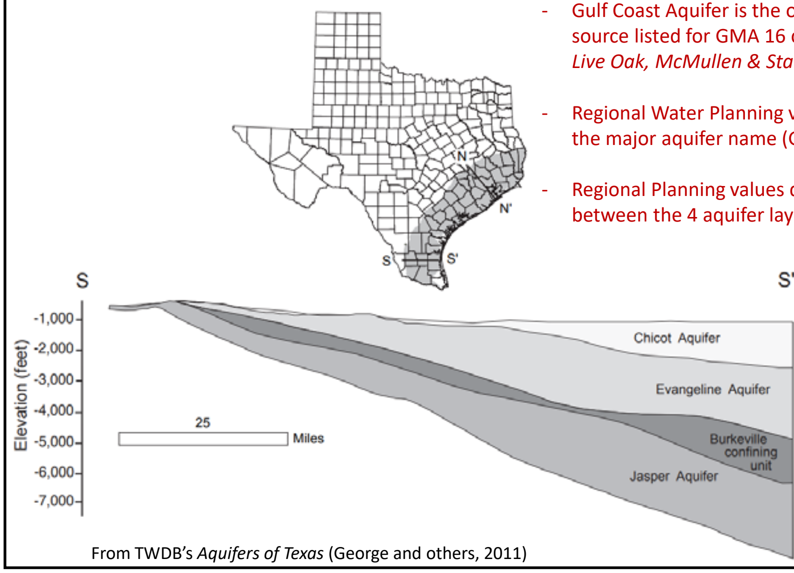




6

Gulf Coast Aquifer System

- Gulf Coast Aquifer is the only groundwater source listed for GMA 16 counties (*except Live Oak, McMullen & Starr*)
- Regional Water Planning values only specify the major aquifer name (Gulf Coast Aquifer)
- Regional Planning values do not distinguish between the 4 aquifer layers



From TWDB's *Aquifers of Texas* (George and others, 2011)

7

Regional Water Plan Accounting

- Regional Water Plan provides values by county, not by GCD
- Values will be presented by County and may include areas that are not part of a GCD
- Unless otherwise stated, groundwater refers to Gulf Coast Aquifer.
- In counties with more than one aquifer (Live Oak, McMullen & Starr), the split between Gulf Coast and other aquifers is provided.

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

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Example of Regional Water Plan Accounting by County

Existing Groundwater Supplies (Kleberg County)

WUG NAME	SOURCE REGION	SOURCE DESCRIPTION	2020	2030	2040	2050	2060	2070
BAFFIN BAY WSC	N	GULF COAST AQUIFER SYSTEM | KLEBERG COUNTY	237	253	268	285	303	320
KINGSVILLE	N	GULF COAST AQUIFER SYSTEM | KLEBERG COUNTY	3781	3946	4168	4415	4424	4561
NAVAL AIR STATION	N	GULF COAST AQUIFER SYSTEM | KLEBERG COUNTY	256	284	303	327	347	366
RIVIERA WATER SYSTEM	N	GULF COAST AQUIFER SYSTEM | KLEBERG COUNTY	114	121	129	137	145	153
COUNTY-OTHER	N	GULF COAST AQUIFER SYSTEM | KLEBERG COUNTY	218	231	247	264	281	297
MANUFACTURING	N	GULF COAST AQUIFER SYSTEM | KLEBERG COUNTY	1809	1809	1809	1809	1809	1809
MINING	N	GULF COAST AQUIFER SYSTEM | KLEBERG COUNTY	218	218	218	218	218	218
LIVESTOCK	N	GULF COAST AQUIFER SYSTEM | KLEBERG COUNTY	673	673	673	673	673	673
IRRIGATION	N	GULF COAST AQUIFER SYSTEM | KLEBERG COUNTY	850	850	850	850	850	850

Existing Surface Water Supplies (Kleberg County)

WUG NAME	SOURCE REGION	SOURCE DESCRIPTION	2020	2030	2040	2050	2060	2070
KINGSVILLE	N	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	211	252	268	289	438	518
KINGSVILLE	P	TEXANA LAKE/RESERVOIR	213	255	270	288	439	520
RICARDO WSC	N	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	170	180	191	202	215	227
RICARDO WSC	P	TEXANA LAKE/RESERVOIR	170	181	191	203	215	227
COUNTY-OTHER	N	CORPUS CHRISTI-CHOKE CANYON LAKE/RESERVOIR SYSTEM	20	21	22	24	25	26
COUNTY-OTHER	P	TEXANA LAKE/RESERVOIR	19	20	22	23	25	26

9

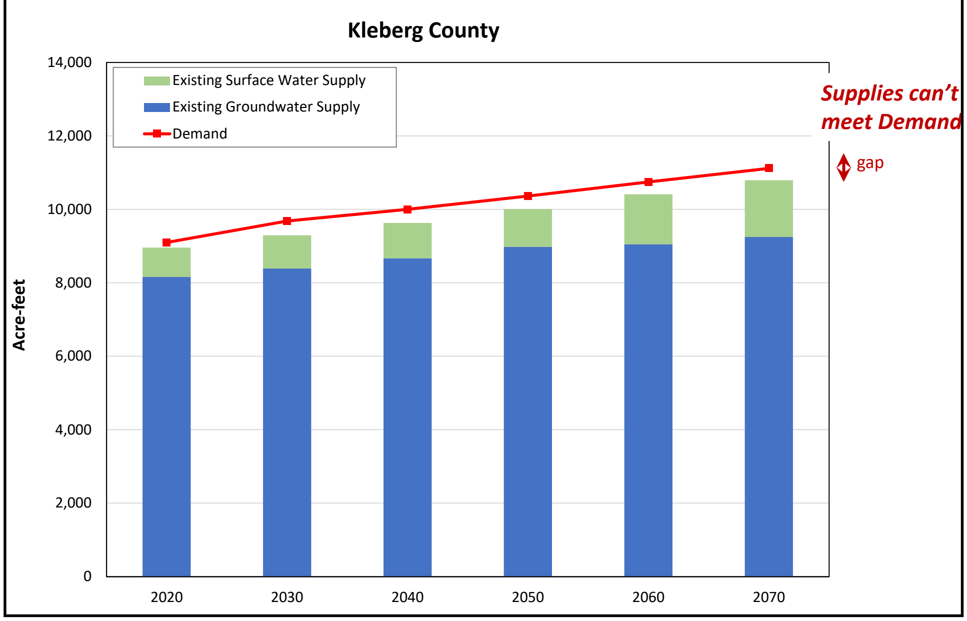
Example of Regional Water Plan Accounting by County

Predicted Demand (Kleberg County)

Demand	2020	2030	2040	2050	2060	2070
Municipal	5,409	5,744	6,078	6,457	6,857	7,241
Manufacturing	1,809	2,056	2,056	2,056	2,056	2,056
Steam-Electric	0	0	0	0	0	0
Mining	357	360	340	324	308	298
Irrigation	850	850	850	850	850	850
Livestock	673	673	673	673	673	673

10

Example of Regional Water Plan Accounting by County



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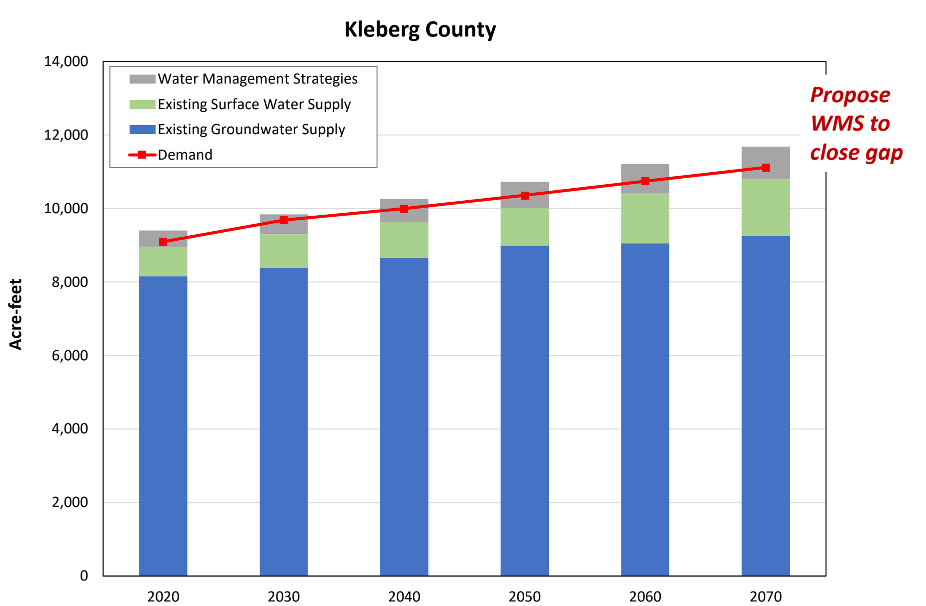
Example of Regional Water Plan Accounting by County



12

Example of Regional Water Plan Accounting by County

Water Management Strategies can include:
- Conservation
- Demand Reduction
- Water Re-use
- Additional Infrastructure
    - Groundwater wells
    - Desalination plants
    - Reservoirs or pipelines

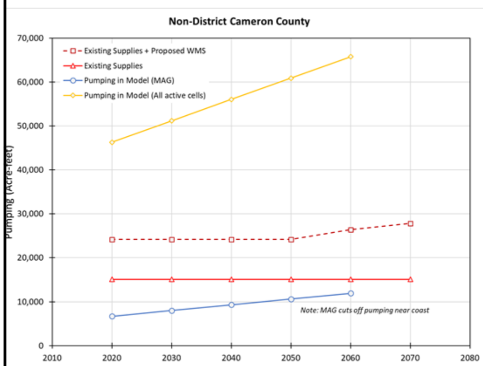
13

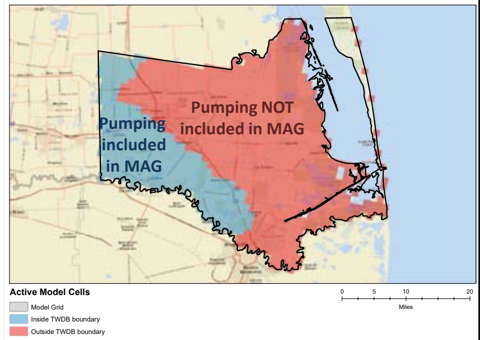
What is the connection between Regional Water Planning & GMA?

- If Water Management Strategy involves groundwater, it has to be possible based on modeled MAG values.
- Existing Supplies & Water Management Strategies listed in Regional Water Planning can be used to double-check that modeled pumping realistically accounts for pumping in the GMA.
- GMA considerations during DFC/MAG development should include whether or not the pumping allowed by Districts is sufficient to meet the future Demands & Water Management Strategies identified in Regional Water Planning.

14

Connection between Regional Water Planning & GMA



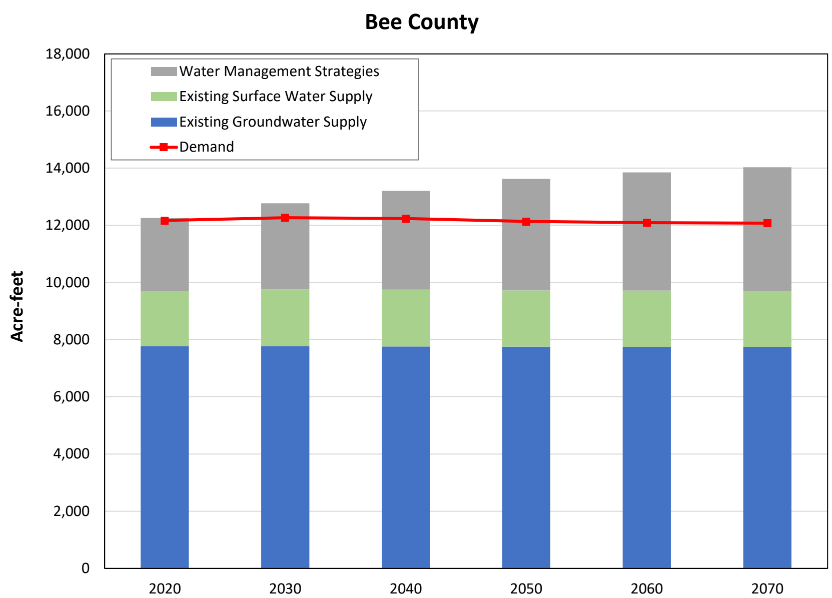


*Cameron County (Region M) could not suggest additional WMS because MAG did not include all pumping

15

** Note: y-scale will change by county*

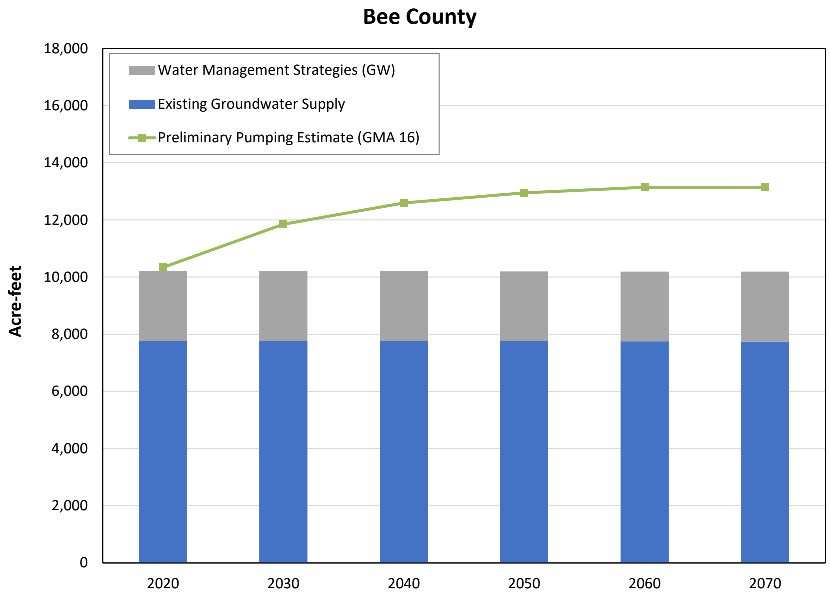
Bee GCD



Note: entire county is not within GCD (Beeville)

16

Bee GCD

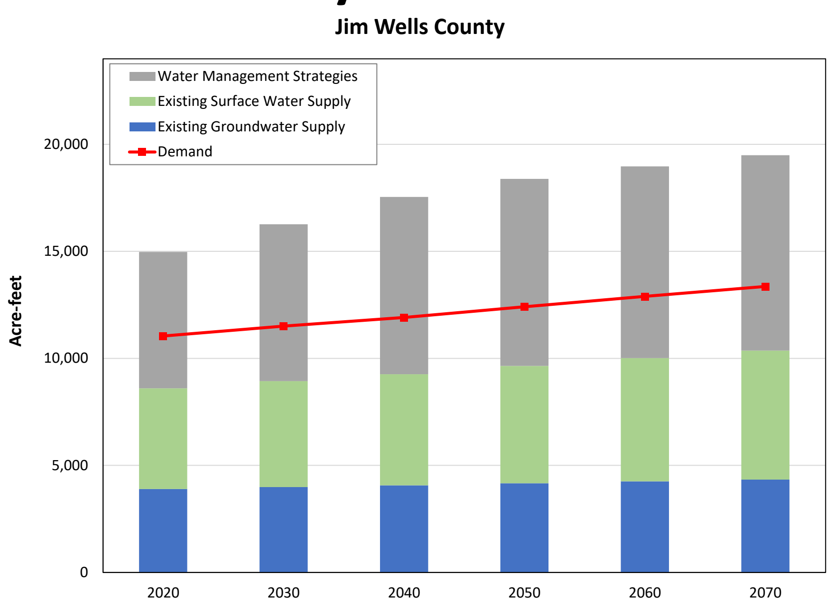


Note: entire county is not within GCD (Beeville)

17

** Note: y-scale will change by county*

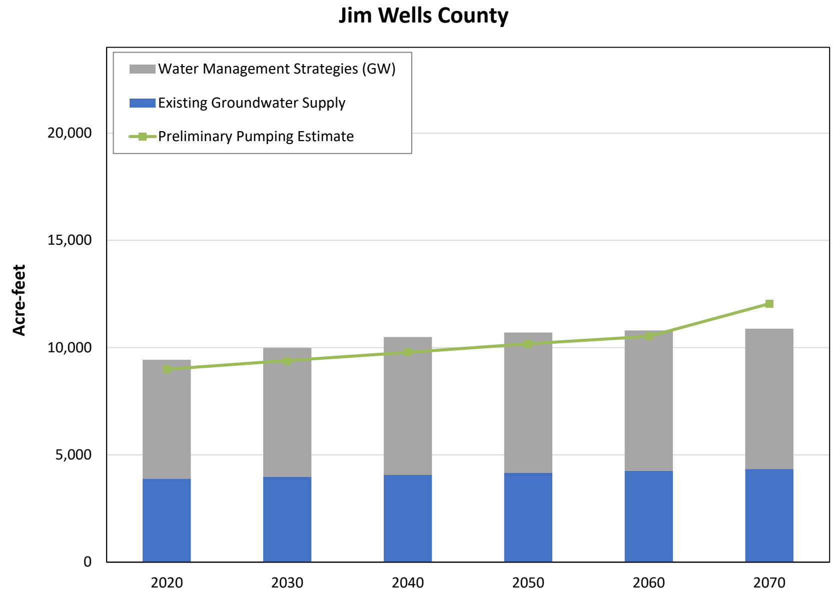
Brush Country GCD



Note: entire county is not within GCD (Alice) & small portion of Jim Wells is in Kenedy County GCD

18

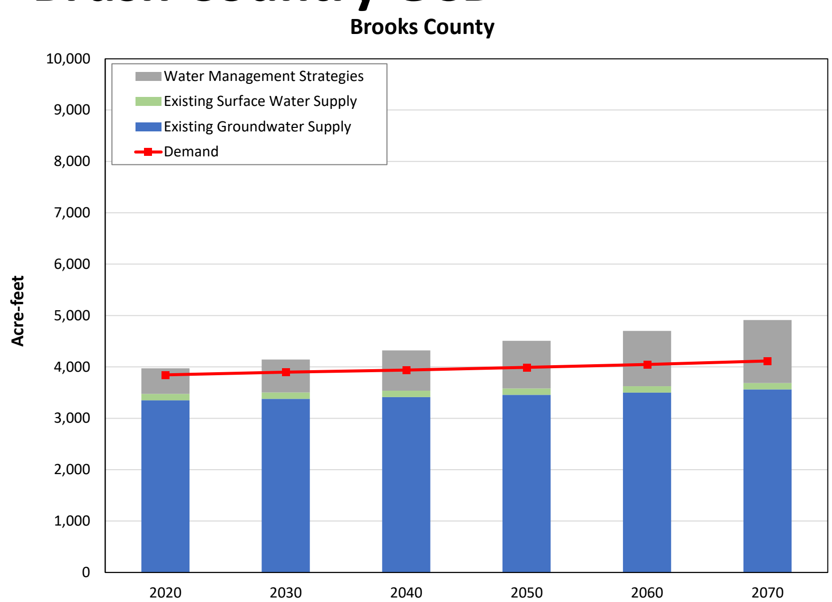
Brush Country GCD



Note: calculated by county, but entire county is not within GCD (Alice) & small portion of Jim Wells is in Kenedy County GCD

19

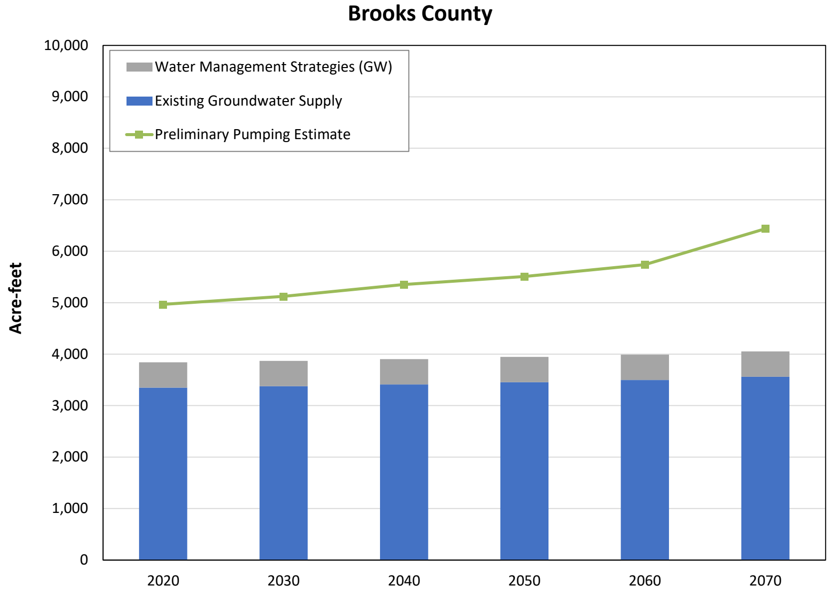
Brush Country GCD



Note: county is split between Brush Country GCD & Kenedy County GCD

20

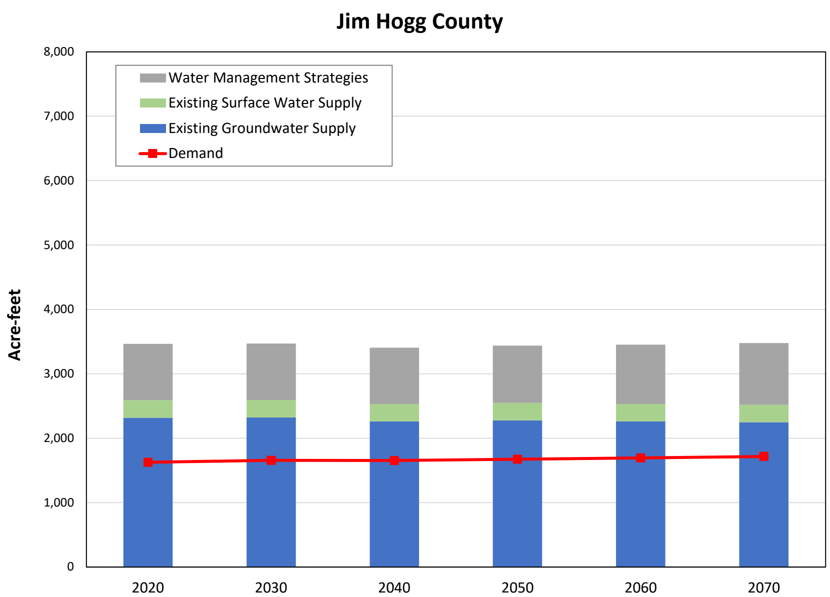
Brush Country GCD



Note: calculated by county, and county is split between Brush Country GCD & Kenedy County GCD

21

Brush Country GCD



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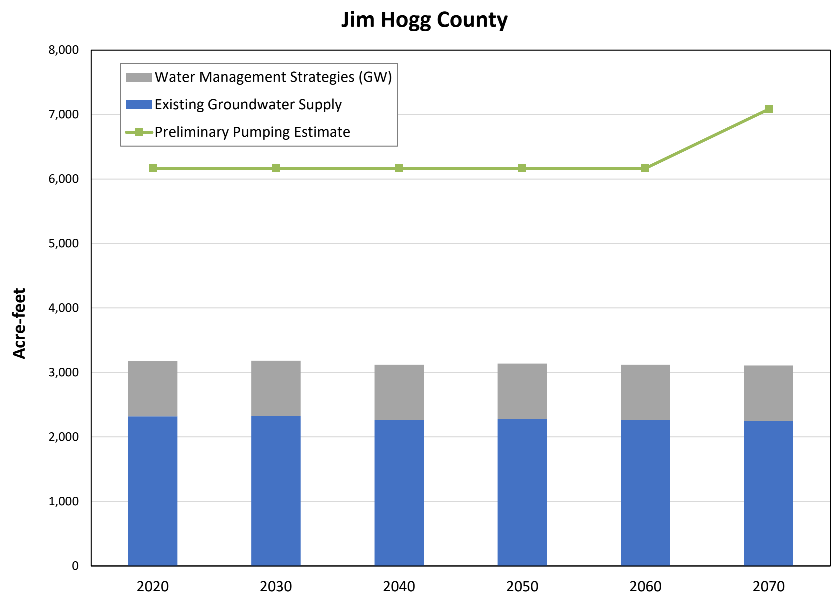
Brush Country GCD



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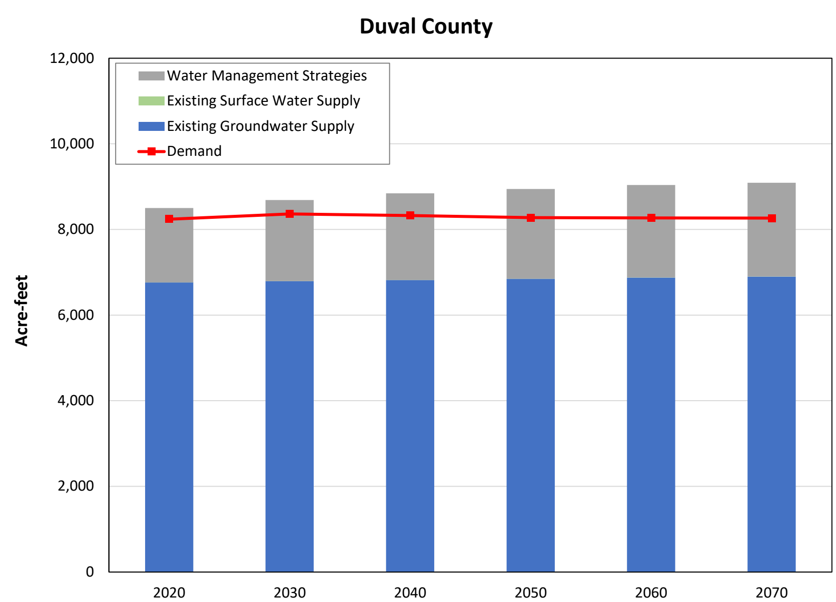
Duval County GCD



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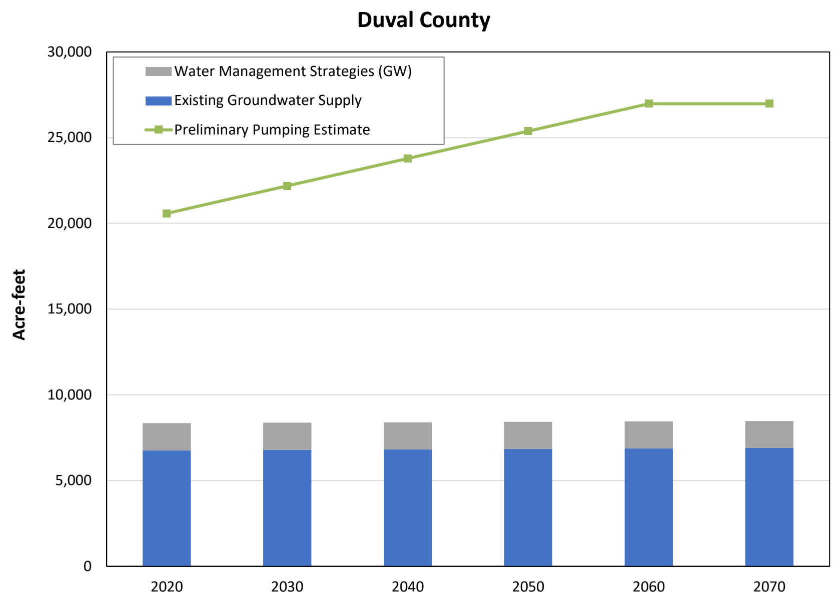
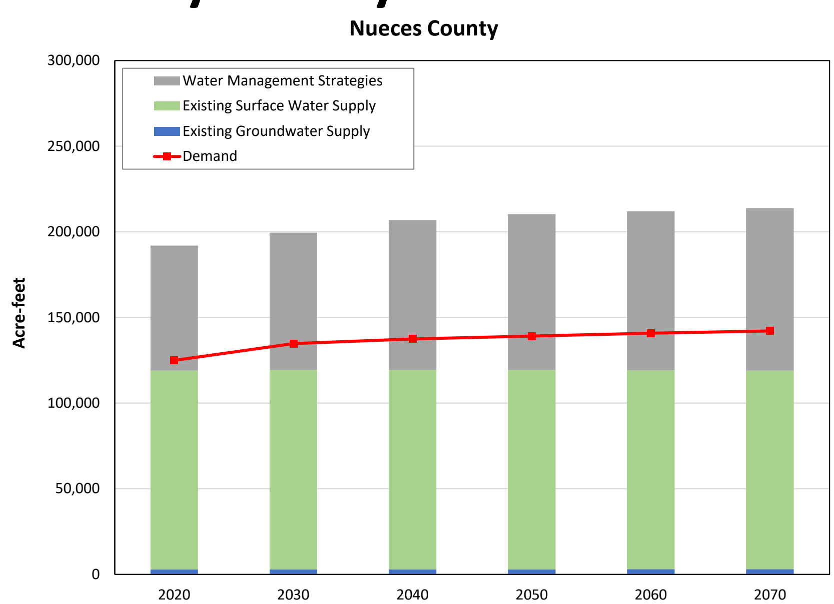
Duval County GCD



25

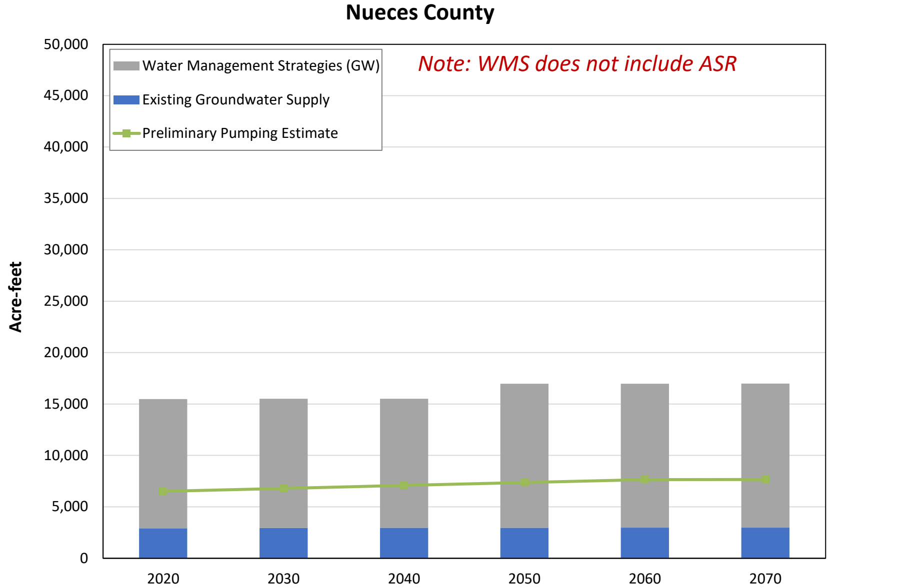
Kenedy County GCD



Note: entire county is not within GCD & part of county overlaps CCASRCD

26

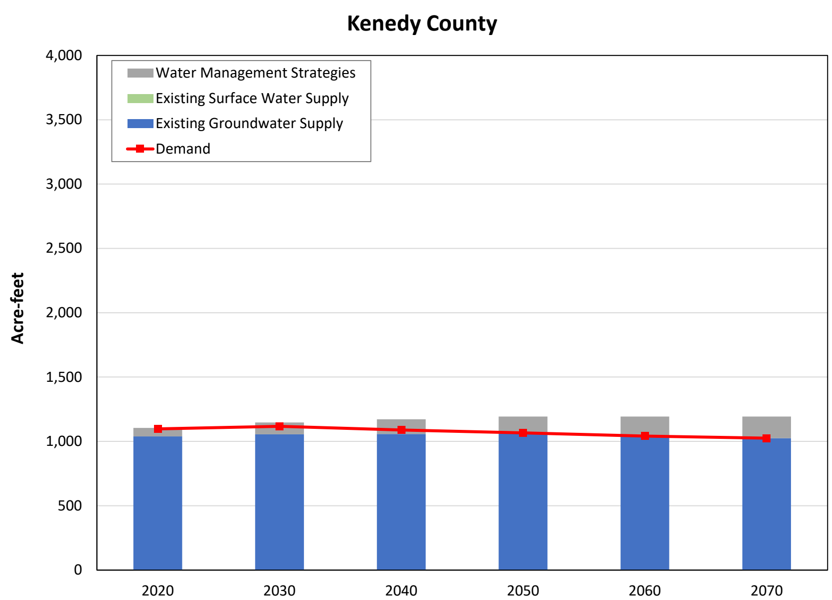
Kenedy County GCD



Note: calculated by county but entire county is not within GCD & part of county overlaps CCASRCD

27

Kenedy County GCD



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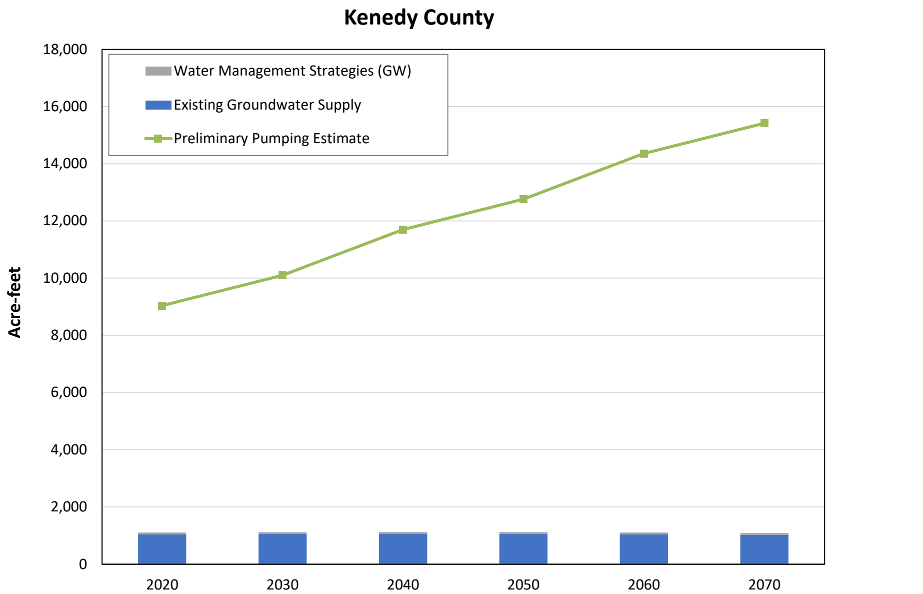
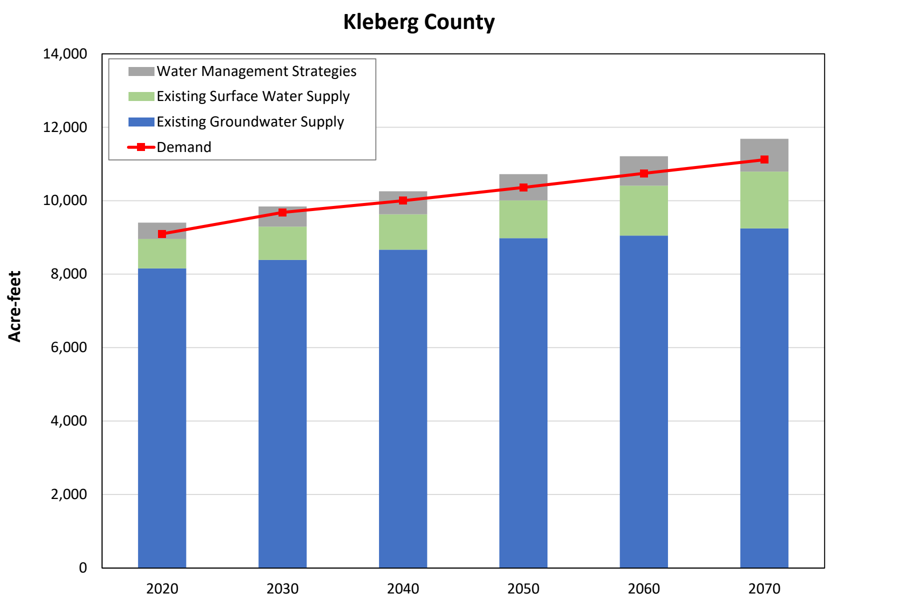
Kenedy County GCD



Note: calculated by county, not by GCD

29

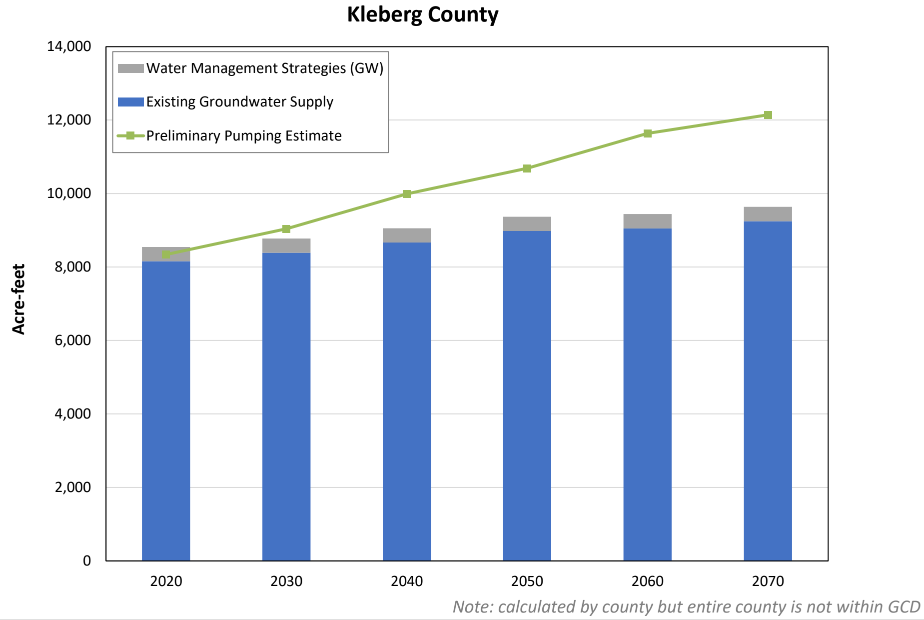
Kenedy County GCD



Note: entire county is not within GCD

30

Kenedy County GCD



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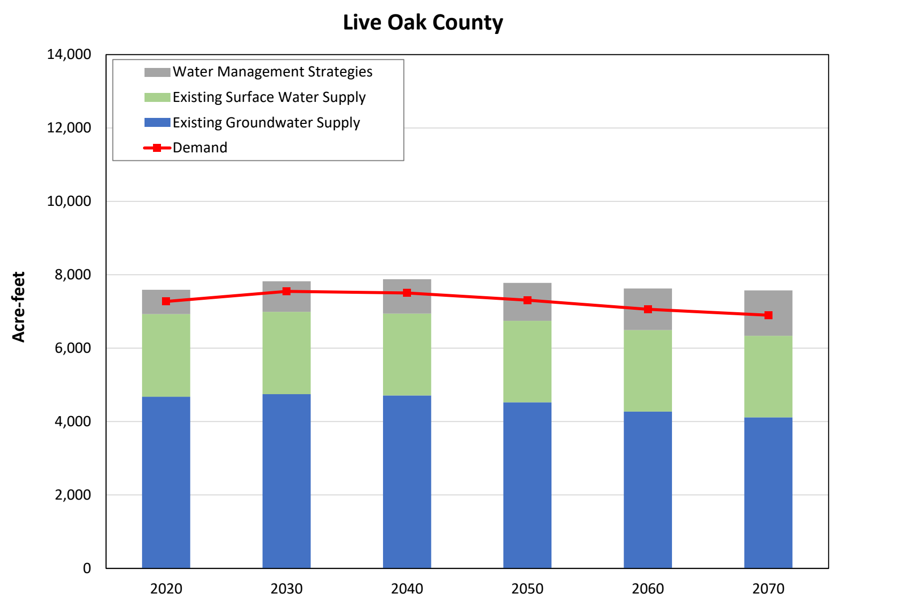
Live Oak GCD



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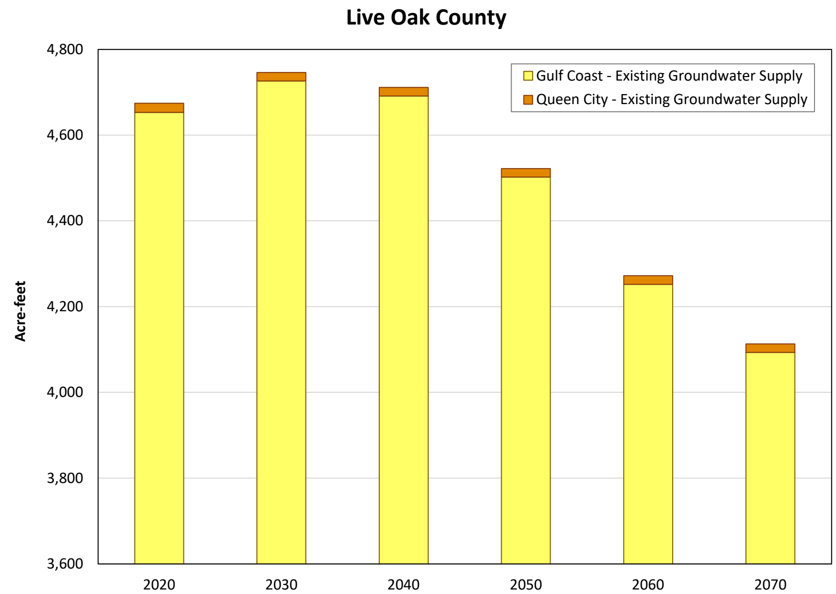
Live Oak GCD



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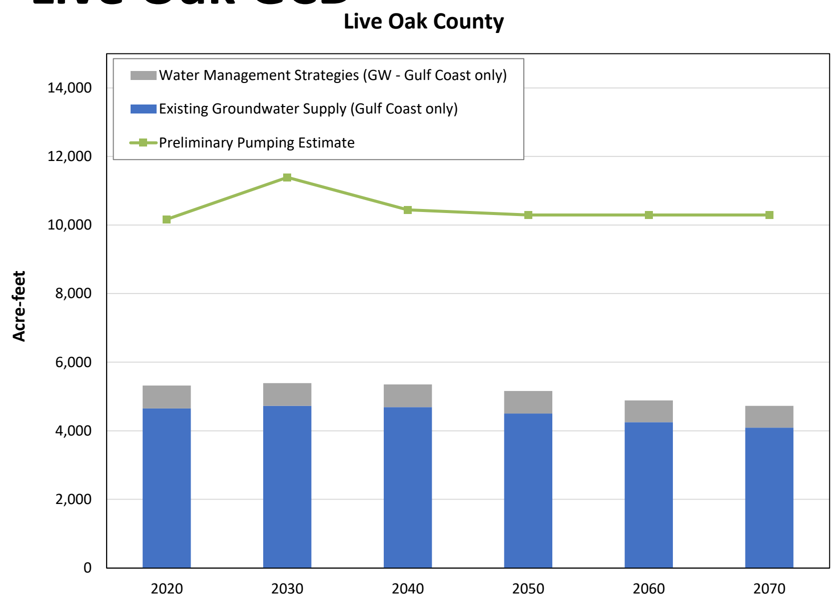
Live Oak GCD



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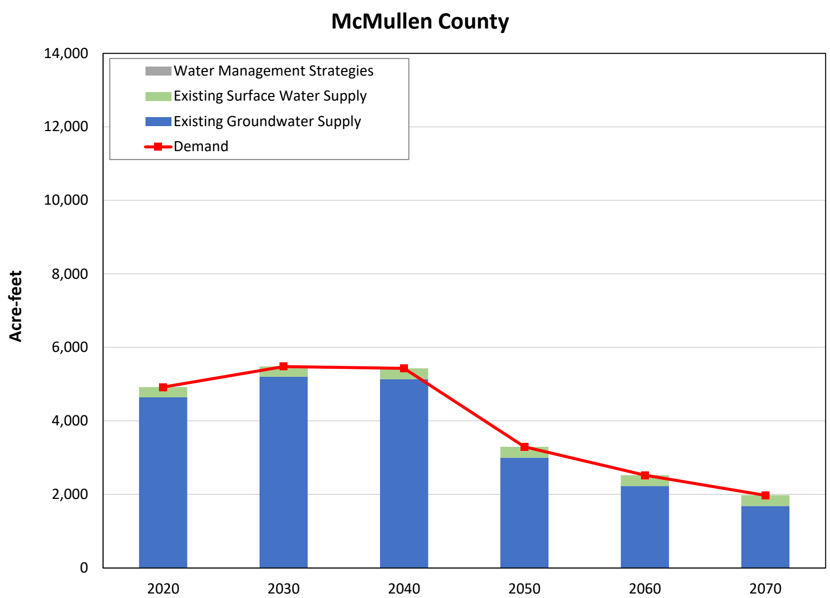
McMullen GCD



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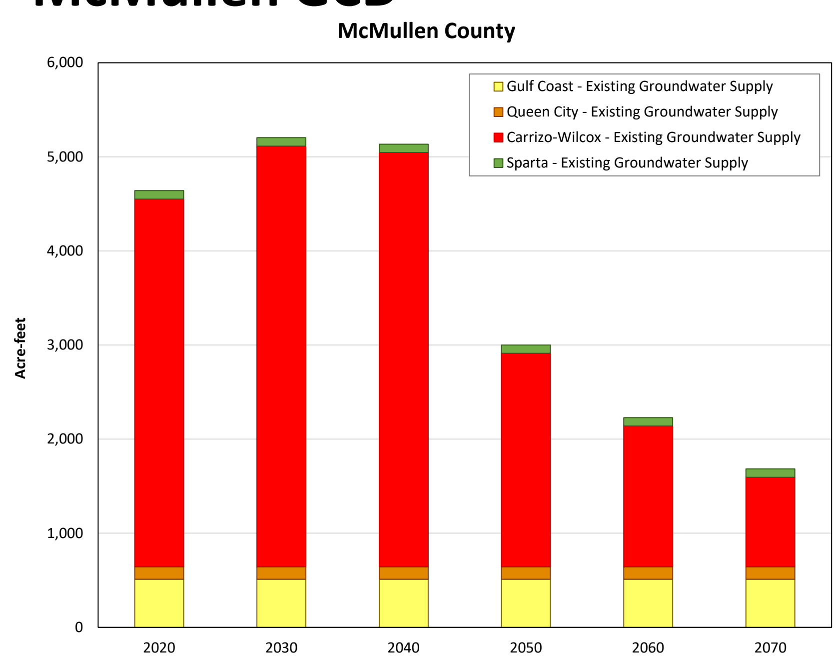
McMullen GCD



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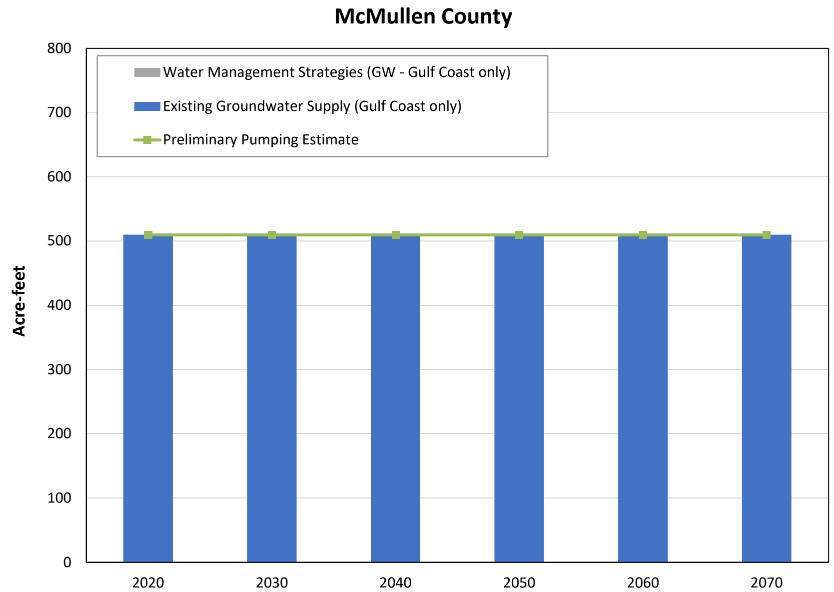
McMullen GCD



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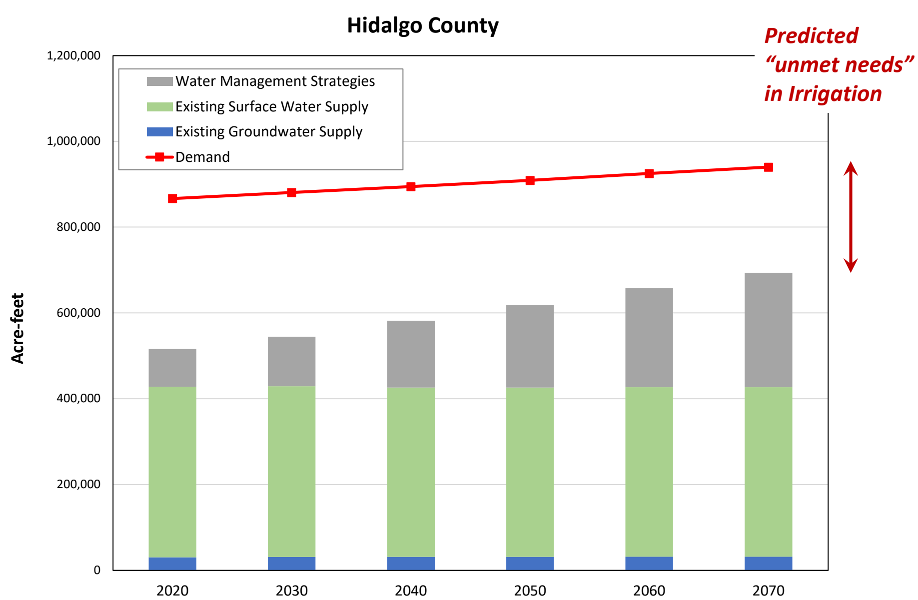
Red Sands GCD



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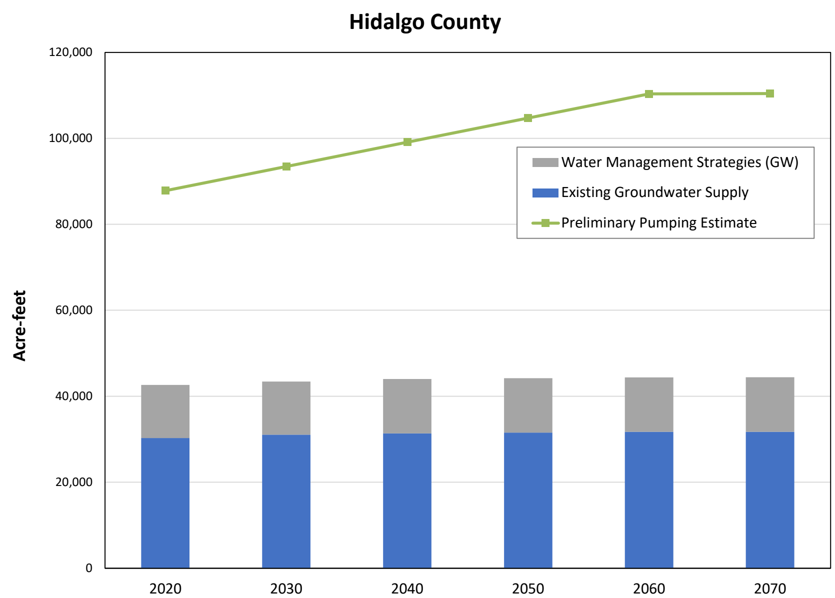
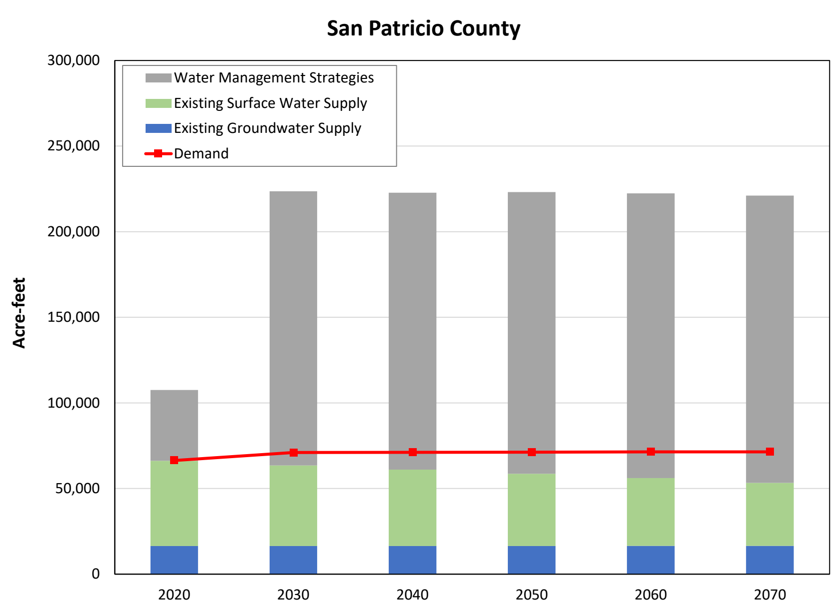
Red Sands GCD



Note: calculated by county, but not all of county is within GCD

39

San Patricio GCD



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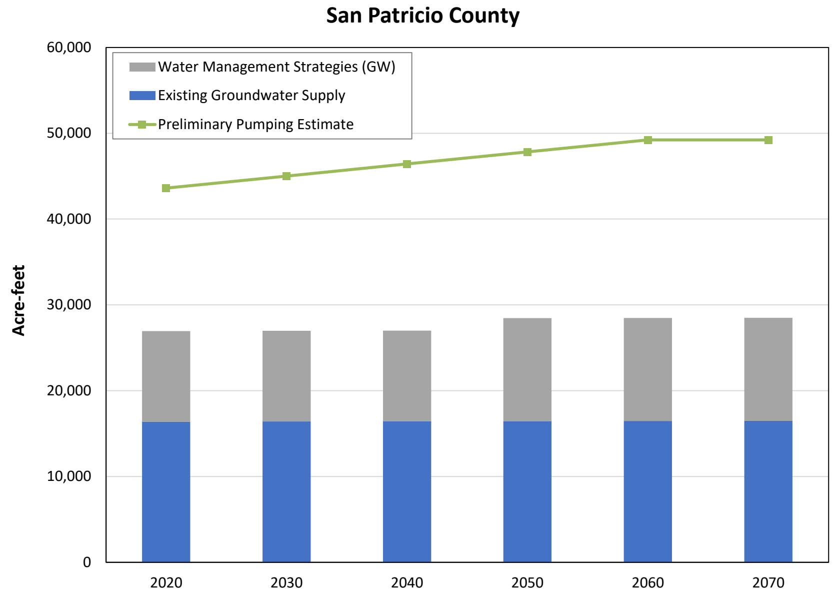
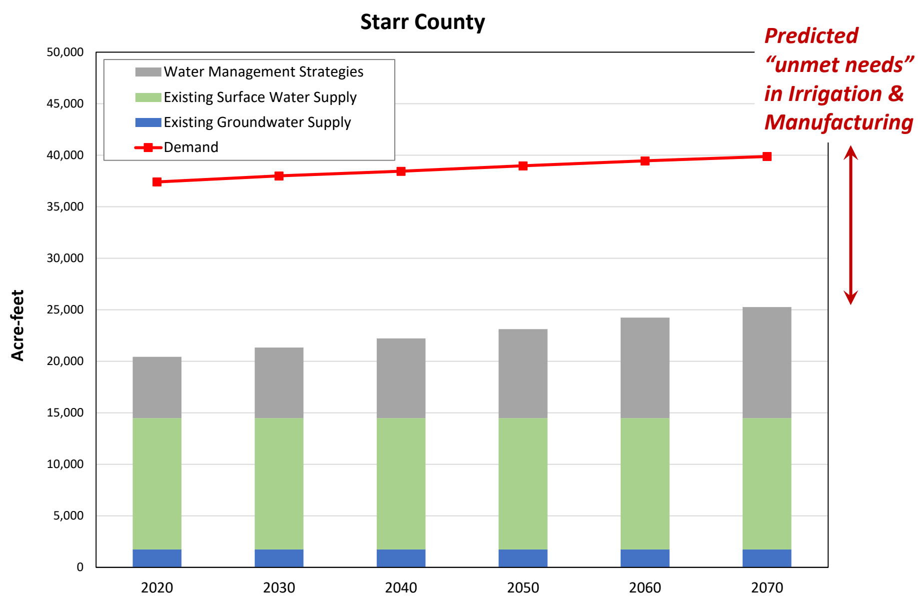
San Patricio GCD



41

Starr County GCD



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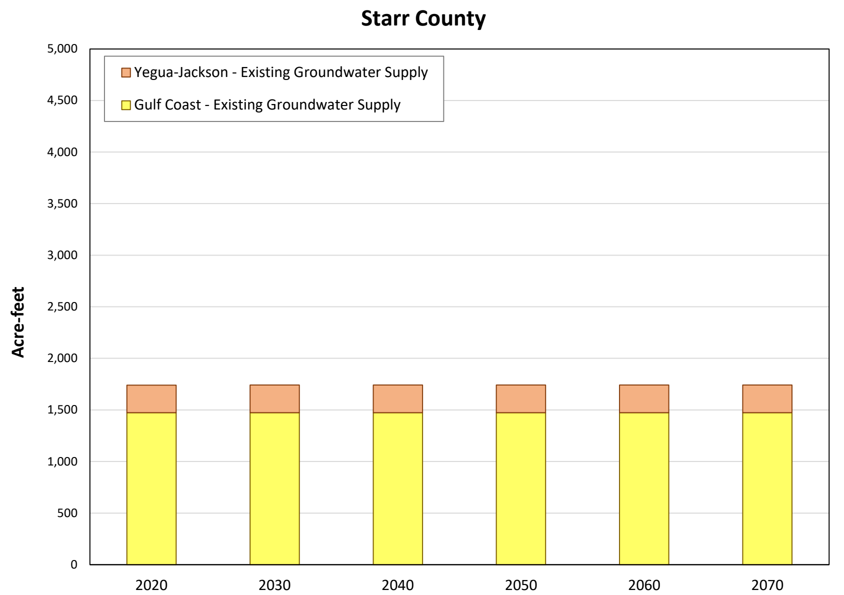
Starr County GCD



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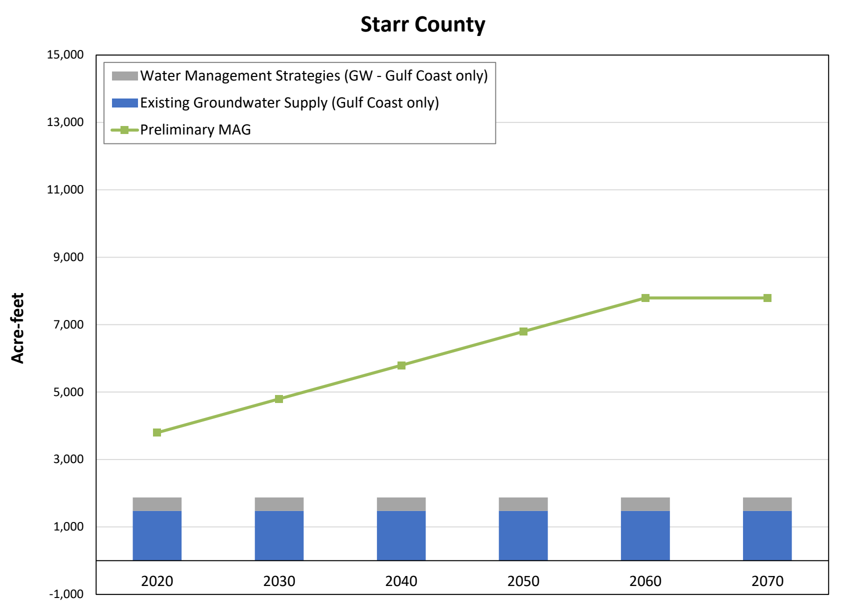
Starr County GCD



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Explanatory Report

DFC Explanatory Report for Groundwater Management Area 16

5.2 Water Supply Needs and Water Management Strategies

The GCDs of GMA 16 considered the following information regarding water supply needs and water management strategies in developing a DFC:

- Data from the 2012 State Water Plan on;
- Identified groundwater sources
- Identified needs
- Water management strategies using a groundwater source
- Modeled Available Groundwater Report; GAM Run 10-047 (Hassan and Jigmond, 2011)
- A tabular summary of the range of future pumping estimates used in developing the proposed DFC

The Rio Grande Valley is expected to have a significant increase in growth and water demands over the next 50 years. The GMA 16 counties in Region N are also expected to grow, although the rate of growth will not be as great as in the Rio Grande Valley (Table 1). A significant part of anticipated new water supplies for portions of these planning regions are expected to be met by increased groundwater production. The Gulf Coast Aquifer is the primary groundwater supply source for these regions. Much of the groundwater in this region is brackish, and may need to be treated to drinking water standards if intended for drinking water supply.

The information on water supply needs and water management strategies considered by the GCDs of GMA 16 are included in Appendix E. Also included in Appendix E is the Modeled Available Groundwater Report (Wade, 2012) that was developed by TWDB associated with the previously developed DFC adopted in 2011. These data were presented to the GMA 16 Board and discussed in the public meeting on March 25, 2014. Revisions to proposed pumping scenarios in light of developing water management strategies discussed by the Board represented a large part of the public meetings conducted from March 5, 2013, through June 23, 2014. Details regarding these alternative pumping scenarios are presented in the technical memos included in Appendix C.

- Explanatory report will briefly summarize this presentation & provide a copy as appendix
- Any District can provide INTERA with more District-specific information or details regarding this topic, if they feel it is necessary
- Deadline for adding District-specific information: next GMA meeting

Previous report (O'Rourke, 2017) will be used as template

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Questions?

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APPENDIX I
PRESENTATION ON HYDROLOGICAL CONDITIONS

Groundwater Management Area 16 Joint Planning Cycle: 2019-2022 Hydrological Conditions

Falfurrias, TX
July 28, 2020

Jevon Harding, P.G.
Steve Young, Ph.D., P.G., P.E.

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Joint Planning Requirements

- Balancing Test
  - 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*"

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Joint Planning Requirements

- Consideration of 9 "factors" (paraphrased)
  - Aquifer uses or conditions
  - Water supply needs and management strategies
  - ***Hydrological conditions***
  - Other environmental impacts
  - Impact on subsidence
  - Socioeconomic impacts
  - Impact on private property rights
  - Feasibility of achieving the DFC
  - Any other relevant information

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Consideration of Hydrological Conditions

- Describe the hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge

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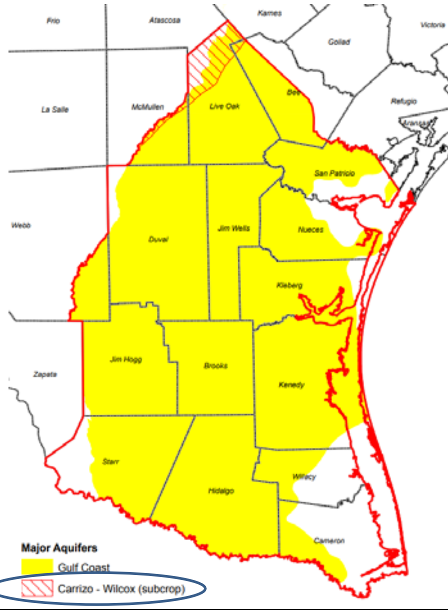
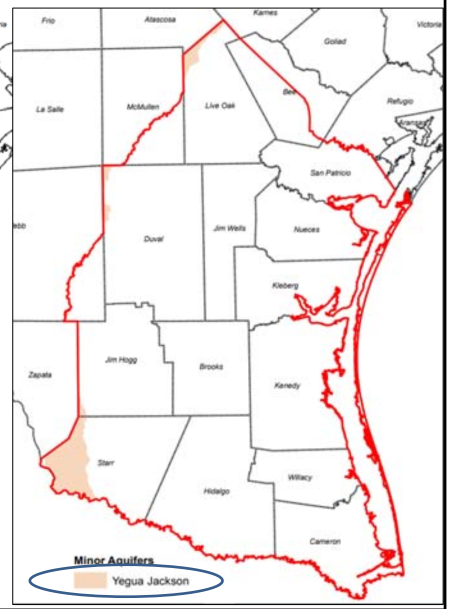
Non-Relevant Aquifers





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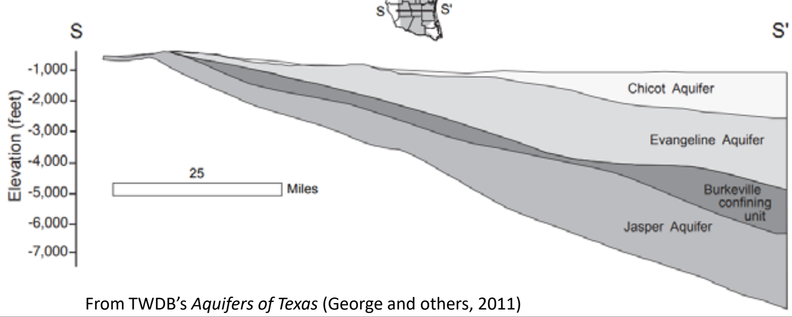
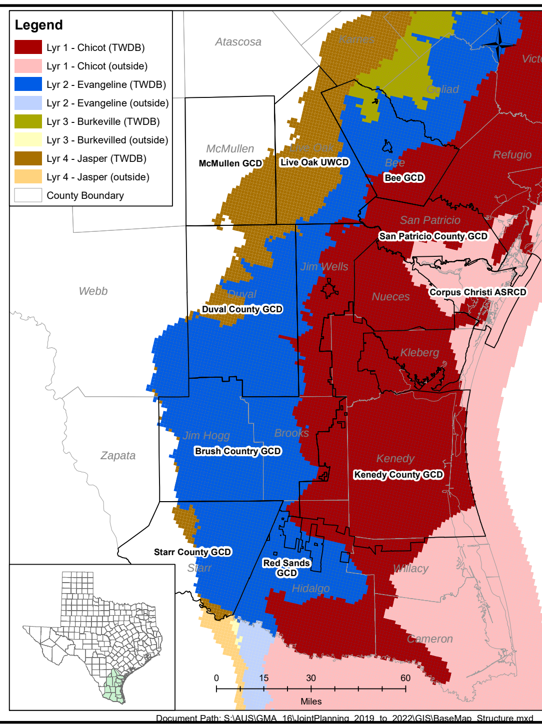
Gulf Coast Aquifer System

- Aquifers outcrop from East to West
- All layers dip towards the coast
- Unconfined in outcrop
- Confined downdip



From TWDB's *Aquifers of Texas* (George and others, 2011)

6



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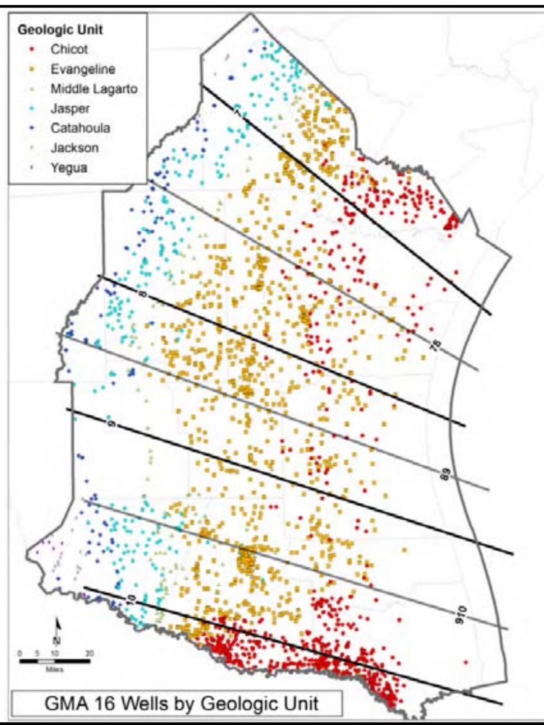
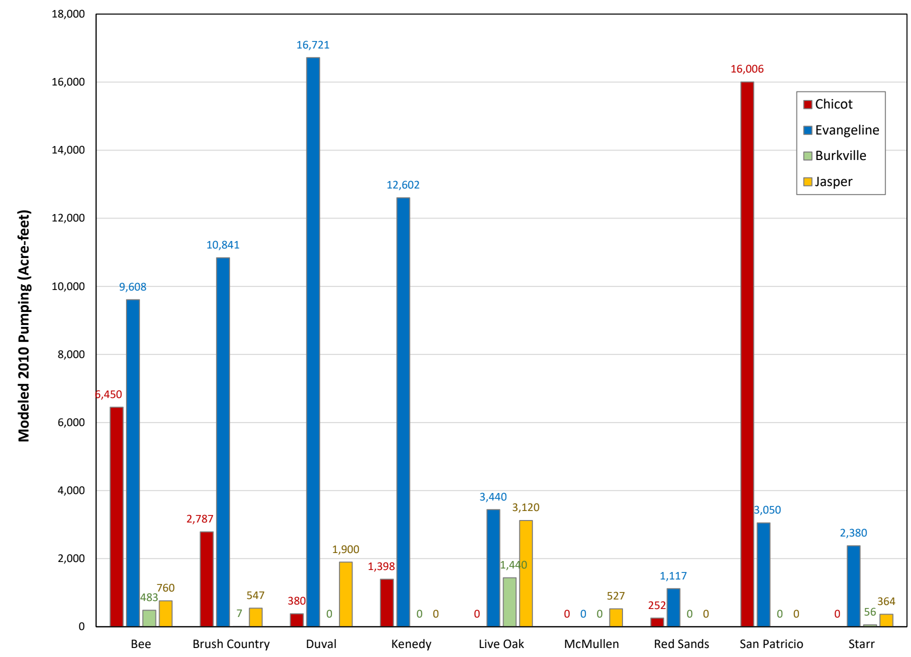


Hydrogeochemical Evaluation of the Texas Gulf Coast Aquifer System and Implications for Developing Groundwater Availability Models (Young & others, 2014)

8



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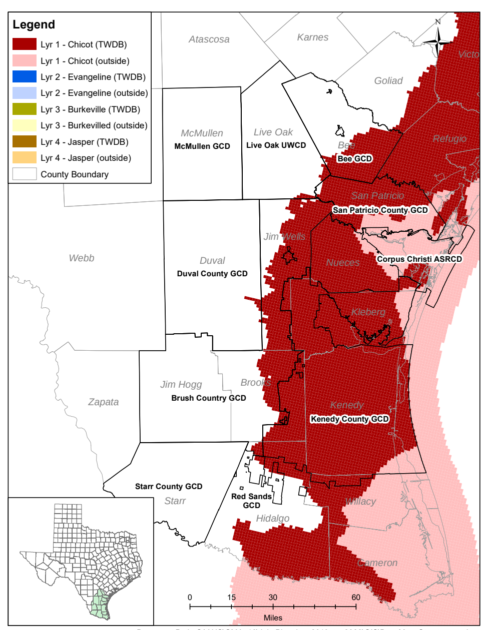
Chicot Aquifer

- Shallowest unit of the Gulf Coast Aquifer
- Sandy unit composed of Beaumont, Lissie & Willis Formations
- Most common source of water in San Patricio & near Rio Grande
- Also provides water to Bee, Brush Country, Duval, Kenedy & Red Sands
- Some wells in eastern section of GMA 16 but water quality degrades towards the coast



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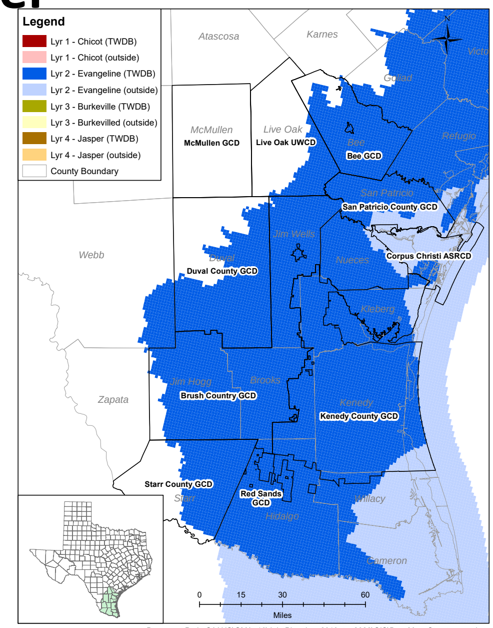
10

Evangeline Aquifer

- Unit of the Gulf Coast Aquifer below Chicot Aquifer
- Sandy unit comprised of the Goliad Formation
- Most common source of groundwater in GMA 16, except in McMullen and San Patricio



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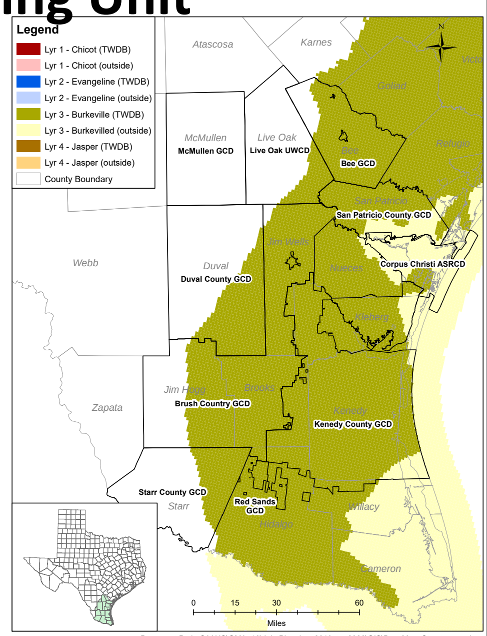
Burkeville Confining Unit

- Unit of the Gulf Coast Aquifer below Evangeline Aquifer
- It acts as a confining unit in some places but can produce water in others
- Composed of Lagarto Formation
- Wells generally clustered in shallow Burkeville in western section of GMA 16
- Provides a small % of water in Bee, Live Oak, Starr & Brush Country



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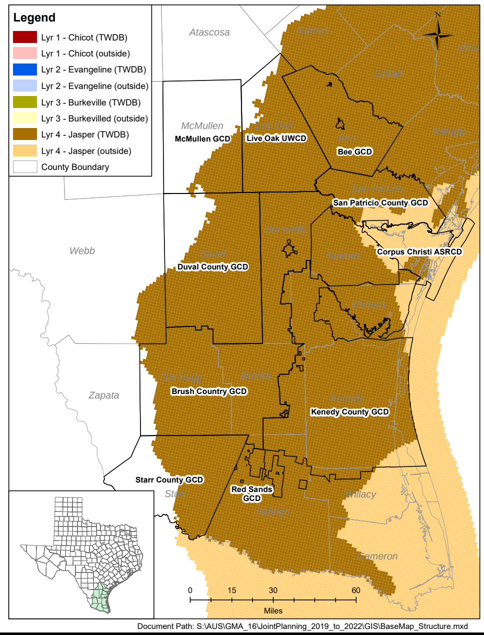
Jasper Aquifer

- Deepest unit of the Gulf Coast Aquifer
- Sandy unit comprised of Oakville Formation
- Wells generally found in shallower section in western/northwestern part of GMA 16
- Water quality generally poor (varies spatially) and declines downdip
- Only source of Gulf Coast Aquifer water in McMullen
- Provides a large % of water in Live Oak and smaller % in Bee, Brush Country, Duval & Starr



13

Total Estimated Recoverable Storage (TERS)

- **Total Estimated Recoverable Storage**—The estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25% and 75% of the porosity-adjusted aquifer volume
- TERS is a <u>required consideration</u> as part of the DFC process
- TERS is :
  - The amount of water physically present in the aquifer
  - NOT the amount of water available for production
  - NOT the amount of pumping that will prevent harm to the aquifer/users

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"Recoverable" is Aquifer Specific

- The range of 25% - 75% is not an appropriate range for all aquifers.
  - Could be 55 -75% or more for highly productive, unconfined aquifers at the surface such as the Ogallala and Seymour.
  - Likely no more than 3 - 15% for most dipping, confined aquifers in Texas (Trinity, Carrizo-Wilcox, Gulf Coast, etc.). Recovery of anywhere close to 75% is physically impossible given current well depths and impacts to water levels, quality, existing wells, well yields, surface water, and subsidence.
  - For karst aquifers, total storage is practically irrelevant to aquifer planning and management long term (Edwards). Total storage is relatively small and fluctuates significantly over time due to recharge events.

- Wade Oliver (INTERA), Feb 2014 TAGD Quarterly Meeting

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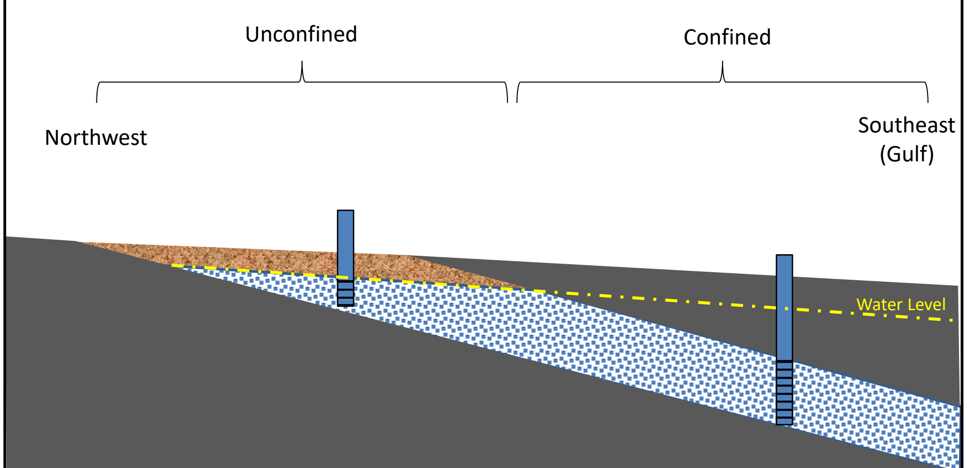
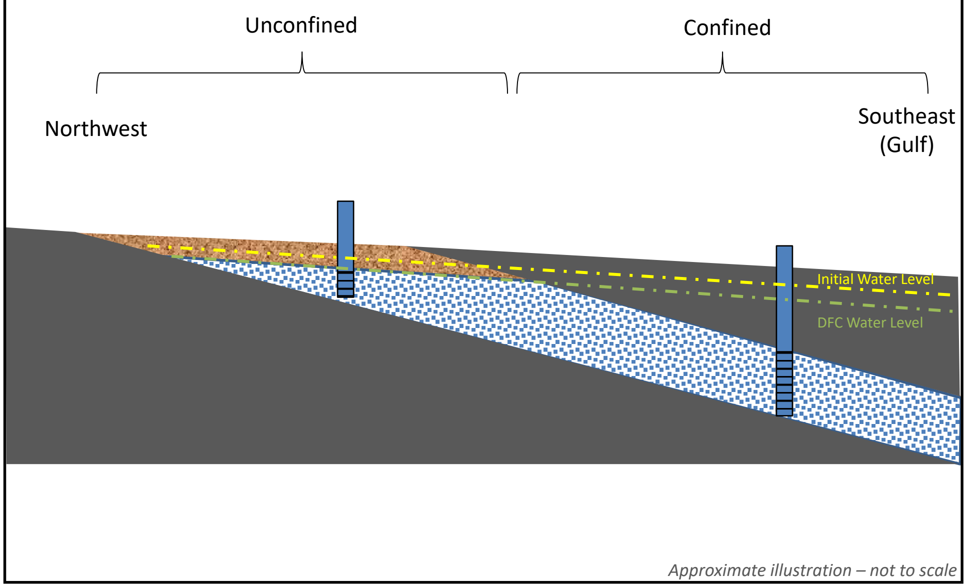
Typical Dipping Aquifer in South/Southeast Texas



Approximate illustration – not to scale

16

Typical DFC Water Level Change in South/Southeast Texas



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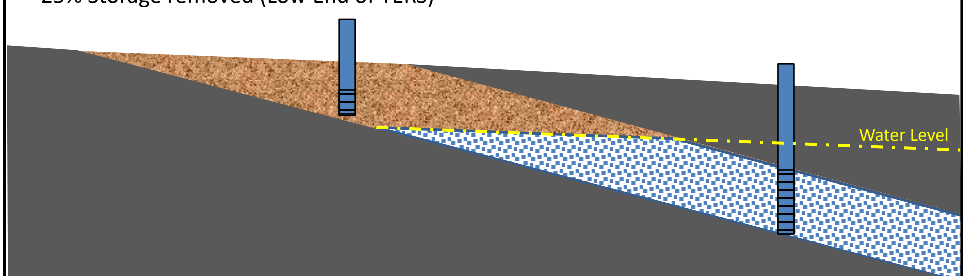
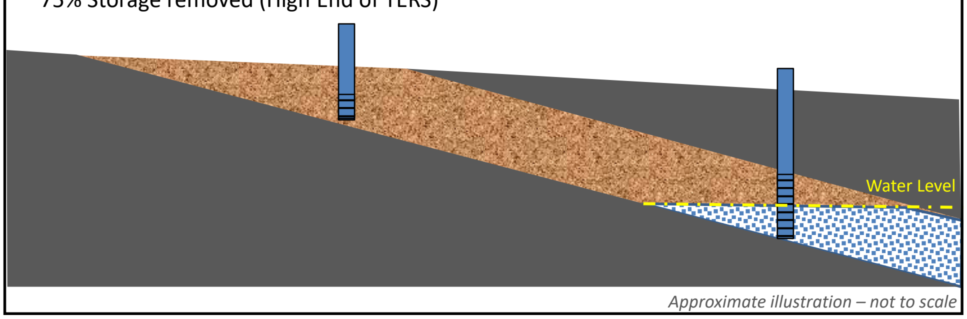
~25% Storage removed (Low End of TERS)



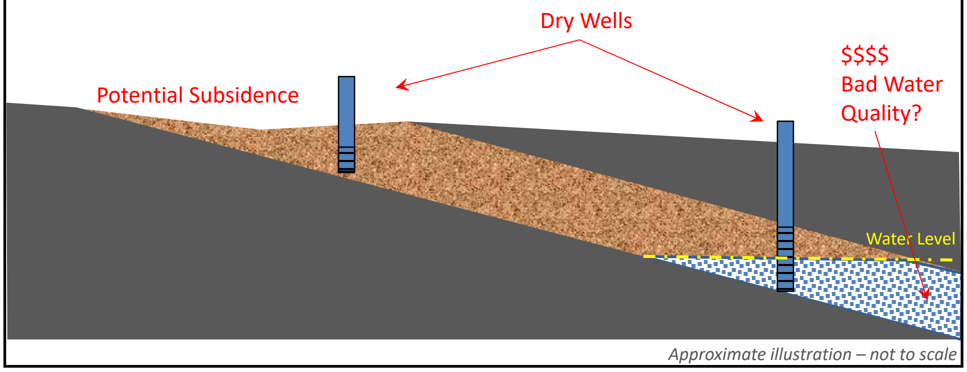
~75% Storage removed (High End of TERS)



18

Total Estimated Recoverable Storage (TERS)

TERS does not account for :
- Aquifer water quality
- Water levels dropping below pumps
- Land surface subsidence
- Degradation of water quality
- Changes to surface water-groundwater interaction
- Practicality/economics of development



19

Total Estimated Recoverable Storage (TERS)

*Note: TWDB only provides TERS values for entire Gulf Coast Aquifer, not the individual 4 units

Source for GMA 16: TWDB report GAM RUN 12-025 (March 28, 2013)

By County

County	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Bee	25,000,000	6,250,000	18,750,000
Brooks	90,000,000	22,500,000	67,500,000
Cameron	49,000,000	12,250,000	36,750,000
Duval	45,000,000	11,250,000	33,750,000
Hidalgo	160,000,000	40,000,000	120,000,000
Jim Hogg	40,000,000	10,000,000	30,000,000
Jim Wells	61,000,000	15,250,000	45,750,000
Kenedy	210,000,000	52,500,000	157,500,000
Kleberg	110,000,000	27,500,000	82,500,000
Live Oak	35,000,000	8,750,000	26,250,000
McMullen	2,100,000	525,000	1,575,000
Nueces	76,000,000	19,000,000	57,000,000
San Patricio	51,000,000	12,750,000	38,250,000
Starr	15,000,000	3,750,000	11,250,000
Webb	250,000	62,500	187,500
Willacy	45,000,000	11,250,000	33,750,000
Total	**1,014,350,000**	**253,587,500**	**760,762,500**

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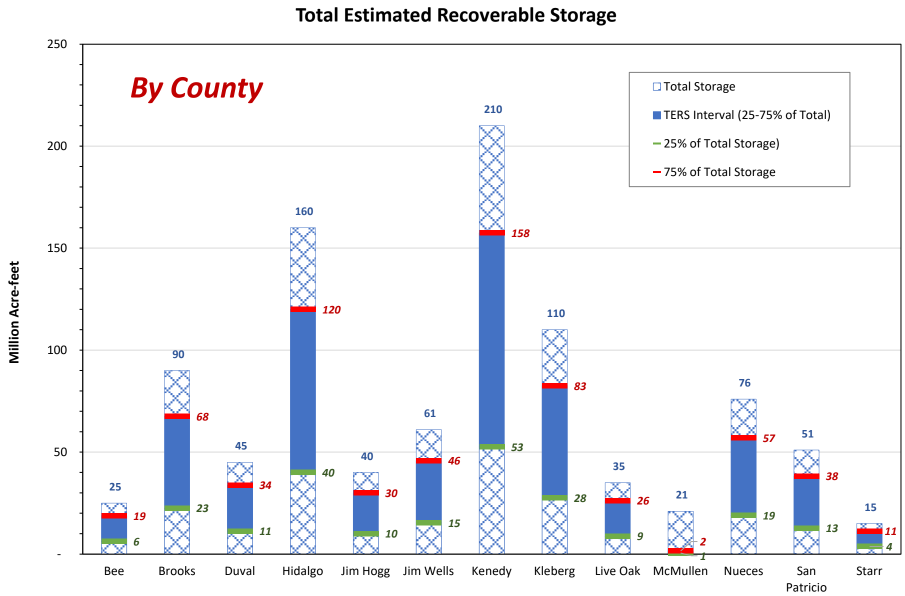
Total Estimated Recoverable Storage (TERS)



21

Total Estimated Recoverable Storage (TERS)

*Note: TWDB only provides TERS values for entire Gulf Coast Aquifer, not the individual 4 units

Source for GMA 16: TWDB report GAM RUN 12-025 (March 28, 2013)

By GCD

Groundwater Conservation District	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Bee	25,000,000	6,250,000	18,750,000
Brush Country	150,000,000	37,500,000	112,500,000
Corpus Christi ASRCD	6,000,000	1,500,000	4,500,000
Duval County	45,000,000	11,250,000	33,750,000
Kenedy County	360,000,000	90,000,000	270,000,000
Live Oak	35,000,000	8,750,000	26,250,000
McMullen	2,100,000	525,000	1,575,000
Red Sands	3,100,000	775,000	2,325,000
San Patricio County	51,000,000	12,750,000	38,250,000
Starr County	15,000,000	3,750,000	11,250,000
No District	310,000,000	77,500,000	232,500,000
Total	**1,002,200,000**	**250,550,000**	**751,650,000**

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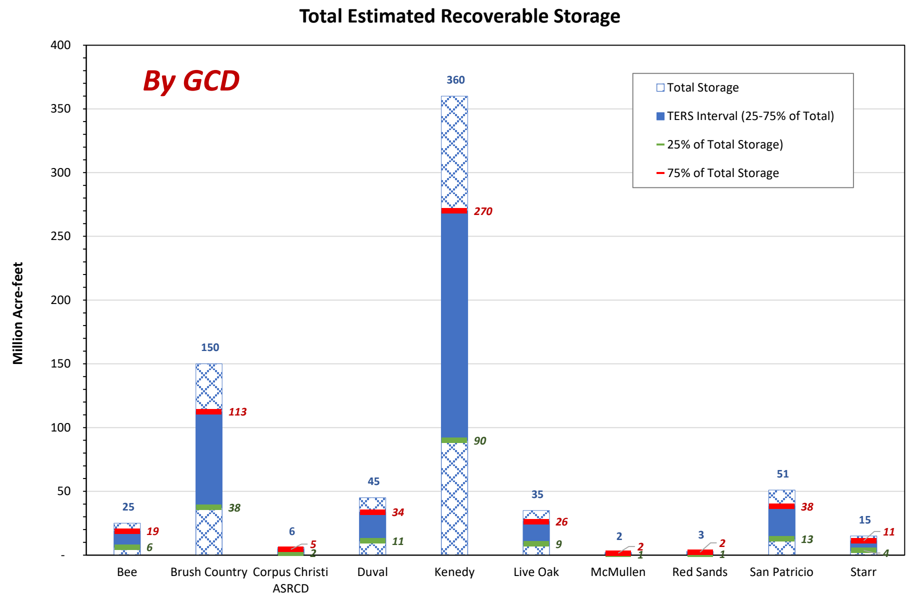
Total Estimated Recoverable Storage (TERS)



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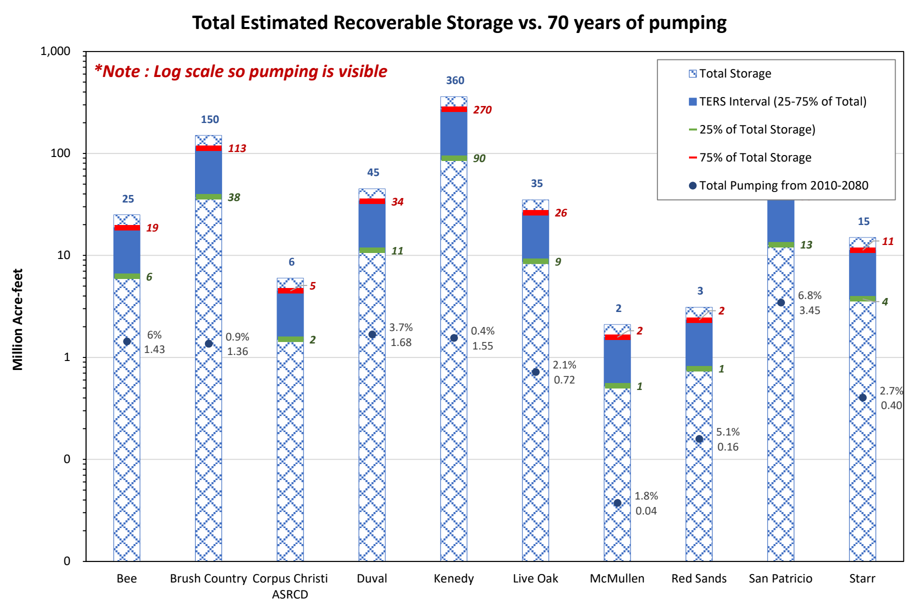
Total Estimated Recoverable Storage (TERS)



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Annual Recharge, Inflows & Discharge

- Annual Recharge, Inflow & Discharges are required consideration as part of the DFC process
- TWDB provides GAM Run reports in support of management plan development

*Note: TWDB only provides annual values for entire Gulf Coast Aquifer, not the individual 4 units

GCD	Report Name	Report Date
Bee	GAM Run 17-015	1/31/2018
Brush Country	GAM Run 17-001	10/4/2017
Corpus Christi ASRCD	GAM Run 18-012	6/27/2018
Duval County	GAM Run 16-011	10/21/2016
Kenedy County	GAM Run 16-009	3/18/2016
Live Oak	GAM Run 14-014	12/12/2014
McMullen	GAM Run 17-011	11/20/2017
Red Sands	GAM Run 16-008	5/16/2016
San Patricio County	GAM Run 16-003	8/4/2016
Starr County	GAM Run 18-016	2/28/2019

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Annual Recharge, Inflows & Discharge – Bee GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	21,081
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer System	13,055
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	4,000
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	17,080
Estimated net annual volume of flow between each aquifer in the district	Flow from the Catahoula Formation into the Jasper Aquifer[1]	332
	Flow to the Catahoula Formation from the Upper Jackson Formation subcrop[1]	46

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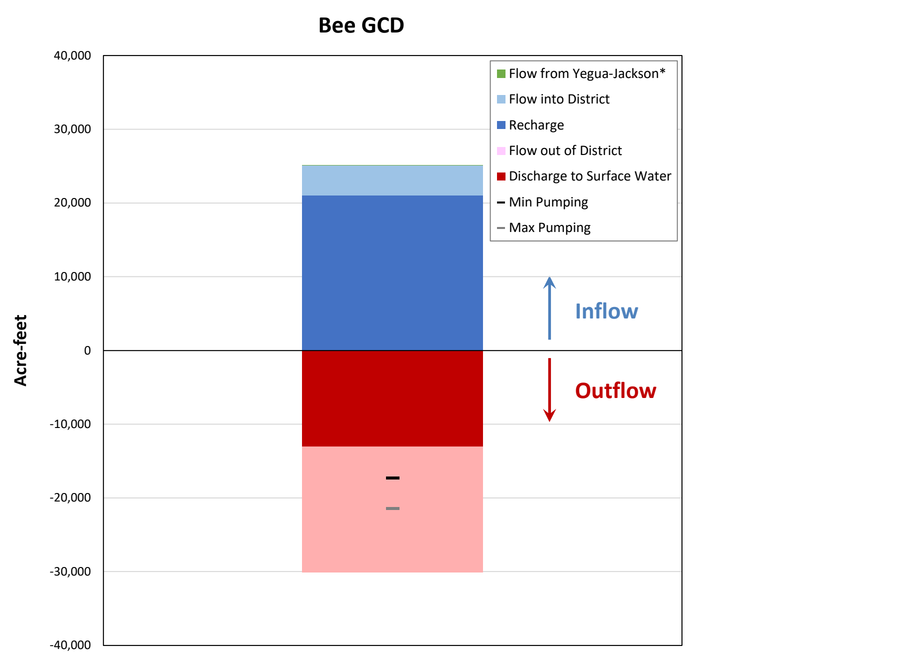

*refers to Catahoula Formation in Yegua-Jackson GAM

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Annual Recharge, Inflows & Discharge – Brush Country GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer	8,291
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer	2,633
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer	26,724
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer	43,886
Estimated net annual volume of flow between each aquifer in the district	From the Gulf Coast Aquifer into the underlying Yegua-Jackson Aquifer	401

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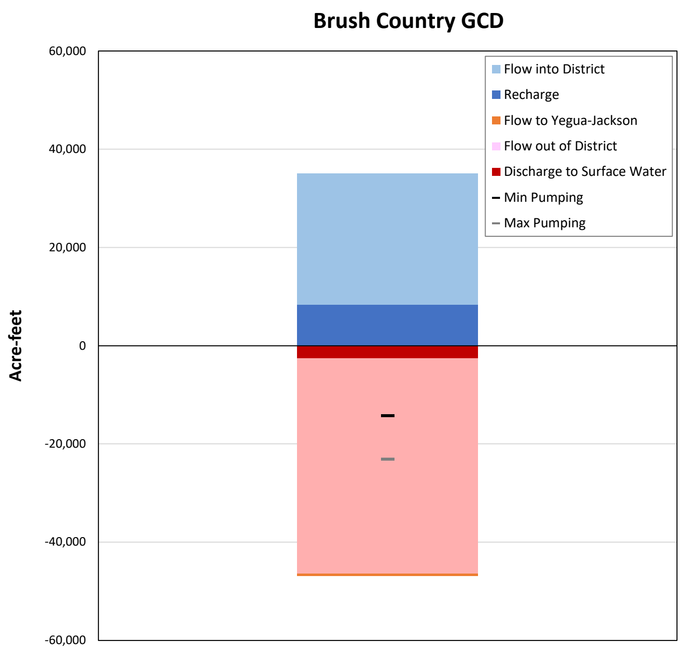

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Annual Recharge, Inflows & Discharge – Corpus Christi ASRCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	7
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer System	417[1]
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	202
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	89
Estimated net annual volume of flow between each aquifer in the district	Flow from brackish units into the Gulf Coast Aquifer System	396

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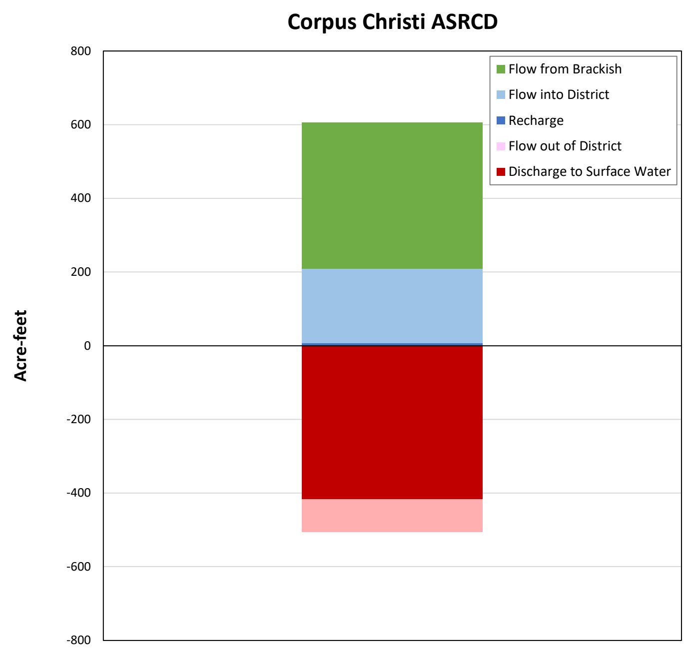

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Annual Recharge, Inflows & Discharge – Duval County GCD

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	18,509
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer System	11,537
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	3,830
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	10,341
Estimated net annual volume of flow between each aquifer in the district[1]	Not applicable	Not applicable

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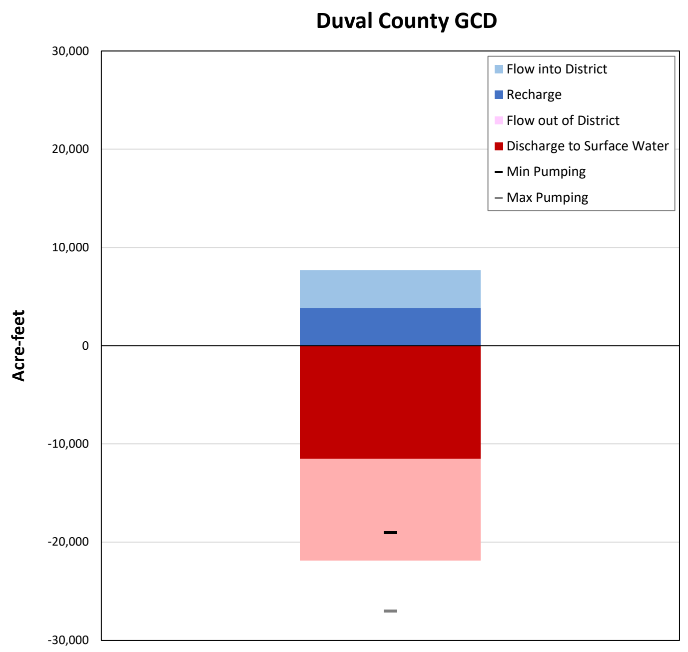

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Annual Recharge, Inflows & Discharge – Kenedy County GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	5,998
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer System	20,643
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	41,396
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	32,644
Estimated net annual volume of flow between each aquifer in the district *	From Gulf Coast Aquifer System to brackish water containing formations	1,216

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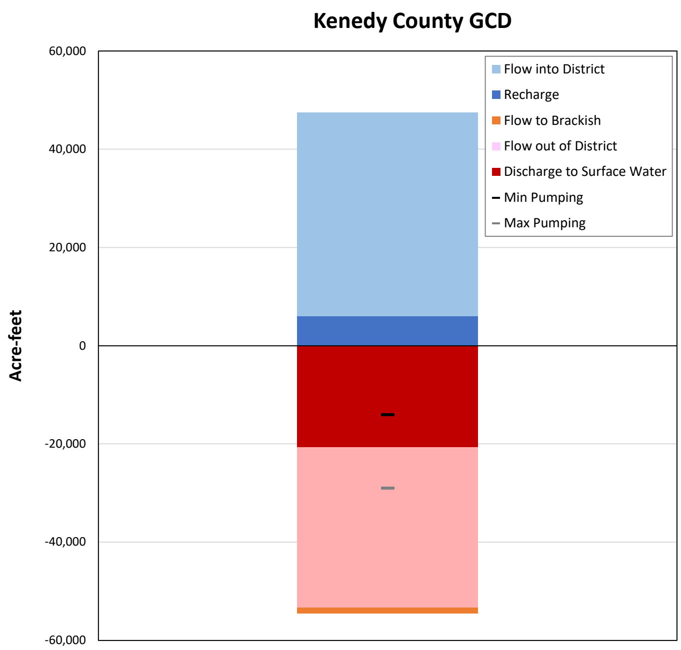

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Annual Recharge, Inflows & Discharge – Live Oak GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	5,487
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer System	10,378
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	4,124
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	1,572
Estimated net annual volume of flow between each aquifer in the district	From the Catahoula Formation into Yegua-Jackson Aquifer[1]	7
	From the confined Yegua-Jackson units into the Catahoula Formation[2]	273

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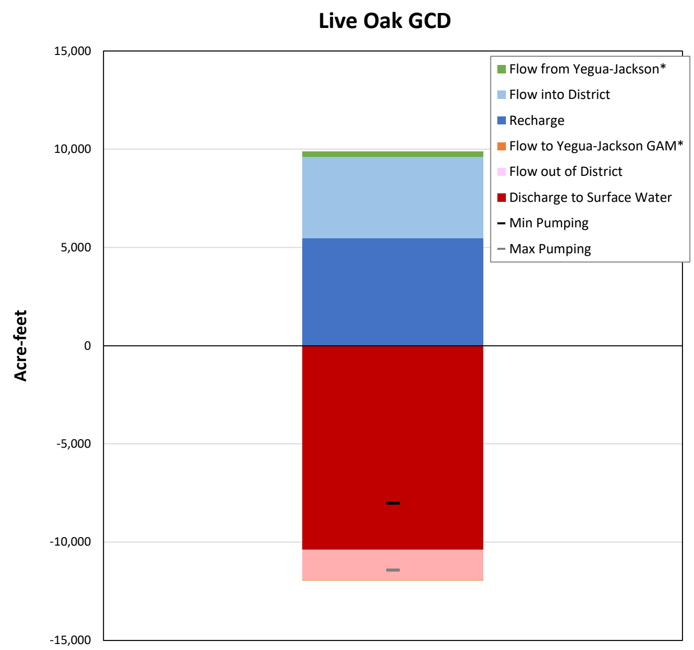

** Refers to Catahoula Formation in Yegua-Jackson GAM*

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Annual Recharge, Inflows & Discharge – McMullen GCD

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	244
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer System	809
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	242
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	594
Estimated net annual volume of flow between each aquifer in the district	Not Applicable*	Not Applicable*

*Model assumes no-flow conditions at the base

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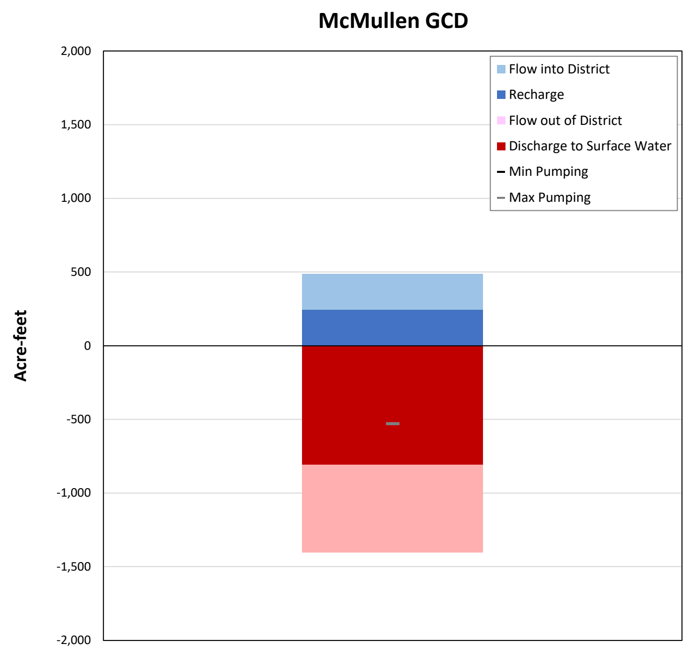

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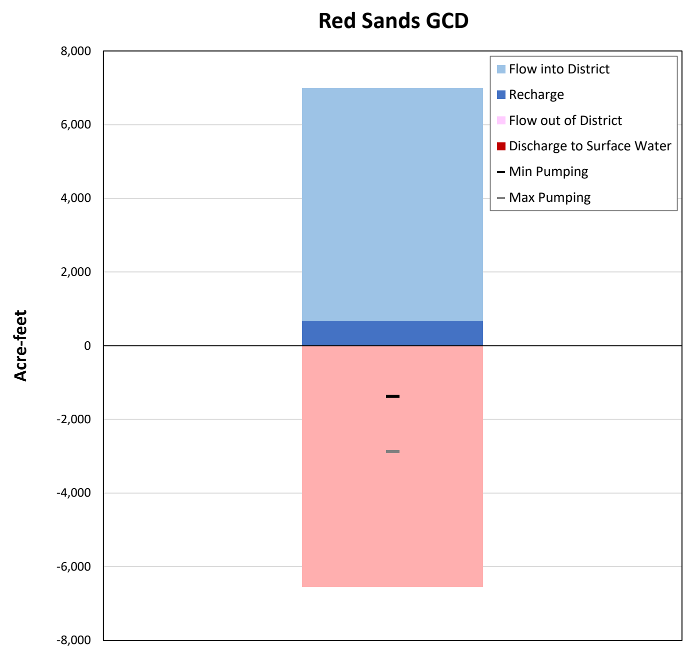
Annual Recharge, Inflows & Discharge – Red Sands GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	675
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, rivers, springs, and flowing wells	Gulf Coast Aquifer System	0
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	6,324
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	6,548
Estimated net annual volume of flow between each aquifer in the district	Not applicable*	Not applicable

40



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Annual Recharge, Inflows & Discharge – San Patricio GCD

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	9,977
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Gulf Coast Aquifer System	10,100
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	9,013
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	3,807
Estimated net annual volume of flow between each aquifer in the district[1]	From Gulf Coast Aquifer System to formations containing brackish water	3,216

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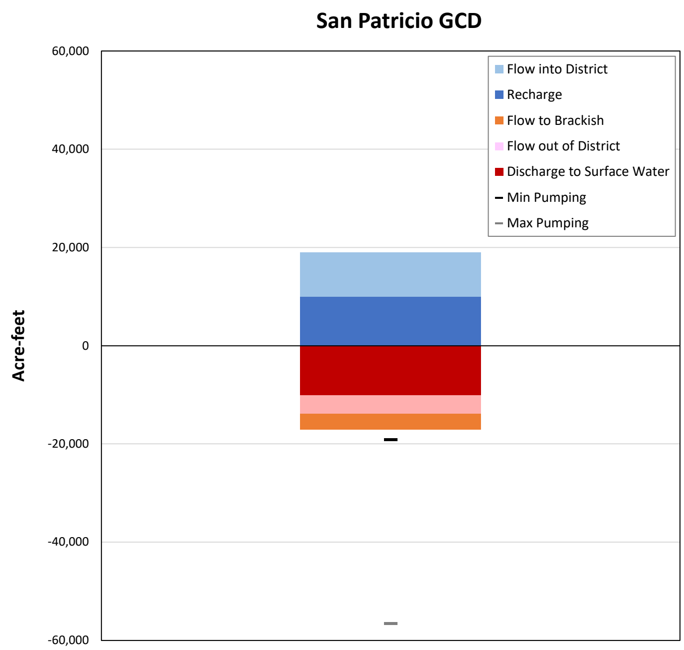

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Annual Recharge, Inflows & Discharge – Starr County GCD

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Gulf Coast Aquifer System	4,119
Estimated annual volume of water that discharges from the aquifer to springs and any surface-water body including lakes, streams, and rivers	Gulf Coast Aquifer System	167
Estimated annual volume of flow into the district within each aquifer in the district	Gulf Coast Aquifer System	1,241
Estimated annual volume of flow out of the district within each aquifer in the district	Gulf Coast Aquifer System	5,046
Estimated net annual volume of flow between each aquifer in the district	From Gulf Coast Aquifer System (Catahoula Formation) to Yegua-Jackson Aquifer	210*

*: Flow calculated from the groundwater availability model for the Yegua-Jackson Aquifer.

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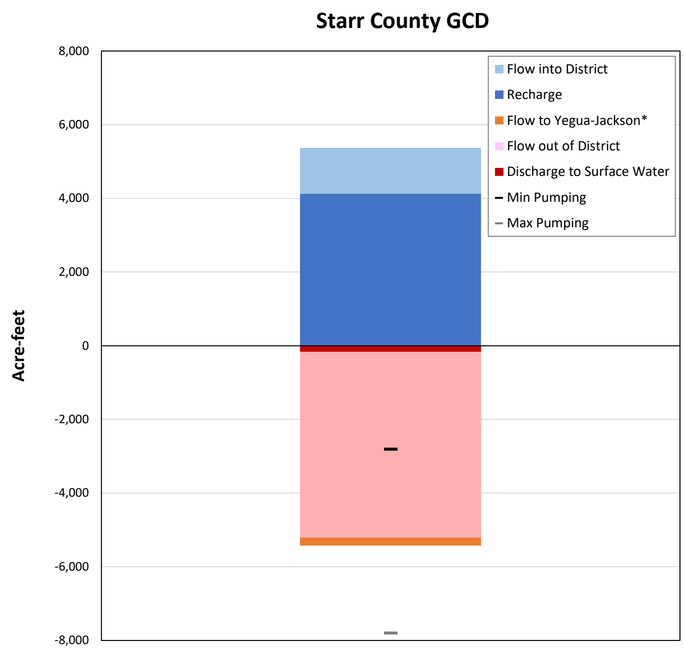

* *Refers to Catahoula Formation in Yegua-Jackson GAM*

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Explanatory Report

- Previous report (O'Rourke, 2017) will be used as template
- Explanatory report will briefly summarize this presentation & provide a copy as appendix
- Any District can provide INTERA with more District-specific information or details regarding this topic, if they feel it is necessary
- Deadline for addl District-specific information: next GMA meeting

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Questions?

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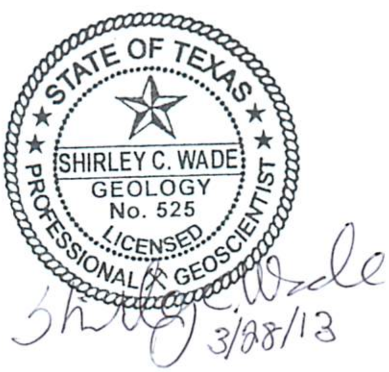
APPENDIX J

GAM RUN 12-025: TOTAL ESTIMATED RECOVERABLE STORAGE FOR AQUIFERS IN GROUNDWATER MANAGEMENT AREA 16

GAM Run 12-025: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 16

by Marius Jigmond and Shirley Wade
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 936-0883
March 28, 2013



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GAM RUN 12-025: TOTAL ESTIMATED RECOVERABLE STORAGE FOR AQUIFERS IN GROUNDWATER MANAGEMENT AREA 16

by Marius Jigmond and Shirley Wade
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 936-0883
March 28, 2013

EXECUTIVE SUMMARY:

Texas Water Code, § 36.108 (d) states that, before voting on the proposed desired future conditions for a relevant aquifer within a groundwater management area, the groundwater conservation districts shall consider the total estimated recoverable storage as provided by the executive administrator of the Texas Water Development Board (TWDB) along with other factors listed in §36.108 (d). Texas Administrative Code Rule §356.10 defines the total estimated recoverable storage as the estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume.

This report discusses the methods, assumptions, and results of an analysis to estimate the total recoverable storage for the Carrizo-Wilcox, Yegua-Jackson, and Gulf Coast (including parts of the Catahoula Formation) aquifers within groundwater management area 16. Tables 1 through 7 summarize the total estimated recoverable storage required by the statute. Figures 2 through 4 indicate the extent of the groundwater availability models used to estimate the total recoverable storage.

DEFINITION OF TOTAL ESTIMATED RECOVERABLE STORAGE:

The total estimated recoverable storage is defined as the estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume, in other words, we assume that only 25 to 75 percent of groundwater held within an aquifer can be removed by pumping.

The total recoverable storage was estimated for the portion of the aquifer within the official lateral aquifer boundaries as published in the 2007 State Water Plan. Total estimated recoverable storage values may include a mixture of water quality types, including fresh, brackish, and saline groundwater, because the available data and the existing groundwater availability models do not permit the differentiation of different water quality types.

METHODS:

To estimate the total recoverable storage of an aquifer, we first calculated the total storage in an aquifer within the official aquifer boundary. The total storage is the volume of groundwater removed by pumping that completely drains the aquifer.

Aquifers can be either unconfined or confined (figure 1). A well screened in an unconfined aquifer will have a water level equal to the water level outside the well or in the aquifer. Thus, unconfined aquifers have water levels within the aquifers. A confined aquifer is bounded by low permeable geologic units at the top and bottom, and the aquifer is under hydraulic pressure above the ambient atmospheric pressure. The water level at a well screened in a confined aquifer will be above the top of the aquifer. As a result, calculation of total storage is also different between unconfined and confined aquifers. For an unconfined aquifer, the total storage is equal to the volume of groundwater removed by pumping that makes the water level fall to the aquifer bottom. For a confined aquifer, the total storage contains two parts. The first part is the groundwater released from the aquifer when the water level falls from above the top of the aquifer to the top of the aquifer. The reduction of hydraulic pressure in the aquifer by pumping causes expansion of groundwater and deformation of aquifer solids. The aquifer is still fully saturated to this point. The second part, just like unconfined aquifer, is the groundwater released from the aquifer when the water level falls from the top to the bottom of the aquifer. Given the same aquifer area and water level drop, the amount of water released in the second part is much greater than the first part. The difference is quantified by two parameters: storativity related to confined aquifer and specific yield related to unconfined aquifer. For example, storativity values range from 10^{-5} to 10^{-3} for most confined aquifers, while the specific yield values can be 0.01 to 0.3 for most unconfined aquifers. The equations for calculating the total storage are presented below:

- for unconfined aquifers

$$Total\ Storage\ = V_{drained} = Area \times S_y \times (Water\ Level - Bottom)$$

- for confined aquifers

$$Total\ Storage\ = V_{confined} + V_{drained}$$

  - confined part

$$V_{confined} =\ Area \times [\ S \times (Water\ Level - Top)]$$

or

$$V_{confined} =\ Area \times [\ S_s\ \times (\mathrm{Top} - \mathrm{Bottom}) \times (Water\ Level - Top)]$$

  - unconfined part

$$V_{drained} =\ Area \times \left[S_y \times (Top - Bottom)\right]$$

where:

- $V_{drained}$ = storage volume due to water draining from the formation (acre-feet)
- $V_{confined}$ = storage volume due to elastic properties of the aquifer and water(acre-feet)
- *Area* = area of aquifer (acre)
- *Water Level* = groundwater elevation (feet above mean sea level)
- *Top* = elevation of aquifer top (feet above mean sea level)
- *Bottom* = elevation of aquifer bottom (feet above mean sea level)
- S_y = specific yield (no units)
- S_s = specific storage (1/feet)
- S = storativity or storage coefficient (no units)

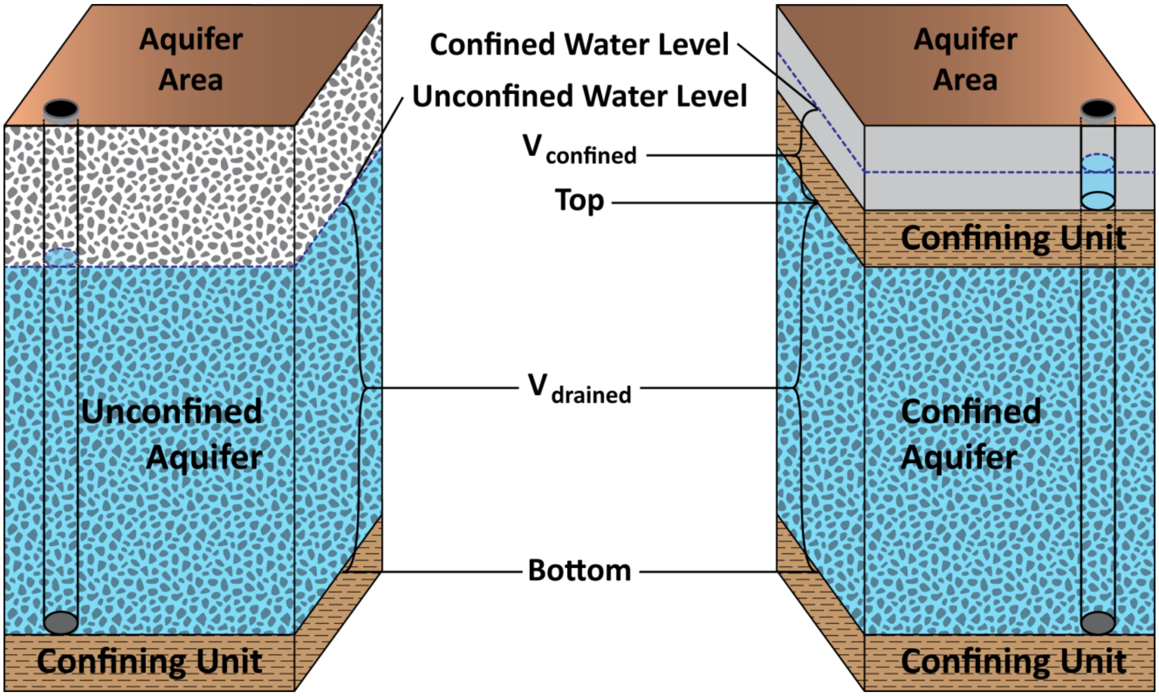

FIGURE 1. SCHEMATIC GRAPH SHOWING THE DIFFERENCE BETWEEN UNCONFINED AND CONFINED AQUIFERS.

As presented in the equations, calculation of the total storage requires data, such as aquifer top, aquifer bottom, aquifer storage properties, and water level. For groundwater management area 16, we extracted this information from existing groundwater availability models. This information was contained in model input and output files on a cell-by-cell basis. In the absence of groundwater availability model(s), the total storage will be calculated using other approaches. Finally, the total recoverable storage was calculated as the product of the total storage and an estimated factor ranging from 25 percent to 75 percent.

PARAMETERS AND ASSUMPTIONS:

Carrizo-Wilcox, Queen City, and Sparta aquifers

- We used version 2.01 of the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers to estimate the total recoverable storage of the Carrizo-Wilcox Aquifer. The Sparta and Queen City aquifers are not present in groundwater management area 16, so these aquifers were not included in this analysis. See Deeds and others (2003) and Kelley and others (2004) for assumptions and limitations of the groundwater availability model for the southern part of the Carrizo-Wilcox, Queen City, and Sparta aquifers.
- This groundwater availability model includes eight layers which generally represent the Sparta Aquifer (Layer 1), the Weches Confining Unit (Layer 2), the Queen City Aquifer (Layer 3), the Reklaw Confining Unit (Layer 4), the Carrizo Aquifer (Layer 5), the Upper Wilcox Formation (Layer 6), the Middle Wilcox Formation (Layer 7), and the Lower Wilcox Formation (Layer 8). To develop the estimates for the total estimated recoverable storage, we used layers 5 through 8 (Carrizo-Wilcox Aquifer system).
- The down-dip boundary of the model is based on the location of the Wilcox Growth Fault Zone which is considered to be a barrier to flow (Kelley and others, 2004). This boundary is relatively deep and in the portion of the aquifer that is characterized as brackish to saline; consequently, the model includes parts of the formation beyond potable portions of the aquifer. The groundwater in the Carrizo-Wilcox, Queen City, and Sparta aquifers ranges from fresh to brackish in composition (Kelley and others, 2004).

Yegua-Jackson Aquifer

- We used version 1.01 of the groundwater availability model to estimate the total recoverable storages of the Yegua-Jackson Aquifer and the Catahoula Formation. See Deeds and others (2010) for assumptions and limitations of the groundwater availability model.

- This groundwater availability model includes five layers which represent the outcrop section for the Yegua-Jackson Aquifer and the Catahoula Formation and other younger overlying units (Layer 1), the upper portion of the Jackson Group (Layer 2), the lower portion of the Jackson Group (Layer 3), the upper portion of the Yegua Group (Layer 4), and the lower portion of the Yegua Group (Layer 5). To develop the estimates for the total estimated recoverable storage in the Yegua-Jackson Aquifer, we used layers 1 through 5; however, we only used model cells in layer 1 that represent the outcrop area of the Yegua-Jackson Aquifer. We also used selected model cells in layer 1 to develop the estimates for the total estimated recoverable storage in the Catahoula Formation, which is considered part of the Gulf Coast Aquifer system.
- The down-dip boundary for the Yegua-Jackson Aquifer in this model was set to approximately coincide with the extent of the available geologic data, well beyond any active portion (groundwater use) of the aquifer (Deeds and others, 2010). Consequently, the model extends into zones of brackish and saline groundwater.

Gulf Coast Aquifer

- We used the alternative model (of the Gulf Coast Aquifer) for groundwater management area 16 to estimate the total recoverable storage of the Gulf Coast Aquifer. See Hutchison and others (2011) for assumptions and limitations of the model.
- The groundwater flow model encompasses the boundaries of groundwater management area 16. The model includes portions of the underlying Gulf Coast, Yegua-Jackson, and Sparta, Queen City, and Carrizo-Wilcox aquifer systems. Layers 1 through 4 represent the Gulf Coast Aquifer system which is comprised of the Chicot Aquifer, Evangeline Aquifer, Burkeville confining unit, and Jasper Aquifer in descending order. Layer 5 is a bulk representation of the Yegua-Jackson Aquifer System including parts of the Catahoula Formation and layer 6 is a bulk representation of the Sparta, Queen-City, Carrizo-Wilcox aquifers (Hutchison and others, 2011).To develop the estimate for the total estimated recoverable storage, we used layers 1 through 4 (Gulf Coast Aquifer system). We used the Yegua-

Jackson Aquifer model for the Catahoula Formation, which is considered part of the Gulf Coast Aquifer system. These values are reported separately.

- The down-dip extents for all aquifer systems in this model are based on previously developed groundwater availability models of the Gulf Coast Aquifer central (Chowdhury and others, 2004) and southern (Chowdhury and Mace, 2007) portions, Yegua-Jackson Aquifer (Deeds and others, 2010), and Sparta, Queen City, and Carrizo-Wilcox aquifers southern portion (Kelley and others, 2004). As such, these model layers extend well past the slightly saline water line and into zones of brackish and saline groundwater.

RESULTS:

Tables 1 through 7 summarize the total estimated recoverable storage required by statute. The county and groundwater conservation district total estimates are rounded within one percent of the total. Figures 2 through 4 indicate the area of the groundwater availability models from which the storage information was extracted.

TABLE 1. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY AND GROUNDWATER CONSERVATION DISTRICT FOR THE CARRIZO-WILCOX AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 16. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN ONE PERCENT OF THE TOTAL.

County	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Bee	4,700,000	1,175,000	3,525,000
Live Oak	89,000,000	22,250,000	66,750,000
McMullen	11,000,000	2,750,000	8,250,000
Total	**104,700,000**	**26,175,000**	**78,525,000**

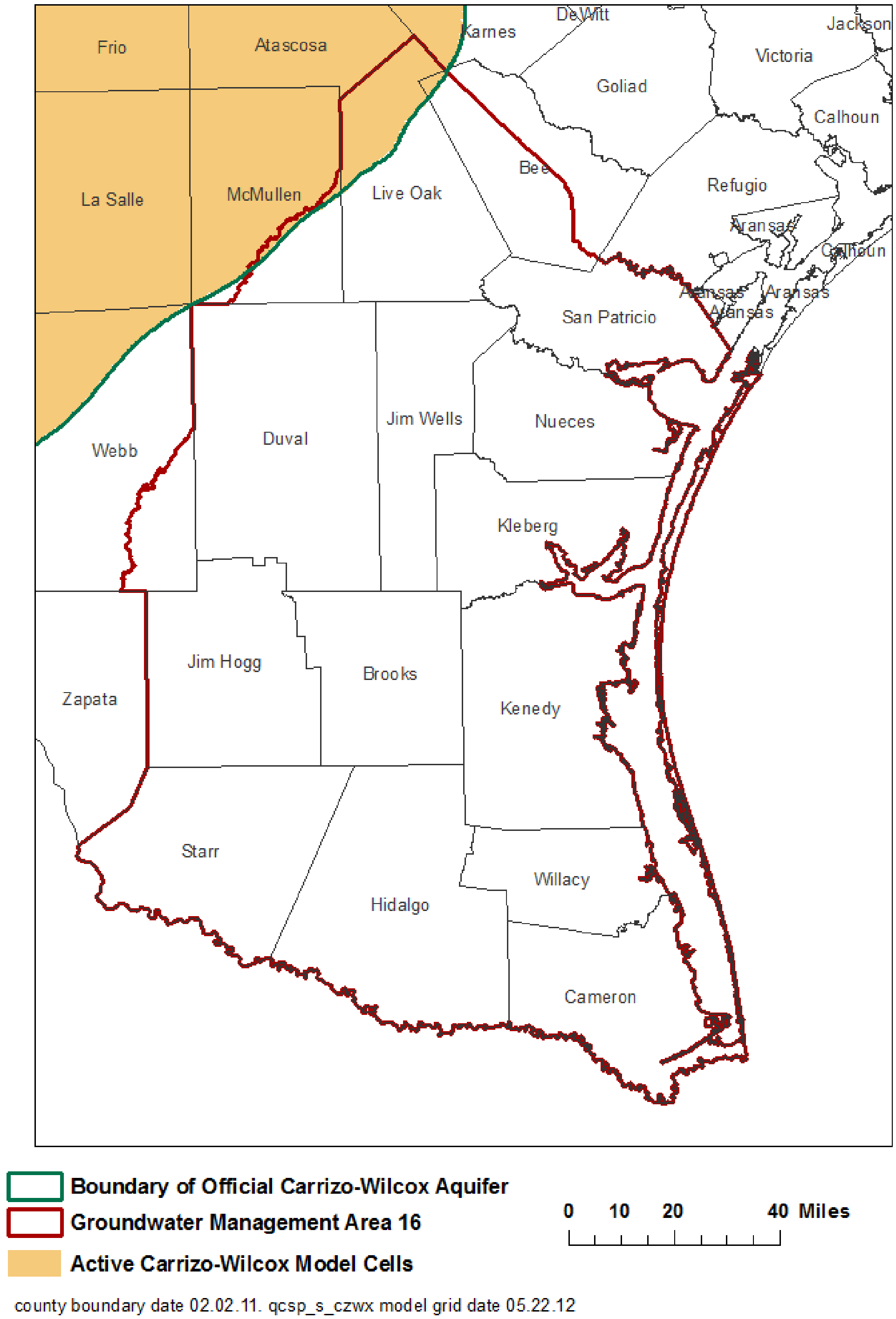

FIGURE 2. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL OF THE CARRIZO-WILCOX, QUEEN CITY, AND SPARTA AQUIFERS USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLE 1) FOR THE CARRIZO-WILCOX AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 16.

TABLE 2. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE YEGUA-JACKSON AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 16. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN ONE PERCENT OF THE TOTAL.

County	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Duval	7,200,000	1,800,000	5,400,000
Jim Hogg	3,000,000	750,000	2,250,000
Live Oak	11,000,000	2,750,000	8,250,000
Starr	46,000,000	11,500,000	34,500,000
Webb	820,000	205,000	615,000
Total	**68,020,000**	**17,005,000**	**51,015,000**

TABLE 3. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT FOR THE YEGUA-JACKSON AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 16. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN ONE PERCENT OF THE TOTAL.

Groundwater Conservation District	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Brush Country	3,000,000	750,000	2,250,000
Duval County	7,200,000	1,800,000	5,400,000
Live Oak	11,000,000	2,750,000	8,250,000
Starr County	46,000,000	11,500,000	34,500,000
No District	820,000	205,000	615,000
Total	**68,020,000**	**17,005,000**	**51,015,000**

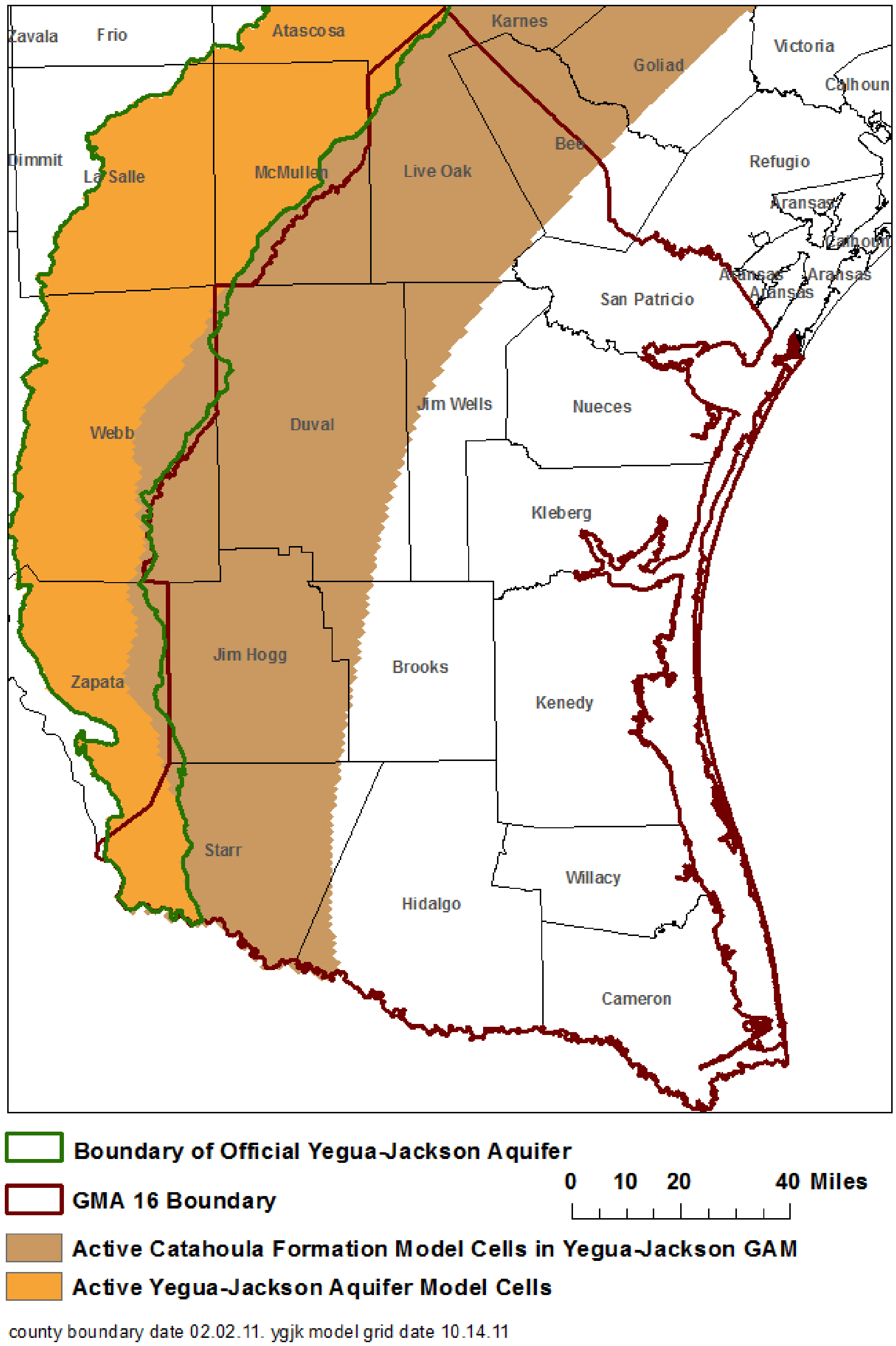

FIGURE 3. EXTENT OF THE GROUNDWATER AVAILABILITY MODEL OF THE YEGUA-JACKSON AQUIFER USED TO ESTIMATE TOTAL RECOVERABLE STORAGE FOR THE YEGUA-JACKSON AQUIFER (TABLES 2 AND 3) AND CATAHOULA FORMATION (TABLES 4 AND 5) WITHIN GROUNDWATER MANAGEMENT AREA 16.

TABLE 4. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE CATAHOULA FORMATION WITHIN GROUNDWATER MANAGEMENT AREA 16. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN ONE PERCENT OF THE TOTAL.

County	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Bee	60,000,000	15,000,000	45,000,000
Brooks	32,000,000	8,000,000	24,000,000
Duval	280,000,000	70,000,000	210,000,000
Hidalgo	21,000,000	5,250,000	15,750,000
Jim Hogg	220,000,000	55,000,000	165,000,000
Jim Wells	50,000,000	12,500,000	37,500,000
Live Oak	140,000,000	35,000,000	105,000,000
McMullen	21,000,000	5,250,000	15,750,000
Starr	170,000,000	42,500,000	127,500,000
Webb	24,000,000	6,000,000	18,000,000
Total	**1,018,000,000**	**254,500,000**	**763,500,000**

TABLE 5. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[1] FOR THE CATAHOULA FORMATION WITHIN GROUNDWATER MANAGEMENT AREA 16. GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN ONE PERCENT OF THE TOTAL.

Groundwater Conservation District	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Bee	58,000,000	14,500,000	43,500,000
Brush Country	310,000,000	77,500,000	232,500,000
Duval County	280,000,000	70,000,000	210,000,000
Live Oak	140,000,000	35,000,000	105,000,000
McMullen	21,000,000	5,250,000	15,750,000
Starr County	170,000,000	42,500,000	127,500,000
No District	47,000,000	11,750,000	35,250,000
Total	**1,026,000,000**	**256,500,000**	**769,500,000**

[1] The total estimated recoverable storages by groundwater conservation district and county aquifer may not be the same because the numbers have been rounded to within one percent.

TABLE 6. TOTAL ESTIMATED RECOVERABLE STORAGE BY COUNTY FOR THE GULF COAST AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 16. COUNTY TOTAL ESTIMATES ARE ROUNDED WITHIN ONE PERCENT OF THE TOTAL. NOTE: WE REPORT THE CATAHOULA FORMATION SEPARATELY IN TABLE 4.

County	***Total Storage (acre-feet)***	***25% of Total Storage (acre-feet)***	***75% of Total Storage (acre-feet)***
Bee	25,000,000	6,250,000	18,750,000
Brooks	90,000,000	22,500,000	67,500,000
Cameron	49,000,000	12,250,000	36,750,000
Duval	45,000,000	11,250,000	33,750,000
Hidalgo	160,000,000	40,000,000	120,000,000
Jim Hogg	40,000,000	10,000,000	30,000,000
Jim Wells	61,000,000	15,250,000	45,750,000
Kenedy	210,000,000	52,500,000	157,500,000
Kleberg	110,000,000	27,500,000	82,500,000
Live Oak	35,000,000	8,750,000	26,250,000
McMullen	2,100,000	525,000	1,575,000
Nueces	76,000,000	19,000,000	57,000,000
San Patricio	51,000,000	12,750,000	38,250,000
Starr	15,000,000	3,750,000	11,250,000
Webb	250,000	62,500	187,500
Willacy	45,000,000	11,250,000	33,750,000
Total	**1,014,350,000**	**253,587,500**	**760,762,500**

TABLE 7. TOTAL ESTIMATED RECOVERABLE STORAGE BY GROUNDWATER CONSERVATION DISTRICT[2] FOR THE GULF COAST AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 16 . GROUNDWATER CONSERVATION DISTRICT TOTAL ESTIMATES ARE ROUNDED WITHIN ONE PERCENT OF THE TOTAL. NOTE: WE REPORT THE CATAHOULA FORMATION SEPARATELY IN TABLE 5.

Groundwater Conservation District	*Total Storage (acre-feet)*	*25% of Total Storage (acre-feet)*	*75% of Total Storage (acre-feet)*
Bee	25,000,000	6,250,000	18,750,000
Brush Country	150,000,000	37,500,000	112,500,000
Corpus Christi ASRCD	6,000,000	1,500,000	4,500,000
Duval County	45,000,000	11,250,000	33,750,000
Kenedy County	360,000,000	90,000,000	270,000,000
Live Oak	35,000,000	8,750,000	26,250,000
McMullen	2,100,000	525,000	1,575,000
Red Sands	3,100,000	775,000	2,325,000
San Patricio County	51,000,000	12,750,000	38,250,000
Starr County	15,000,000	3,750,000	11,250,000
No District	310,000,000	77,500,000	232,500,000
Total	**1,002,200,000**	**250,550,000**	**751,650,000**

[2] The total estimated recoverable storages by groundwater conservation district and county aquifer may not be the same because the numbers have been rounded to within one percent.

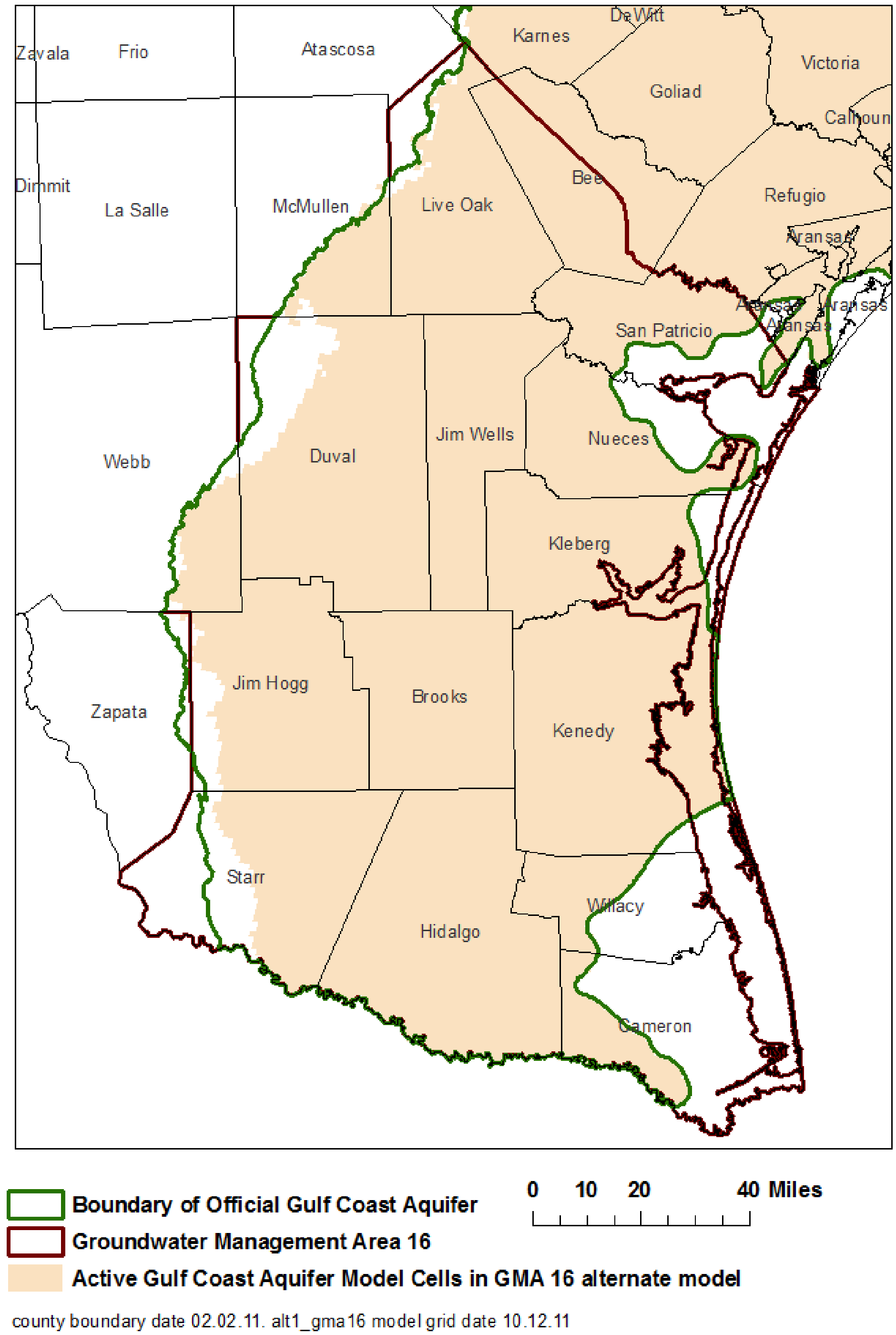

FIGURE 4. EXTENT OF THE ALTERNATIVE MODEL FOR GROUNDWATER MANAGEMENT AREA 16 USED TO ESTIMATE TOTAL RECOVERABLE STORAGE (TABLES 6 AND 7) FOR THE GULF COAST AQUIFER WITHIN GROUNDWATER MANAGEMENT AREA 16.

LIMITATIONS

The groundwater models used in completing this analysis are the best available scientific tools that can be used to meet the stated objective(s). To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> *"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."*

Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

REFERENCES:

Chowdhury, A. H. and Mace, R. E., 2007. Groundwater Resource Evaluation and Availability Model of the Gulf Coast Aquifer in the Lower Rio Grande Valley of Texas.

Deeds, N., Kelley, V., Fryar, D., Jones, T., Whallon, A.J., and Dean, K.E., 2003, Groundwater Availability Model for the Southern Carrizo-Wilcox Aquifer: Contract report to the Texas Water Development Board, 452 p., http://www.twdb.texas.gov/groundwater/models/gam/czwx_s/CZWX_S_Full_Report.pdf.

Deeds, N.E., Yan, T., Singh, A., Jones, T.L., Kelley, V.A., Knox, P.R., Young, S.C., 2010, Groundwater availability model for the Yegua-Jackson Aquifer: Final report prepared for the Texas Water Development Board by INTERA, Inc., 582 p., http://www.twdb.texas.gov/groundwater/models/gam/ygjk/YGJK_Model_Report.pdf.

Hutchison, W. R., Hill, M. E., Anaya, R., Hassan, M. M., Oliver, W., Jigmond, M., Wade, S., and Aschenbach, E., 2011. Groundwater Management Area 16 Groundwater Flow Model, http://www.twdb.texas.gov/groundwater/models/alt/gma16/GMA16_Model_Report_DRAFT.pdf.

Kelley, V.A., Deeds, N.E., Fryar, D.G., and Nicot, J.P., 2004, Groundwater availability models for the Queen City and Sparta aquifers: Contract report to the Texas Water Development Board, 867 p., http://www.twdb.texas.gov/groundwater/models/gam/qcsp/QCSP_Model_Report.pdf.

National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p., http://www.nap.edu/catalog.php?record_id=11972.

APPENDIX K
PRESENTATION ON POTENTIAL ENVIRONMENTAL IMPACTS

Groundwater Management Area 16 Joint Planning Cycle: 2019-2022 Environmental Impacts

Virtual Meeting
October 27, 2020

Steve Young, Ph.D., P.G., P.E.
Jevon Harding, P.G.

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1

Joint Planning Requirements

- Balancing Test
  - 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*"

2

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Joint Planning Requirements

- Consideration of 9 “factors” (paraphrased)
  - Aquifer uses or conditions
  - Water supply needs and management strategies
  - Hydrological conditions
  - ***Other environmental impacts***
  - Impact on subsidence
  - Socioeconomic impacts
  - Impact on private property rights
  - Feasibility of achieving the DFC
  - Any other relevant information

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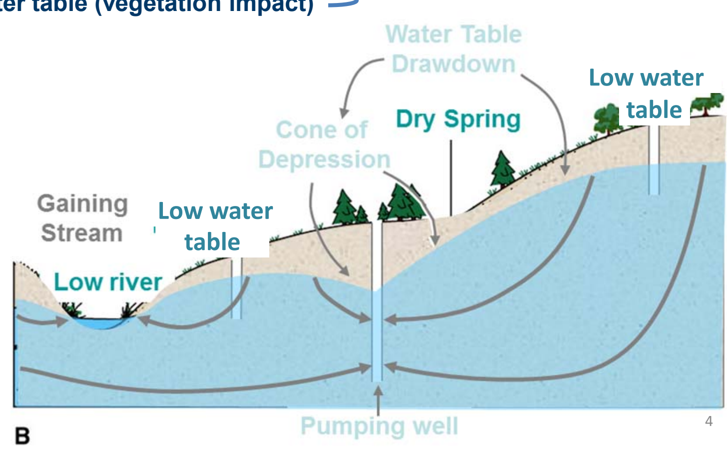
EXAMPLES OF HOW PUMPING CAN CAUSE ENVIRONMENTAL IMPACTS

- **Reduced flows to rivers**
- **Withdrawal from rivers (losing streams)**
- **Reduced spring flows**
- **Dried springs**
- **Lowered water table (vegetation impact)**

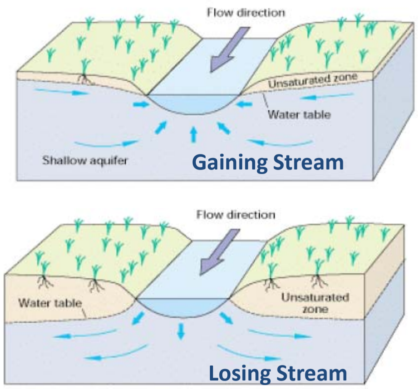
Caused by lower of water levels



INTERA 4

4

Conditions Associated with Gaining and Losing Streams



USGS Circular 1186, 1999

- Gaining:
  - Net discharge of groundwater to surface water "base flow"
- Losing:
  - Net discharge of surface water to groundwater "recharge"

The TCEQ rules define baseflow as "*[t]he portion of streamflow uninfluenced by recent rainfall or flood runoff and is comprised of springflow, seepage, discharge from artesian wells or other groundwater sources, and the delayed drainage of large lakes and swamps.*

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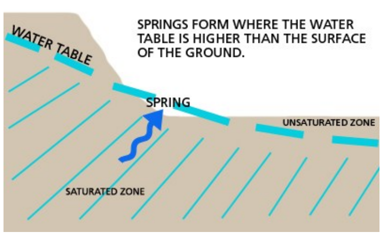
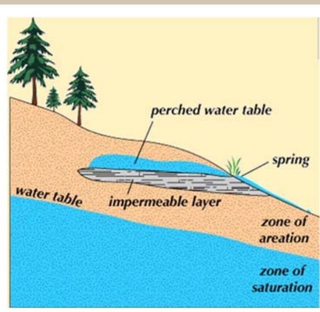
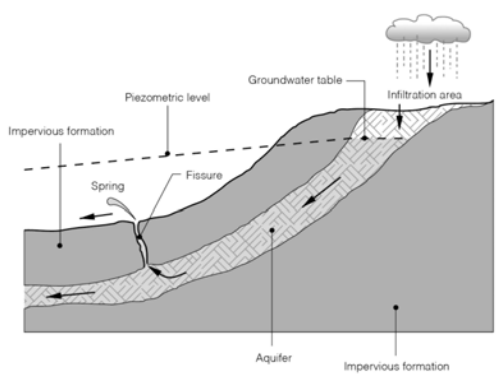
Conditions Associated with Springs



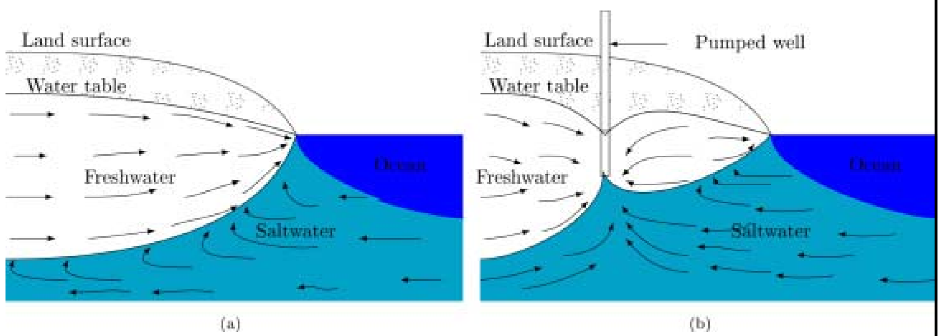




https://www.nps.gov/thro/learn/nature/springs.htm INTERA 6

6

Conditions Associated with Sea Water Intrusion



https://www.sciencedirect.com/science/article/abs/pii/S0378475418301538

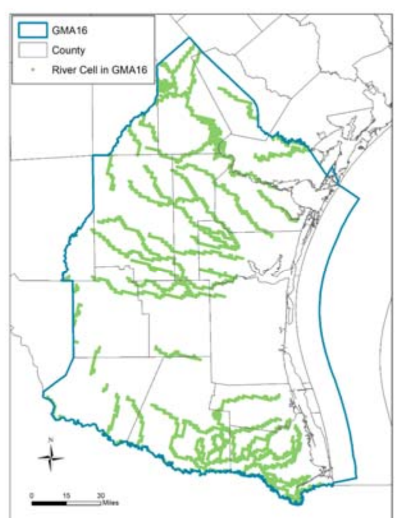
INTERA 7

7

Stream – Groundwater Interaction

River Nodes in the GMA 16 GFM

- Streams are located using river nodes
- River nodes are assigned a water elevation
- Direction of flow exchange is toward the lower water level
- Amount of flow exchange determined by aquifer & stream hydraulic properties



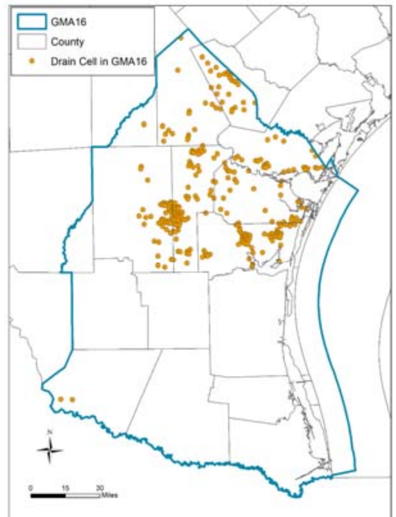
INTERA 8

8

Groundwater – Spring Interaction

- Wetlands and Spring locations are represented by drain nodes
- Groundwater can only leave aquifer
- Spring and seepage occurs when groundwater level is higher than the elevation assigned the drain cell

Drain Nodes in the GMA 16 GFM



INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Ocean – Groundwater Interaction

- Ocean is located using general head nodes
- General Head nodes are assigned a water elevation
- Direction of flow exchange is toward the lower water level
- Amount of flow exchange determined by aquifer & stream hydraulic properties

General Head Nodes in the GMA 16 GFM

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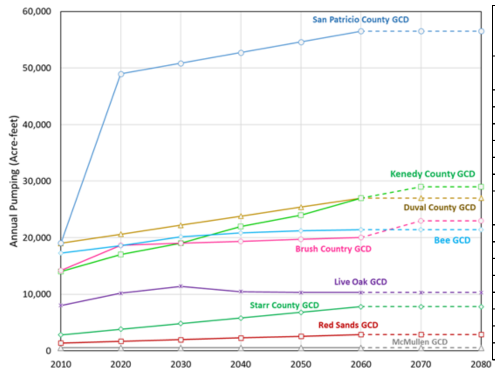
Flow Scenario #2



GCD or Region	Simulated Drawdown (ft) 2010-2080				
	Chicot	Evangeline	Burkeville	Jasper	Gulf Coast Aquifer
Bee GCD	125	101	89	74	91
Brush Country GCD	60	100	88	90	90
Duval County	98	181	120	107	136
Kenedy County GCD	18	56	18	18	28
Live Oak UWCD	100	83	78	25	44
McMullen GCD	0	0	0	12	12
Red Sands GCD	48	63	61	61	61
San Patricio County GCD	114	84	40	40	69
Starr County GCD	0	112	100	76	94
Non-district Cameron	126	196	78	78	120
Non-district Hidalgo	154	171	120	118	139
Non-district Kleberg	15	47	11	11	21
Non-district Nueces	33	40	16	16	26
Non-district Webb	0	228	0	89	161
Non-district Willacy	47	85	23	23	45
GMA 16 TOTAL	61	110	67	65	78

INTERA
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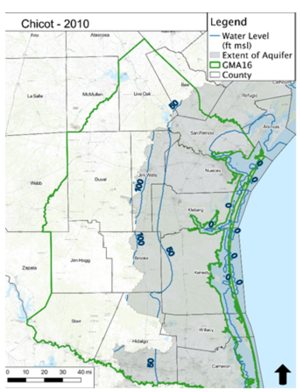
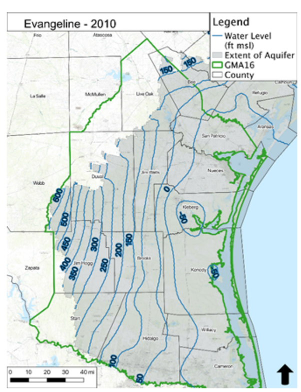
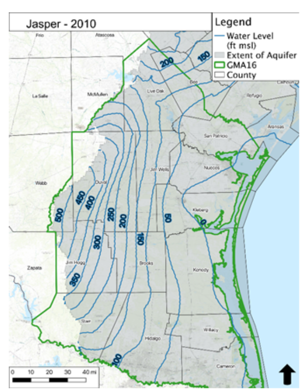
Flow Scenario #2 – Water Levels 2009







INTERA
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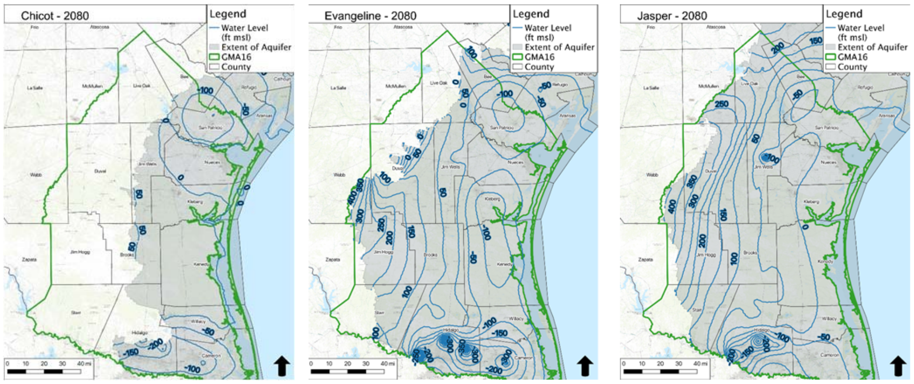
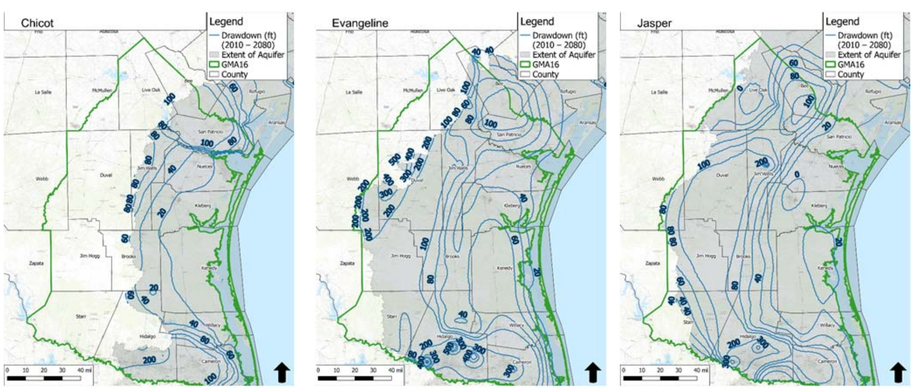
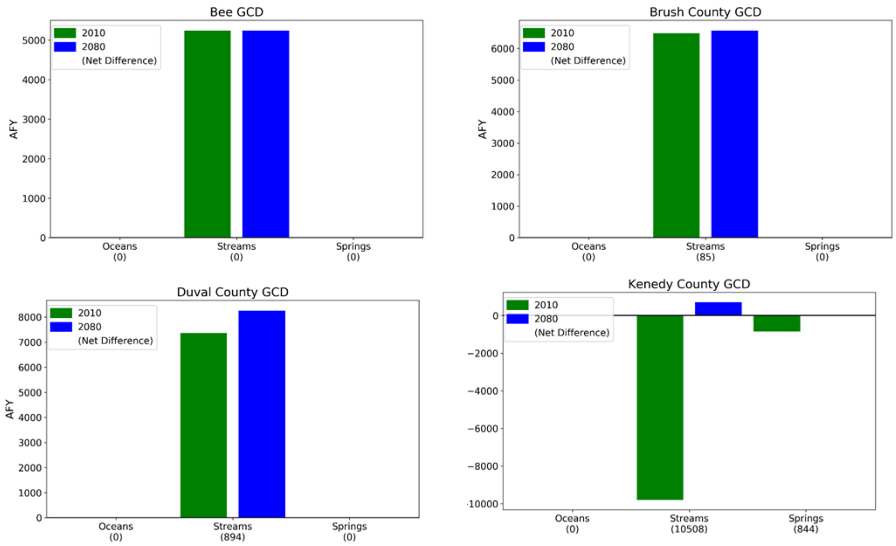
Flow Scenario #2 – Water Levels 2080



Flow Scenario #2 – Drawdowns



Surface Water – Groundwater Exchange



Note: positive numbers indicate surface water is lost to groundwater

INTERA

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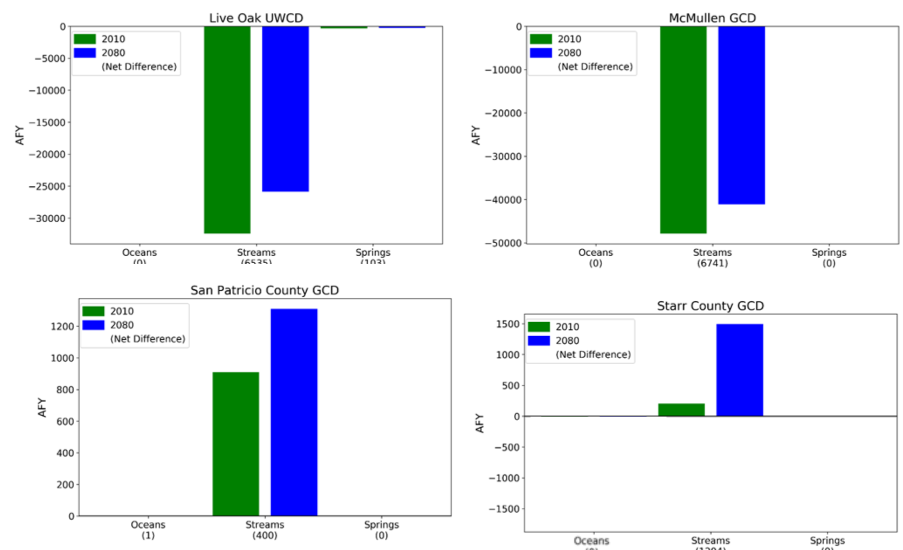
Surface Water – Groundwater Exchange



Note: positive numbers indicate surface water is lost to groundwater

Note: Red Sands GCD has no surface water – groundwater exchange

INTERA

16

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Bee County GCD Water Budget

Aquifer or Hydrogeologic Unit	Storage	Recharge	Surface Water - Groundwater Interaction			Groundwater Flow		Wells
			Ocean/ Lake	Stream	Spring/ Wetlands	Lateral	Vertical	
2010 Annual Net Flux (acre-ft/year)								
Chicot	3,935	988	0	731	0	-2,914	3,719	-6,458
Evangeline	4,028	2,008	0	104	0	727	2,761	-9,629
Burkeville	722	142	0	4,023	0	-327	-4,074	-485
Jasper	3,042	591	0	383	0	90	-3,343	-762
Yegua-Jackson	255	0	0	0	0	-155	13	-112
SP,QC, CW	12	0	0	0	0	-803	924	-132
Total	11,994	3,729	0	5,241	0	-3,382	0	-17,578
2080 Annual Net Flux (acre-ft/year)								
Chicot	1,738	988	0	731	0	-2,905	7,047	-7,599
Evangeline	1,387	2,008	0	104	0	2,471	6,144	-12,115
Burkeville	126	142	0	4,023	0	3,129	-6,731	-689
Jasper	1,762	591	0	383	0	626	-2,355	-1,007
Yegua-Jackson	79	0	0	0	0	2,890	-2,646	-323
SP,QC, CW	2	0	0	0	0	1,801	-1,459	-344
Total	5,094	3,729	0	5,241	0	8,012	0	-22,077
2080 Annual Net Flux (acre-ft/year) minus 2010 Annual Net Flux (acre-ft/year)								
Chicot	-2,197	0	0	0	0	9	3,328	-1,141
Evangeline	-2,641	0	0	0	0	1,744	3,383	-2,486
Burkeville	-596	0	0	0	0	3,456	-2,657	-204
Jasper	-1,280	0	0	0	0	536	988	-245
Yegua-Jackson	-176	0	0	0	0	3,045	-2,659	-211
SP,QC, CW	-10	0	0	0	0	2,604	-2,383	-212
Total	-6,900	0	0	0	0	11,394	0	-4,499

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Brush Country GCD Water Budget

Aquifer or Hydrogeologic Unit	Storage	Recharge	Surface Water - Groundwater Interaction			Groundwater Flow		Wells
			Ocean/ Lake	Stream	Spring/ Wetlands	Lateral	Vertical	
2010 Annual Net Flux (acre-ft/year)								
Chicot	4,659	1,955	0	1,590	0	-19,957	14,496	-2,788
Evangeline	7,236	6,197	0	208	0	-1,790	-1,006	-10,847
Burkeville	178	0	0	0	0	-167	-3	-7
Jasper	2,059	41	0	1,580	0	316	-3,449	-547
Yegua-Jackson	3,939	657	0	3,104	0	2,337	-10,038	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	18,071	8,850	0	6,482	0	-19,261	0	-14,189
2080 Annual Net Flux (acre-ft/year)								
Chicot	4,360	1,955	0	1,675	0	-10,032	5,241	-3,199
Evangeline	4,835	6,197	0	208	0	-7,004	8,210	-12,447
Burkeville	137	0	0	0	0	299	-427	-9
Jasper	2,958	41	0	1,580	0	1,811	939	-7,330
Yegua-Jackson	1,468	657	0	3,104	0	8,733	-13,962	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	13,758	8,850	0	6,567	0	-6,193	1	-22,985
2080 Annual Net Flux (acre-ft/year) minus 2010 Annual Net Flux (acre-ft/year)								
Chicot	-299	0	0	85	0	9,925	-9,255	-411
Evangeline	-2,401	0	0	0	0	-5,214	9,216	-1,600
Burkeville	-41	0	0	0	0	466	-424	-2
Jasper	899	0	0	0	0	1,495	4,388	-6,783
Yegua-Jackson	-2,471	0	0	0	0	6,396	-3,924	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	-4,313	0	0	85	0	13,068	1	-8,796

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Duval County GCD Water Budget

Aquifer or Hydrogeologic Unit	Storage	Recharge	Surface Water - Groundwater Interaction			Groundwater Flow		Wells
			Ocean/ Lake	Stream	Spring/ Wetlands	Lateral	Vertical	
2010 Annual Net Flux (acre-ft/year)								
Chicot	91	30	0	0	0	-648	906	-380
Evangeline	7,638	4,502	0	149	0	-1,780	6,185	-16,695
Burkeville	85	0	0	0	0	-5,486	5,400	0
Jasper	8,470	2,492	0	4,836	0	-1,179	-12,720	-1,899
Yegua-Jackson	3,592	1,993	0	2,377	0	-8,181	229	-10
SP,QC, CW	0	0	0	0	0	0	0	0
Total	19,876	9,017	0	7,362	0	-17,274	0	-18,984
2080 Annual Net Flux (acre-ft/year)								
Chicot	47	30	0	0	0	-165	628	-540
Evangeline	3,504	4,502	0	149	0	3,153	12,415	-23,723
Burkeville	35	0	0	0	0	-2,265	2,229	0
Jasper	4,253	2,492	0	4,836	0	-683	-8,201	-2,699
Yegua-Jackson	3,090	1,993	0	3,271	0	-1,182	-7,072	-100
SP,QC, CW	0	0	0	0	0	0	0	0
Total	10,929	9,017	0	8,256	0	-1,142	-1	-27,062
2080 Annual Net Flux (acre-ft/year) minus 2010 Annual Net Flux (acre-ft/year)								
Chicot	-44	0	0	0	0	483	-278	-160
Evangeline	-4,134	0	0	0	0	4,933	6,230	-7,028
Burkeville	-50	0	0	0	0	3,221	-3,171	0
Jasper	-4,217	0	0	0	0	496	4,519	-800
Yegua-Jackson	-502	0	0	894	0	6,999	-7,301	-90
SP,QC, CW	0	0	0	0	0	0	0	0
Total	-8,947	0	0	894	0	16,132	-1	-8,078

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Kenedy County GCD Water Budget

Aquifer or Hydrogeologic Unit	Storage	Recharge	Surface Water - Groundwater Interaction			Groundwater Flow		Wells
			Ocean/ Lake	Stream	Spring/ Wetlands	Lateral	Vertical	
2010 Annual Net Flux (acre-ft/year)								
Chicot	5,128	6,593	0	-9,801	-844	2,514	-2,092	-1,497
Evangeline	1,532	26	0	4	0	4,294	7,644	-13,500
Burkeville	166	0	0	0	0	3,870	-4,036	0
Jasper	851	0	0	0	0	664	-1,515	0
Yegua-Jackson	0	0	0	0	0	0	0	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	7,677	6,619	0	-9,797	-844	11,342	1	-14,997
2080 Annual Net Flux (acre-ft/year)								
Chicot	9,623	6,593	0	707	0	-7,072	-6,958	-2,893
Evangeline	2,269	26	0	4	0	7,665	16,123	-26,087
Burkeville	159	0	0	0	0	1,322	-1,482	0
Jasper	7,175	0	0	0	0	509	-7,684	0
Yegua-Jackson	0	0	0	0	0	0	0	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	19,226	6,619	0	711	0	2,424	-1	-28,980
2080 Annual Net Flux (acre-ft/year) minus 2010 Annual Net Flux (acre-ft/year)								
Chicot	4,495	0	0	10,508	844	-9,586	-4,866	-1,396
Evangeline	737	0	0	0	0	3,371	8,479	-12,587
Burkeville	-7	0	0	0	0	-2,548	2,554	0
Jasper	6,324	0	0	0	0	-155	-6,169	0
Yegua-Jackson	0	0	0	0	0	0	0	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	11,549	0	0	10,508	844	-8,918	-2	-13,983

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Live Oak County GCD Water Budget

Aquifer or Hydrogeologic Unit	Storage	Recharge	Surface Water - Groundwater Interaction			Groundwater Flow		Wells
			Ocean/ Lake	Stream	Spring/ Wetlands	Lateral	Vertical	
2010 Annual Net Flux (acre-ft/year)								
Chicot	201	72	0	0	0	-772	499	0
Evangeline	2,701	1,195	0	-72	0	409	-881	-3,352
Burkeville	11	0	0	0	0	-526	1,919	-1,403
Jasper	1,261	5,836	0	-8,679	-361	39	4,939	-3,040
Yegua-Jackson	256	1,036	0	-23,657	0	5,678	16,768	-100
SP,QC, CW	15	0	0	0	0	23,330	-23,244	-100
Total	4,445	8,139	0	-32,408	-361	28,158	0	-7,995
2080 Annual Net Flux (acre-ft/year)								
Chicot	120	72	0	0	0	-1,142	949	0
Evangeline	2,430	1,195	0	86	0	37	678	-4,426
Burkeville	8	0	0	0	0	-1,110	2,955	-1,853
Jasper	4,815	5,836	0	-4,712	-258	-576	-1091	-4,014
Yegua-Jackson	80	1,036	0	-21,247	0	1,575	18,755	-199
SP,QC, CW	3	0	0	0	0	22,543	-22,246	-300
Total	7,456	8,139	0	-25,873	-258	21,327	0	-10,792
2080 Annual Net Flux (acre-ft/year) minus 2010 Annual Net Flux (acre-ft/year)								
Chicot	-81	0	0	0	0	-370	450	0
Evangeline	-271	0	0	158	0	-372	1,559	-1,074
Burkeville	-3	0	0	0	0	-584	1,036	-450
Jasper	3,554	0	0	3,967	103	-615	-6,030	-974
Yegua-Jackson	-176	0	0	2,410	0	-4,103	1,987	-99
SP,QC, CW	-12	0	0	0	0	-787	998	-200
Total	3,011	0	0	6,535	103	-6,831	0	-2,797

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McMullen County GCD Water Budget

Aquifer or Hydrogeologic Unit	Storage	Recharge	Surface Water - Groundwater Interaction			Groundwater Flow		Wells
			Ocean/ Lake	Stream	Spring/ Wetlands	Lateral	Vertical	
2010 Annual Net Flux (acre-ft/year)								
Chicot	0	0	0	0	0	0	0	0
Evangeline	0	0	0	0	0	0	0	0
Burkeville	0	0	0	0	0	0	0	0
Jasper	2,747	2,269	0	1,505	0	-163	-5,831	-527
Yegua-Jackson	1,621	5,252	0	-49,346	0	3,000	39,473	0
SP,QC, CW	41	0	0	0	0	33,603	-33,642	-2
Total	4,409	7,521	0	-47,841	0	36,440	0	-529
2080 Annual Net Flux (acre-ft/year)								
Chicot	0	0	0	0	0	0	0	0
Evangeline	0	0	0	0	0	0	0	0
Burkeville	0	0	0	0	0	0	0	0
Jasper	1,947	2,269	0	1577	0	-189	-5,077	-527
Yegua-Jackson	184	5,252	0	-42,677	0	1,680	35,561	0
SP,QC, CW	4	0	0	0	0	30,482	-30,484	-2
Total	2,135	7,521	0	-41,100	0	31,973	0	-529
2080 Annual Net Flux (acre-ft/year) minus 2010 Annual Net Flux (acre-ft/year)								
Chicot	0	0	0	0	0	0	0	0
Evangeline	0	0	0	0	0	0	0	0
Burkeville	0	0	0	0	0	0	0	0
Jasper	-800	0	0	72	0	-26	754	0
Yegua-Jackson	-1,437	0	0	6,669	0	-1,320	-3,912	0
SP,QC, CW	-37	0	0	0	0	-3,121	3,158	0
Total	-2,274	0	0	6,741	0	-4,467	0	0

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

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Red Sands GCD Water Budget

Aquifer or Hydrogeologic Unit	Storage	Recharge	Surface Water - Groundwater Interaction			Groundwater Flow		Wells
			Ocean/ Lake	Stream	Spring/ Wetlands	Lateral	Vertical	
2010 Annual Net Flux (acre-ft/year)								
Chicot	37	47	0	0	0	-445	612	-252
Evangeline	472	337	0	0	0	201	105	-1114
Burkeville	4	0	0	0	0	446	-450	0
Jasper	196	0	0	0	0	71	-266	0
Yegua-Jackson	0	0	0	0	0	0	0	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	709	384	0	0	0	273	1	-1,366
2080 Annual Net Flux (acre-ft/year)								
Chicot	72	47	0	0	0	255	294	-669
Evangeline	2148	337	0	0	0	-908	617	-2194
Burkeville	19	0	0	0	0	-249	230	0
Jasper	1159	0	0	0	0	-18	-1141	0
Yegua-Jackson	0	0	0	0	0	0	0	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	3,398	384	0	0	0	-920	0	-2,863
2080 Annual Net Flux (acre-ft/year) minus 2010 Annual Net Flux (acre-ft/year)								
Chicot	35	0	0	0	0	700	-318	-417
Evangeline	1676	0	0	0	0	-1109	512	-1080
Burkeville	15	0	0	0	0	-695	680	0
Jasper	963	0	0	0	0	-89	-875	0
Yegua-Jackson	0	0	0	0	0	0	0	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	2,689	0	0	0	0	-1,193	-1	-1,497

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San Patricio County GCD Water Budget

Aquifer or Hydrogeologic Unit	Storage	Recharge	Surface Water - Groundwater Interaction			Groundwater Flow		Wells
			Ocean/ Lake	Stream	Spring/ Wetlands	Lateral	Vertical	
2010 Annual Net Flux (acre-ft/year)								
Chicot	5,284	2,101	0	895	0	7,227	454	-15,995
Evangeline	718	39	0	15	0	1,447	829	-3,048
Burkeville	25	0	0	0	0	613	-638	0
Jasper	353	0	0	0	0	211	-564	0
Yegua-Jackson	2	0	0	0	0	79	-81	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	6,382	2,140	0	910	0	9,577	0	-19,043
2080 Annual Net Flux (acre-ft/year)								
Chicot	5,512	2,101	1	1,295	0	40,490	2,177	-51,575
Evangeline	719	39	0	15	0	3,113	1,013	-4,899
Burkeville	49	0	0	0	0	538	-587	0
Jasper	2,242	0	0	0	0	221	-2,463	0
Yegua-Jackson	2	0	0	0	0	138	-139	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	8,524	2,140	1	1,310	0	44,500	1	-56,474
2080 Annual Net Flux (acre-ft/year) minus 2010 Annual Net Flux (acre-ft/year)								
Chicot	228	0	1	400	0	33,263	1,723	-35,580
Evangeline	1	0	0	0	0	1,666	184	-1,851
Burkeville	24	0	0	0	0	-75	51	0
Jasper	1,889	0	0	0	0	10	-1,899	0
Yegua-Jackson	0	0	0	0	0	59	-58	0
SP,QC, CW	0	0	0	0	0	0	0	0
Total	2,142	0	1	400	0	34,923	1	-37,431

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Starr County GCD Water Budget

Aquifer or Hydrogeologic Unit	Storage	Recharge	Surface Water - Groundwater Interaction			Groundwater Flow		Wells
			Ocean/ Lake	Stream	Spring/ Wetlands	Lateral	Vertical	
2010 Annual Net Flux (acre-ft/year)								
Chicot	0	0	0	0	0	0	0	0
Evangeline	1,850	2,537	0	18	0	-1,935	-93	-2,378
Burkeville	24	0	0	0	0	-965	997	-56
Jasper	1,743	592	0	1,537	0	-149	-3,359	-364
Yegua-Jackson	470	2,419	0	-1,353	0	-2,172	2,455	-100
SP,QC, CW	0	0	0	0	0	0	0	0
Total	4,087	5,548	0	202	0	-6,938	0	-2,898
2080 Annual Net Flux (acre-ft/year)								
Chicot	0	0	0	0	0	0	0	0
Evangeline	1,914	2,537	0	18	0	-2,229	4,385	-6,625
Burkeville	21	0	0	0	0	-1,042	1,177	-156
Jasper	2,369	592	0	2,251	0	-196	-4,003	-1,013
Yegua-Jackson	2,171	2,419	0	-773	0	-1,330	-1,559	-200
SP,QC, CW	0	0	0	0	0	0	0	0
Total	6,475	5,548	0	1,496	0	-5,526	0	-7,994
2080 Annual Net Flux (acre-ft/year) minus 2010 Annual Net Flux (acre-ft/year)								
Chicot	0	0	0	0	0	0	0	0
Evangeline	64	0	0	0	0	-294	4,478	-4,247
Burkeville	-3	0	0	0	0	-77	180	-100
Jasper	626	0	0	714	0	-47	-644	-649
Yegua-Jackson	1,701	0	0	580	0	842	-4,014	-100
SP,QC, CW	0	0	0	0	0	0	0	0
Total	2,388	0	0	1,294	0	1,412	0	-5,096

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Explanatory Report

DFC Explanatory Report for Groundwater Management Area 16

Based on a review of the TERS and simulated water budgets associated with the model run, the adoption of the recommended DFCs of GMA 16 are not anticipated to impact the hydrological conditions within GMA significantly during the planning horizon. They are intended to 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.

5.4 Other Environmental Impacts Including Spring Flow and Other Interactions Between Groundwater and Surface Water

The relevant GAM water budget values are presented in Section 5.3.2 above.

As discussed previously, the purpose of the GMA 16 GAM is to evaluate regional drawdown in support of developing DFCs. It may not be suited to adequately predict groundwater-surface water interaction in a quantitative fashion. Water budgets presented previously indicate that reduced water levels may affect streams in the GMA. However, GMA 16 anticipates that the pumping rates associated with the DFC scenario will not impact environmental conditions significantly during the planning horizon and would 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.

Previous report (O'Rourke, 2017) will be used as template

- Explanatory report will briefly summarize this presentation & provide a copy as appendix
- Any District can provide INTERA with more District-specific information or details regarding this topic, if they feel it is necessary
- Deadline for addl District-specific information: next GMA meeting

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Questions?

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APPENDIX L
PRESENTATION ON CONSIDERATION OF LAND SUBSIDENCE

Groundwater Management Area 16 Joint Planning Cycle: 2019-2022 Consideration of Land Subsidence

- **Falfurrias, TX**
- **July 28, 2020**
- **Jevon Harding, P.G.**
- **Steve Young, Ph.D., P.G., P.E.**

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July 28, 2020

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Joint Planning Requirements

- Balancing Test
  - 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**"

*36.108 (d-2)

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Joint Planning Requirements

- Consideration of 9 “factors” (paraphrased)
  - Aquifer uses or conditions
  - Water supply needs and management strategies
  - *Hydrological conditions*
  - Other environmental impacts
  - **Impact on subsidence**
  - Socioeconomic impacts
  - Impact on private property rights
  - Feasibility of achieving the DFC
  - Any other relevant information

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Outline

- Causes of Land Subsidence
- Measurement of Land Subsidence
- Factors Affecting Land Subsidence
- Aquifer Compressibility
- Simplified Equations for Predicting Land Subsidence
- TWDB Reports on Land Subsidence Predictions
- Evidence of Land Subsidence in GMA 16

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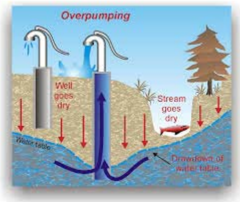
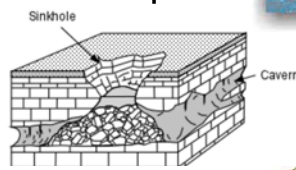
Causes of Land Subsidence

- Compaction-related subsidence can occur because of :
  - Accumulating soft sediments that sink under their own weight over time
  - Dissolution of calcium-rich rocks
  - Over-pumping of groundwater
  - Removal of high pressurized fluids/gases in oil and gas producing areas
  - Tectonic subsidence occurs from movement along faults

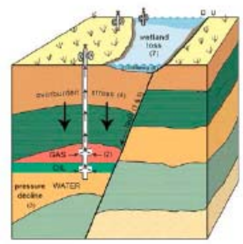
Over pumping



Collapse



Faulting and Geostatic Pressure



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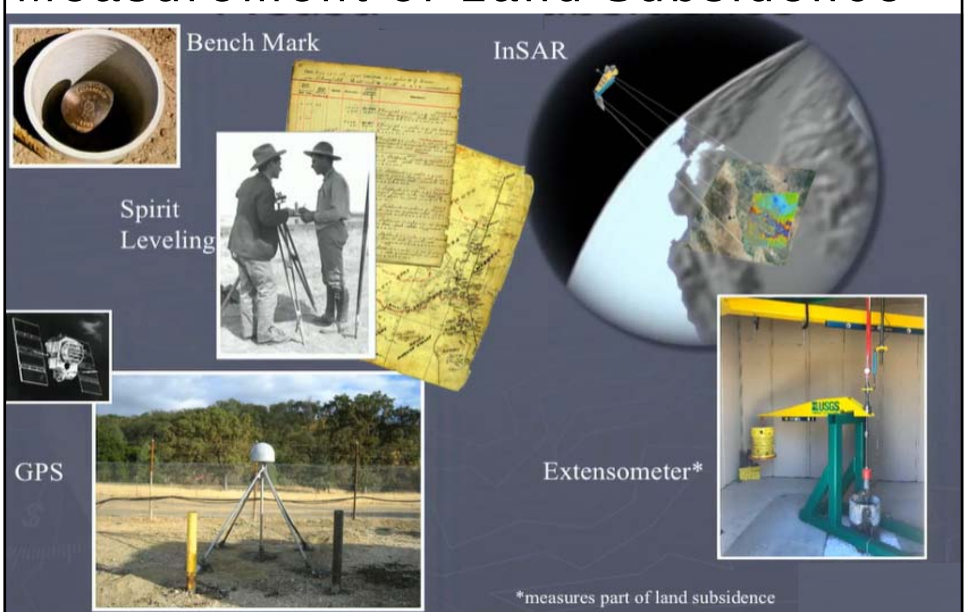
Measurement of Land Subsidence



https://www.usgs.gov/media/videos/pubtalk-32019-land-subsidence

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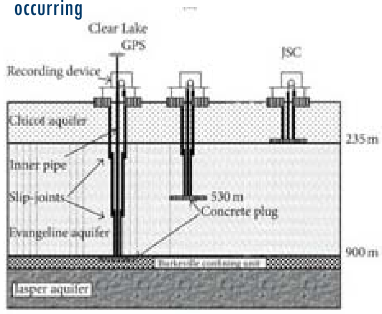
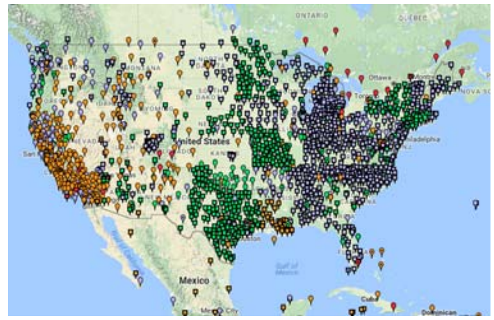
Measurement - GPS Techniques

- Extensometers – pipes covered with slip joints – at which depth interval subsidence is occurring





- Continuously Operating Reference Stations (CORS) – GPS units mounted at top of land surface to measure total land subsidence

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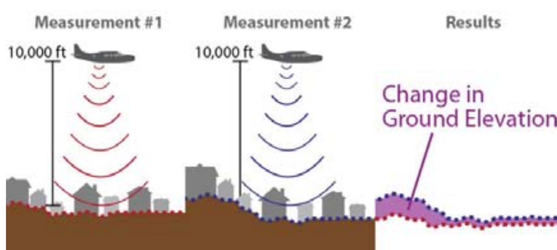
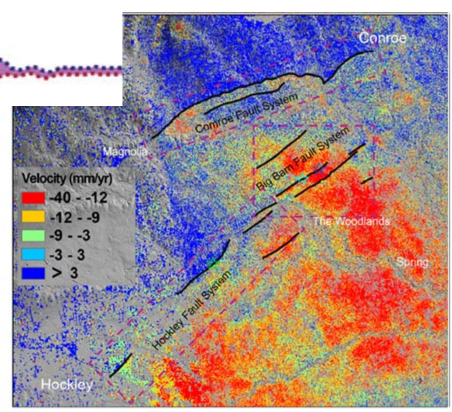
Measurement - Satellite and Aerial Methods



InSAR Analysis
(Qu and others, 2019)



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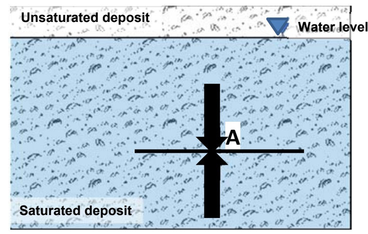
Sediment Compressibility

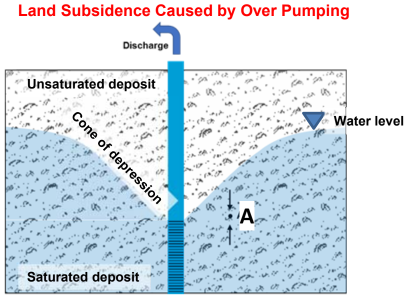
Compressibility of Sediments Occurs As Result of Increased Pressure on Aquifer Matrix:

- Downward force at Point A: weight of soils above Point A minus buoyancy provided by groundwater
- Upward force at Point A: Structural support provided by aquifer-system skeleton and hydraulic pressure of groundwater

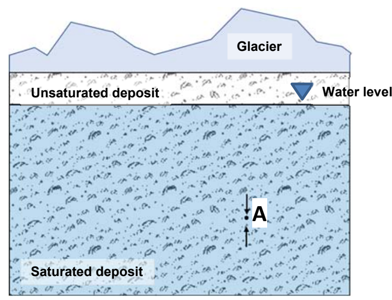
No Land Subsidence Occurring



Land Subsidence Caused by Over Pumping



Land Subsidence Caused by Increased Load



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Factors Controlling Land Subsidence

- Three key factors to assess potential for land subsidence:
  - Amount of drawdown
  - Total thickness of clay
  - Compressibility of clay
- Factors affecting Compressibility of Clay:
  - Type of clay
  - Depth of burial
  - Age of clay
  - History of compaction
- Other potentially important factors:
  - Permeability of clay (affects timing)
  - Thickness of individual clay layers

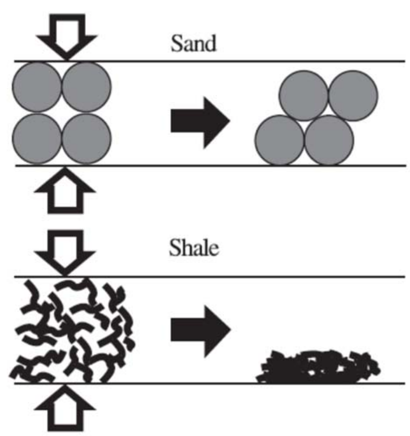

Figure 1 Schematic showing the reorientation and shifting of sand grains and clay particles associated with compaction caused by increased effective stress

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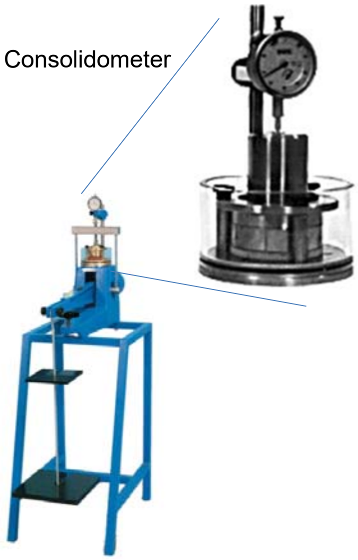
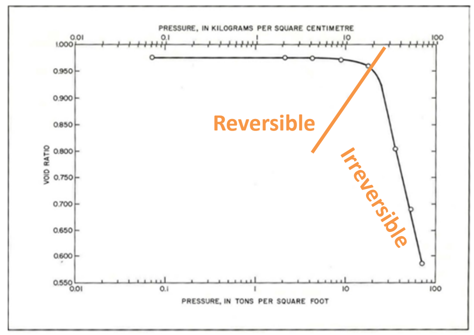
Measurement of Compressibility

Consolidometer



Consolidometer Test Results



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Simplified Subsidence Estimation

$$\Delta b = \Delta d * \alpha_{eff} * C_t$$

Where:

Δb = the thickness that the aquifer has compacted (L)

Δd = Amount of drawdown in the aquifer since predevelopment (L)

α_{eff} = Effective compressibility coefficient for clays in the aquifer (L^{-1})

C_t = Total thickness of the clay units in the aquifer (L)

Gabrysch studies (USGS reports 1975 to 1990)

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Texas Aquifers Vulnerability

Vulnerability of Texas Aquifers to Subsidence (*Furnans and others, 2017*)

- Uses Grabrysh-type simple equation to assess area of vulnerability to subsidence
- Unclear what the risk factor for subsidence vulnerability represents:
  - calculation is missing several important factors, such as age of clay, permeability of clay, type of clay, and depth or burial
  - no data to show a correlation of risk factor and actual land subsidence
- No maps of measured land subsidence in report
- No validation or checking of tool for predicting subsidence against measured subsidence
- Values for effective compressibility, α_{eff} , have large uncertainty

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Rio Grande Model Subsidence Discussion (Hutchison, 2017)

3.4.2 Application of HAGM Results to the Lower Rio Grande Valley

Figure 5 depicts the estimates of HAGM drawdown from 1891 to 2010 in both the Chicot and Evangeline aquifers versus the measured subsidence as shown previously in Figure 3. Please note that it appears that for an equal amount of drawdown, the Chicot Aquifer appears to be more susceptible to subsidence than the Evangeline Aquifer, although there are several instances where they are nearly equal.

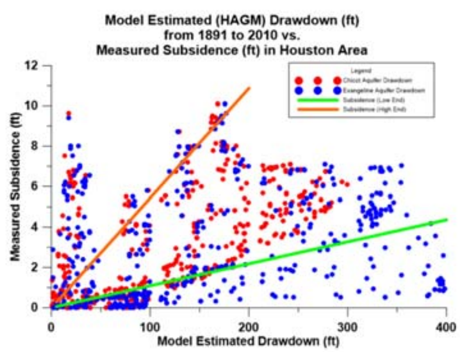

Figure 5. HAGM Drawdown vs. Measured Subsidence

The variation in the response, or scatter of the points demonstrates the complexity of the relationship that provides the ability to estimate subsidence based on pumping amounts and clay content. This complexity results in the inability to develop simple and accurate predictions of subsidence without site specific information. Absent site-specific information, only a general relationship can be developed.

Figure 5 also includes two lines that approximate a range of linear relationship between drawdown and subsidence that were drawn qualitatively to capture the potential reasonable range of subsidence given a specific drawdown. The more conservative line (green) suggests the following relationship:

Subsidence (ft) = 0.010905 * Drawdown (ft)

The higher response line (orange) suggests the following relationship:

Subsidence (ft) = 0.054361 * Drawdown (ft)

These equations were used in conjunction with the drawdown estimates to provide a range of estimates of subsidence for each of the strategies.

It is important to recognize that the Houston area has experienced high pumping for decades and a great deal of effort has been made to understand the relationship between high pumping, clay content and subsidence. The Lower Rio Grande Valley has not experienced the high degree of pumping, and it is difficult to evaluate the potential for subsidence with any accuracy since there is little in the way of calibration data to apply any analytical or numerical approach. The geologic similarity between the Houston area and the Lower Rio Grande Valley can be used to develop some conclusions as to the potential range of subsidence under assumed increased pumping conditions.

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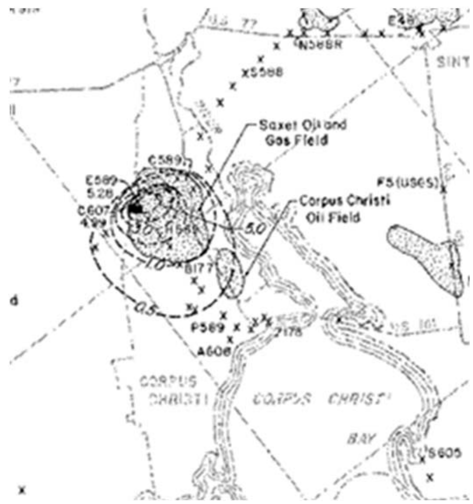
GMA 16: Saxet Oil and Gas

GMA16: Saxet Oil and Gas Field near Corpus Christi *

- Land Subsidence occurred between 1942 and 1975
- Oil field is 4,000 to 8,000 feet below ground surface
- No major water wells in vicinity of the oil field
- Demonstrates that aquifer properties in GMA 16 are susceptible to compaction-related land subsidence



**Ratzlaff, 1982* (only location in GMA 16 with more than 0.5 ft land subsidence)

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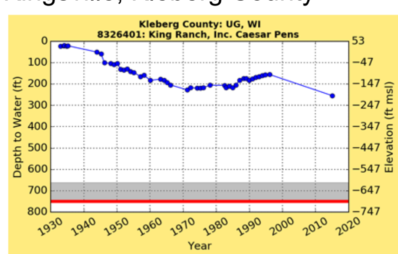
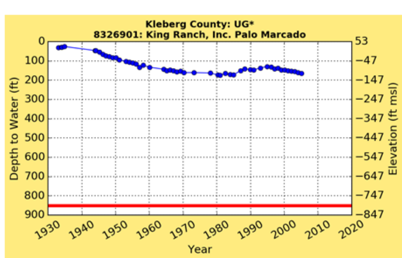
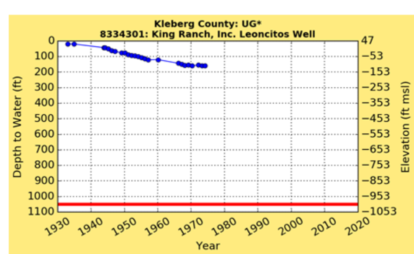
GMA 16: Largest Drawdowns

GMA 16: Largest Drawdowns Occur Near Kingsville, Kleberg County

- About 200 feet of drawdown has occurred near Kingsville
- No reported evidence of land subsidence







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GMA 16: Explanatory Report

5.5 Subsidence

Historically, subsidence has not been identified as an issue in GMA 16. However, it is well documented that dewatering of the clay layers in the Gulf Coast Aquifer can lead to compaction of those strata, ultimately leading to observable subsidence if the dewatering is significant enough in time and volume. Heavy pumping of the Gulf Coast Aquifer in the Houston area has resulted in over 7 feet of subsidence over much of Harris County, with a maximum subsidence of approximately 10 feet over predevelopment conditions along the Houston Ship Channel (Kasmarek et al, 2012). The Gulf Coast Aquifer in GMA 16 is similar in character to the strata in the Houston area, with multiple interlayered strata of clays and sands. Dewatering of clay layers can lead to compaction and ultimately subsidence. Most of the subsidence observed in Texas has been caused by production of oil and gas, and the withdrawal of groundwater.

A study of subsidence along the Texas Gulf Coast, including in the GMA 16 area, was documented in the Texas Department of Water Resources Report 272 (Ratzlaff 1982). The report indicates that measured subsidence of 5.28 feet was observed in western Corpus Christi between 1942 and 1975. The estimated area of subsidence closely approximates the boundaries of the Saxet Oil and Gas field. Subsidence in this area is likely associated with historical oil and gas production. There was no other significant subsidence documented between 1918 and 1975 in the counties of San Patricio, Nueces, Kleberg, and Jim Wells. In the area encompassing Kenedy, Willacy, Cameron, Brooks, and Hidalgo Counties, maximum measured subsidence was 0.42 feet between 1918 and 1951, with 90 percent of the subsidence occurring before 1943.

For this joint-planning session, no district proposed a DFC for land subsidence. However, additional information may be available for the next round of DFC revisions that could provide additional data for consideration. The TWDB has sponsored a research project into the vulnerability of the major and minor aquifers of Texas to subsidence. As information becomes available, GCDs are able to adjust their management plans and groundwater rules to address land subsidence, if so desired

(O'Rourke, 2017)

- Discussion will be similar to 2017 Explanatory Report discussion

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Questions?

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APPENDIX M
PRESENTATION ON CONSIDERATION OF SOCIOECONOMICS

Groundwater Management Area 16 Joint Planning Cycle: 2019-2022 Socioeconomic Impacts Consideration

Virtual Meeting
October 27, 2020

Steve Young, Ph.D., P.G., P.E.
Jevon Harding, P.G.
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Joint Planning Requirements

- Balancing Test
  – 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*"

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Joint Planning Requirements

- Consideration of 9 "factors" (paraphrased)
  - Aquifer uses or conditions
  - Water supply needs and management strategies
  - Hydrological conditions
  - Other environmental impacts
  - Impact on subsidence
  - ***Socioeconomic impacts***
  - Impact on private property rights
  - Feasibility of achieving the DFC
  - Any other relevant information

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Consideration of Socioeconomic Impacts

- Discuss the social and economic impacts of not meeting identified water needs in the GMA
- Evaluate the socioeconomic impacts reasonably expected to occur due to DFC adoption

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Socioeconomic Impacts and Water Planning in Texas

- Texas Administrative Code (TAC), Title 31, Chapter 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."*
- TAC, Title 31, Chapter 357.40 (a) RWPs shall include a quantitative description of the socioeconomic impacts of not meeting the identified water needs pursuant to §357.33 (c) of this title (relating to Needs Analysis: Comparison of Water Supplies and Demands).

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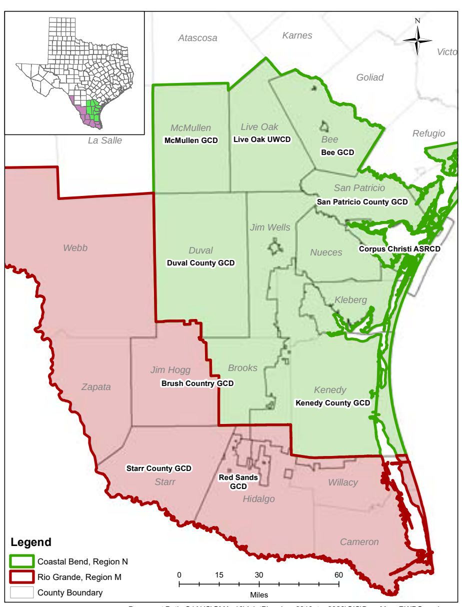
Regional Water Planning Areas



- Texas State Water Plan is compilation of Regional Water Plans
- GMA 16 falls into 2 Regional Water Planning Areas:
  - Region N (Coastal Bend)
  - Region M (Rio Grande)

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Regional Water Planning Areas

** Draft Regional Water Plans available as of March 2020*

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Regional Water Planning & TWDB Socioeconomic Impact Reports

- Texas Administrative Code, Title 31, Chapter 357.40 (a): Regional Water Plans "*shall include a quantitative description of the socioeconomic impacts of not meeting the identified water needs……*"
- TWDB provides socioeconomic impact reports for each Regional Water Planning Area:
  - Region M – Appendix D (Ellis, 2019a)
  - Region N – Appendix B (Ellis, 2019b)
- TWDB reports provide a quantitative description of socioeconomic impacts if identified water supply needs are not met under normal and drought conditions.

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TWDB Socioeconomic Impact Reports

- Evaluates impacts on:
  - *Sales, income and tax revenue*
  - *Jobs*
  - *Population*
  - *School enrollment*
- Input-Output Models combined with Social Accounting Models (IO/SAM) using Impact for Planning Analysis (IMPLAN) software
- Develops an economic baseline based on 440 economic sector codes assigned to the Water User Groups (WUGs) in each RWPA.
- Analyzes WUGs with need for additional water supply (based on water demand estimates from Regional Water Plan)

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TWDB Socioeconomic Impact Reports

From Executive Summary of TWDB report (Ellis, 2019a,2019b):

- *"represents a snapshot of socioeconomic impacts that may occur during a single year repeat of the drought of record with the further caveat that no mitigation strategies are implemented"* (emphasis added)
- *"Decade specific impact estimates assume that growth occurs, and future shocks are imposed on an economy at 10-year intervals"*
- *"The estimates presented are not cumulative…but are simply snapshots of the estimated annual socioeconomic impacts should a drought of record occur in each particular decade"*

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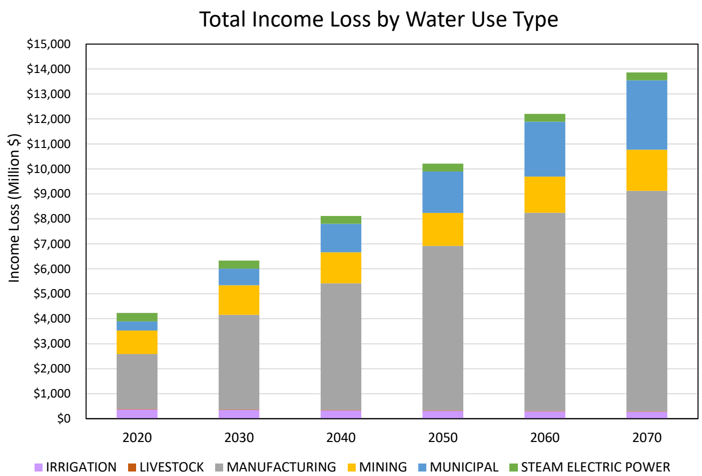
TWDB Socioeconomic Impact Report for GMA 16



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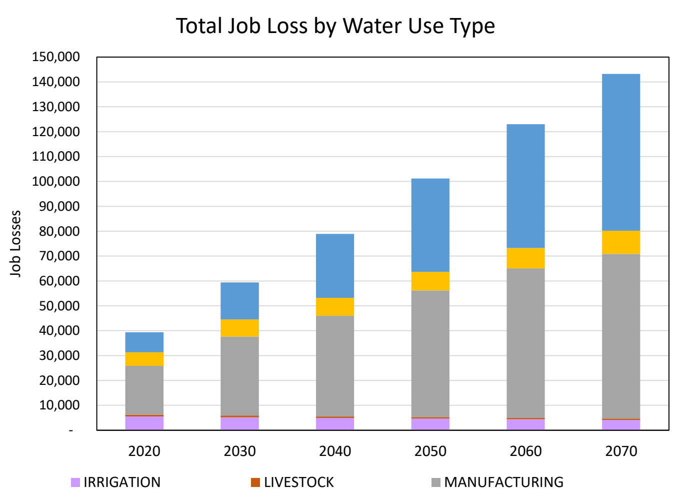
TWDB Socioeconomic Impact Report for GMA 16



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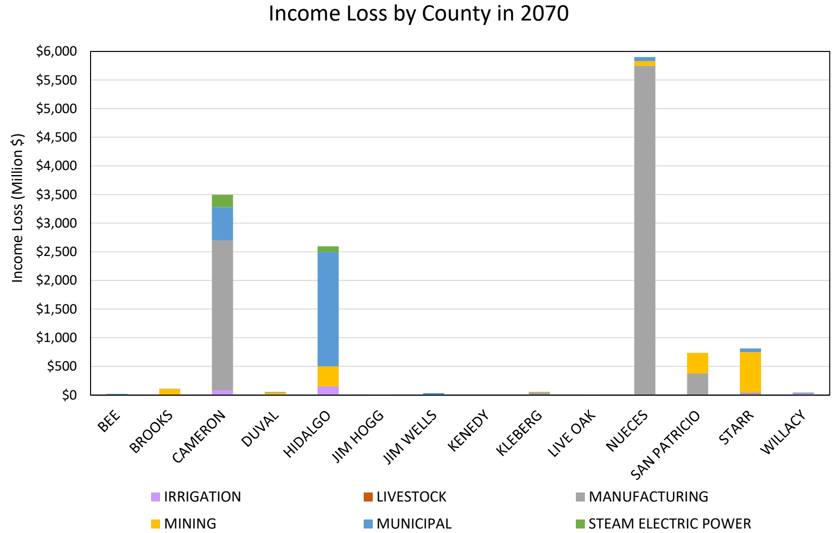
TWDB Socioeconomic Impact Report for GMA 16



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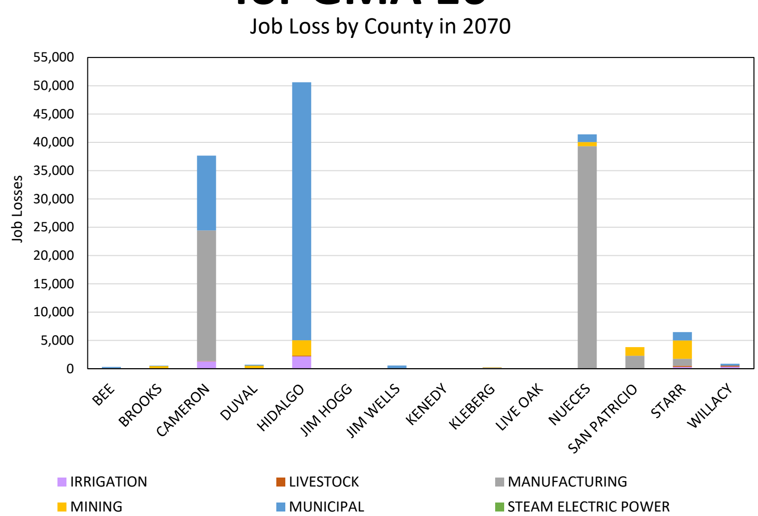
TWDB Socioeconomic Impact Report for GMA 16



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TWDB Socioeconomic Impact Report – Region M

		Income losses (Million $)*						Job losses					
County	Water Use Category	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
CAMERON	IRRIGATION	$103.92	$98.91	$93.90	$88.88	$83.87	$78.86	1,692	1,611	1,529	1,447	1,366	1,284
CAMERON	LIVESTOCK	$2.15	$2.15	$2.15	$2.15	$2.15	$2.15	71	71	71	71	71	71
CAMERON	MANUFACTURING	$2,181.94	$2,617.45	$2,617.45	$2,617.45	$2,617.45	$2,617.45	19,243	23,083	23,083	23,083	23,083	23,083
CAMERON	MUNICIPAL	$39.90	$60.96	$122.19	$225.04	$374.31	$578.29	911	1,391	2,789	5,136	8,543	13,199
CAMERON	STEAM ELECTRIC POWER	$218.99	$218.99	$218.99	$218.99	$218.99	$218.99	-	-	-	-	-	-
CAMERON Total		**$2,546.89**	**$2,998.46**	**$3,054.67**	**$3,152.51**	**$3,296.77**	**$3,495.73**	**21,916**	**26,156**	**27,472**	**29,738**	**33,063**	**37,637**
HIDALGO	IRRIGATION	$207.74	$196.56	$185.39	$174.40	$163.06	$151.89	2,977	2,817	2,657	2,500	2,337	2,177
HIDALGO	LIVESTOCK	$4.49	$3.90	$3.90	$3.90	$3.90	$3.90	152	132	132	132	132	132
HIDALGO	MINING	$54.02	$129.53	$173.99	$221.67	$276.41	$345.75	425	1,019	1,369	1,745	2,175	2,721
HIDALGO	MUNICIPAL	$187.35	$448.46	$851.03	$1,253.55	$1,629.31	$1,997.16	4,276	10,236	19,424	28,611	37,187	45,583
HIDALGO	STEAM ELECTRIC POWER	$114.58	$102.49	$96.10	$96.10	$96.10	$96.10	-	-	-	-	-	-
HIDALGO Total		**$568.18**	**$880.95**	**$1,310.41**	**$1,749.62**	**$2,168.78**	**$2,594.80**	**7,831**	**14,205**	**23,583**	**32,988**	**41,832**	**50,614**
JIM HOGG	IRRIGATION	$0.04	$0.04	$0.04	$0.03	$0.03	$0.02	1	1	1	1	1	1
JIM HOGG	MANUFACTURING	$0.57	$0.57	$0.57	$0.57	$0.57	$0.57	33	33	33	33	33	33
JIM HOGG Total		**$0.61**	**$0.61**	**$0.61**	**$0.60**	**$0.60**	**$0.59**	**34**	**34**	**34**	**34**	**34**	**34**
MAVERICK	IRRIGATION	$12.02	$9.62	$7.43	$5.46	$3.73	$2.29	176	141	109	80	55	33
MAVERICK	MANUFACTURING	$0.23	$0.23	$0.23	$0.23	$0.23	$0.23	2	2	2	2	2	2
MAVERICK	MINING	$362.84	$1,154.08	$1,323.37	$769.69	$81.32	-	1,682	5,349	6,133	3,567	377	-
MAVERICK	MUNICIPAL	$2.57	$7.99	$18.23	$33.51	$52.05	$64.03	59	182	416	765	1,188	1,461
MAVERICK Total		**$377.66**	**$1,171.93**	**$1,349.26**	**$808.90**	**$137.33**	**$66.55**	**1,918**	**5,674**	**6,660**	**4,414**	**1,621**	**1,497**

In 2018 dollars, rounded.
Values are presented only for counties projected economic impacts for at least one decade
Entries denoted by a dash (-) indicate no estimated economic impact.

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TWDB Socioeconomic Impact Report – Region M

		Income losses (Million $)*						Job losses					
County	Water Use Category	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
STARR	IRRIGATION	$27.60	$26.52	$25.44	$24.36	$23.28	$22.20	370	356	341	327	312	298
STARR	LIVESTOCK	$5.86	$5.86	$5.86	$5.86	$5.86	$5.86	200	200	200	200	200	200
STARR	MANUFACTURING	$5.88	$21.46	$21.46	$21.46	$21.46	$21.46	342	1,247	1,247	1,247	1,247	1,247
STARR	MINING	$253.50	$361.78	$428.81	$500.13	$588.64	$700.36	1,175	1,677	1,987	2,318	2,728	3,246
STARR	MUNICIPAL	$25.90	$35.70	$42.88	$50.38	$57.51	$64.09	591	815	979	1,150	1,313	1,463
STARR Total		**$318.74**	**$451.31**	**$524.44**	**$602.18**	**$696.74**	**$813.96**	**2,678**	**4,294**	**4,754**	**5,241**	**5,799**	**6,453**
WEBB	MANUFACTURING	$115.50	$137.76	$137.76	$137.76	$137.76	$137.76	2,017	2,406	2,406	2,406	2,406	2,406
WEBB	MINING	$4,004.31	$1,555.91	$31.86	-	-	-	18,601	7,227	148	-	-	-
WEBB	MUNICIPAL	$0.27	$0.42	$0.62	$16.45	$87.80	$188.59	6	10	14	375	2,004	4,304
WEBB Total		**$4,120.08**	**$1,694.09**	**$170.24**	**$154.21**	**$225.56**	**$326.35**	**20,624**	**9,643**	**2,568**	**2,782**	**4,410**	**6,711**
WILLACY	IRRIGATION	$30.00	$28.79	$27.53	$26.32	$25.11	$23.89	449	431	412	394	375	357
WILLACY	LIVESTOCK	$7.91	$7.91	$4.71	$4.71	$4.71	$4.71	288	288	172	172	172	172
WILLACY	MINING	$23.92	$24.90	$8.79	$2.63	-	-	159	166	58	18	-	-
WILLACY	MUNICIPAL	$2.39	$5.66	$8.53	$10.71	$12.83	$14.85	55	129	195	244	293	339
WILLACY Total		**$64.22**	**$67.26**	**$49.56**	**$44.37**	**$42.65**	**$43.46**	**951**	**1,014**	**837**	**827**	**840**	**868**
ZAPATA	IRRIGATION	$5.43	$5.14	$4.85	$4.55	$4.26	$3.97	72	68	64	60	56	52
ZAPATA	MANUFACTURING	$2.29	$2.29	$2.29	$2.29	$2.29	$2.29	133	133	133	133	133	133
ZAPATA	MUNICIPAL	$0.36	$0.95	$2.14	$4.00	$5.58	$7.16	8	22	49	91	127	163
ZAPATA Total		**$8.08**	**$8.38**	**$9.28**	**$10.85**	**$12.13**	**$13.42**	**213**	**223**	**246**	**285**	**317**	**349**
REGION M Total		**$8,004.47**	**$7,272.98**	**$6,468.47**	**$6,523.25**	**$6,580.56**	**$7,354.85**	**56,165**	**61,242**	**66,154**	**76,308**	**87,917**	**104,162**

In 2018 dollars, rounded.
Values are presented only for counties with projected economic impacts for at least one decade
Entries denoted by a dash (-) indicate no estimated economic impact.

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TWDB Socioeconomic Impact Report – Region N

		Income losses (Million $)*						Job losses					
County	Water Use Category	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
BEE	IRRIGATION	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03	1	1	1	1	1	1
BEE	MINING	$62.11	$58.32	$45.42	$23.86	$13.07	$8.10	371	348	271	143	78	48
BEE	MUNICIPAL	$11.44	$12.80	$12.87	$12.62	$13.39	$13.43	222	248	250	245	258	259
BEE Total		**$73.58**	**$71.15**	**$58.31**	**$36.50**	**$26.49**	**$21.55**	**593**	**597**	**522**	**388**	**337**	**308**
BROOKS	MINING	$160.60	$163.29	$145.34	$130.99	$116.63	$107.66	691	703	626	564	502	463
BROOKS	MUNICIPAL	$2.03	$2.26	$2.51	$2.80	$3.09	$3.27	40	44	49	55	60	64
BROOKS Total		**$162.63**	**$165.55**	**$147.85**	**$133.79**	**$119.72**	**$110.93**	**731**	**747**	**675**	**618**	**562**	**527**
DUVAL	MINING	$75.96	$81.93	$72.12	$60.28	$52.17	$44.05	906	977	860	719	622	526
DUVAL	MUNICIPAL	$7.40	$7.87	$8.28	$8.78	$9.33	$9.83	144	153	161	171	182	191
DUVAL Total		**$83.36**	**$89.81**	**$80.40**	**$69.05**	**$61.50**	**$53.88**	**1,050**	**1,131**	**1,022**	**890**	**804**	**717**
JIM WELLS	IRRIGATION	$0.14	$0.14	$0.14	$0.14	$0.14	$0.14	4	4	4	4	4	4
JIM WELLS	MANUFACTURING	-	$5.77	$5.77	$5.77	$5.77	$5.77	-	21	21	21	21	21
JIM WELLS	MINING	$26.85	$28.40	$18.59	$10.84	$2.26	$0.01	174	184	121	70	15	0
JIM WELLS	MUNICIPAL	$21.77	$22.89	$23.97	$25.33	$26.71	$28.03	424	446	467	494	520	546
JIM WELLS Total		**$48.76**	**$57.20**	**$48.46**	**$42.08**	**$34.88**	**$33.95**	**602**	**655**	**612**	**589**	**560**	**571**
KENEDY	MINING	$10.25	$11.13	$4.81	$0.27	-	-	49	53	23	1	-	-
KENEDY Total		**$10.25**	**$11.13**	**$4.81**	**$0.27**	**-**	**-**	**49**	**53**	**23**	**1**	**-**	**-**
KLEBERG	MANUFACTURING	-	$52.71	$52.71	$52.71	$52.71	$52.71	-	193	193	193	193	193
KLEBERG	MINING	$14.38	$14.91	$11.48	$8.96	$6.64	$5.33	172	178	137	107	79	64
KLEBERG Total		**$14.38**	**$67.62**	**$64.19**	**$61.67**	**$59.36**	**$58.04**	**172**	**371**	**330**	**300**	**272**	**257**
LIVE OAK	IRRIGATION	$0.08	$0.21	$0.21	$0.21	$0.21	$0.21	2	6	6	6	6	6
LIVE OAK Total		**$0.08**	**$0.21**	**$0.21**	**$0.21**	**$0.21**	**$0.21**	**2**	**6**	**6**	**6**	**6**	**6**

In 2018 dollars, rounded.
Values are presented only for counties with projected economic impacts for at least one decade
Entries denoted by a dash (-) indicate no estimated economic impact.

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TWDB Socioeconomic Impact Report – Region N

		Income losses (Million $)*						Job losses					
County	Water Use Category	2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
NUECES	MANUFACTURING	-	$749.71	$2,027.85	$3,537.17	$4,865.74	$5,748.58	-	5,129	13,873	24,198	33,287	39,326
NUECES	MINING	$45.60	$54.30	$60.61	$65.62	$72.94	$81.71	397	473	528	571	635	711
NUECES	MUNICIPAL	$71.34	$71.25	$70.59	$70.27	$70.22	$70.21	1,390	1,388	1,375	1,369	1,368	1,368
NUECES Total		**$116.94**	**$875.26**	**$2,159.05**	**$3,673.05**	**$5,008.90**	**$5,900.50**	**1,787**	**6,989**	**15,775**	**26,138**	**35,289**	**41,405**
SAN PATRICIO	MANUFACTURING	$8.92	$335.90	$341.40	$353.50	$366.80	$377.81	54	2,032	2,065	2,138	2,219	2,285
SAN PATRICIO	MINING	$212.63	$256.60	$273.64	$291.59	$320.30	$357.08	915	1,105	1,178	1,255	1,379	1,537
SAN PATRICIO Total		**$221.55**	**$592.49**	**$615.04**	**$645.08**	**$687.10**	**$734.89**	**969**	**3,136**	**3,243**	**3,393**	**3,597**	**3,822**
REGION N Total		**$731.53**	**$1,930.42**	**$3,178.33**	**$4,661.72**	**$5,998.15**	**$6,913.95**	**5,955**	**13,686**	**22,208**	**32,324**	**41,429**	**47,613**

In 2018 dollars, rounded.
Values are presented only for counties with projected economic impacts for at least one decade
Entries denoted by a dash (-) indicate no estimated economic impact.

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Considerations for GMA

- Evaluate the socioeconomic impacts reasonably expected to occur due to DFC adoption:
  - Do DFCs impede the implementation of any proposed Water Management Strategies (with groundwater source)?
  - What socioeconomic impacts are associated with the Unmet Needs due to not implementing Water Management Strategies?
  - Are the socioeconomic impacts mitigated by benefits to other factors (ex. protection of private property rights, prevention of subsidence, conservation of spring/streamflow) -- the "Balance Test"

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Considerations for GMA

- Region N:
  - Current draft GMA 16 DFCs (based on latest pumping scenario) are not expected to restrict the implementation of any Water Management Strategies proposed in Regional Water Plan (*see July 2020 presentation*)
  - No Unmet Needs are expected in Region N if all Water Management Strategies are implemented.

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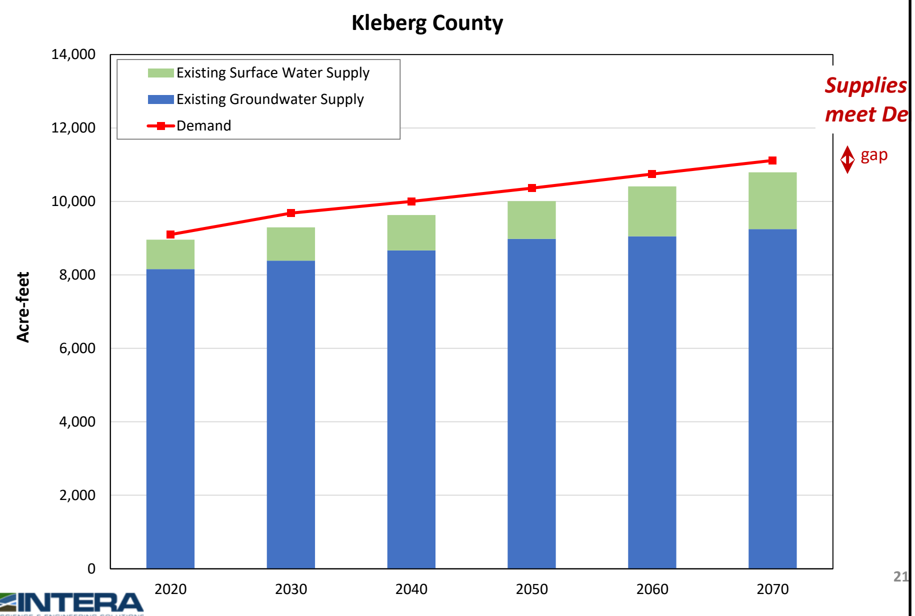
Example of Regional Water Plan Accounting by County



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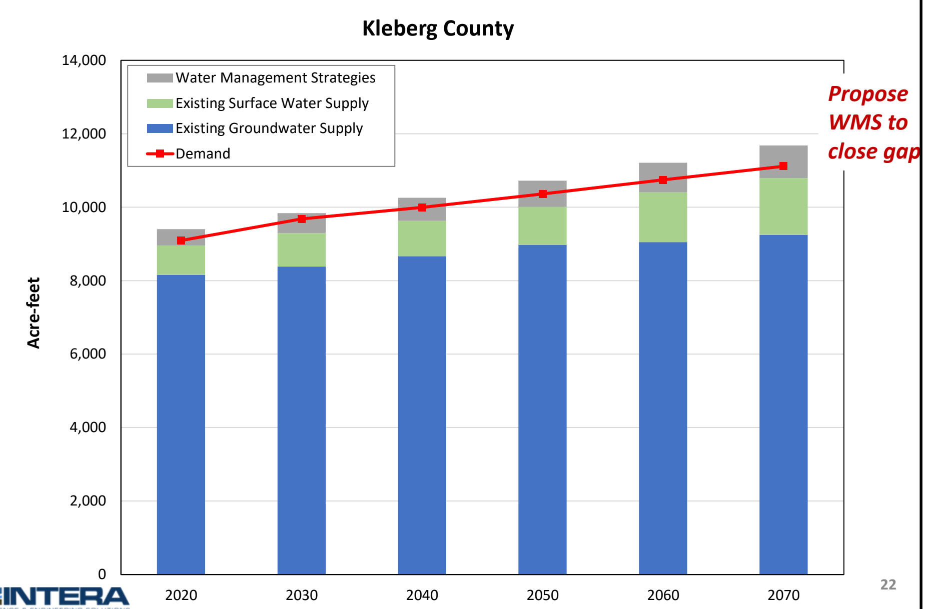
Example of Regional Water Plan Accounting by County



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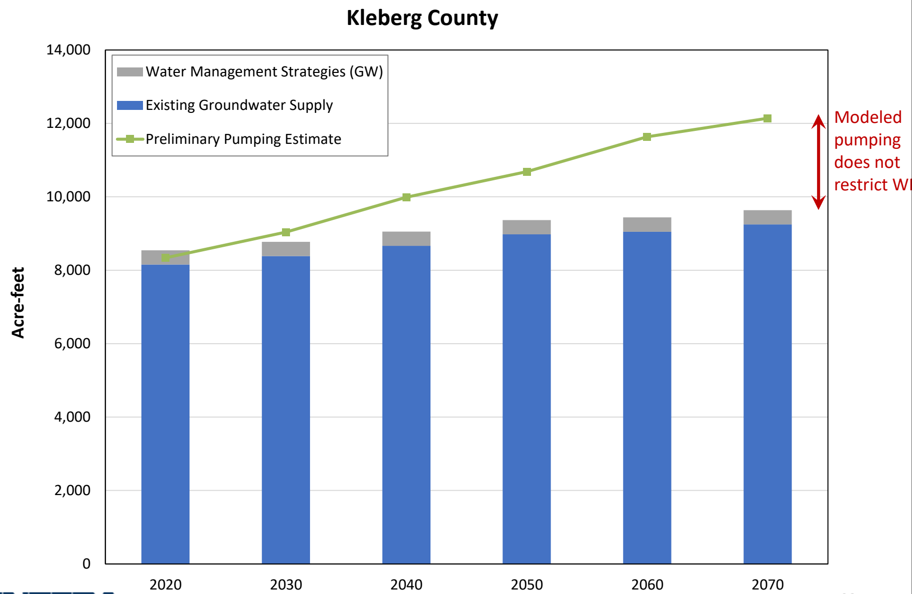
Example of Regional Water Plan Accounting by County



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Considerations for GMA

- Region M:
  - Current draft GMA 16 DFCs (based on latest pumping scenario) are not expected to restrict the implementation of any proposed Water Management Strategies in Regional Water Plan *(see July 2020 presentation)*
  - Region M consultants expressed concern that current MAG values prevent adding new Water Management Strategies to Regional Water Plan *(comments at January 2020 meeting)*
  - Region M does have Unmet Needs (socioeconomic impacts) even if all Water Management Strategies are implemented.
  - Unmet Needs due to restricted groundwater pumping are due to TWDB MAG calculation methodology, not because GMA 16 DFCs are overly restrictive *(see January 2020 presentation)*.

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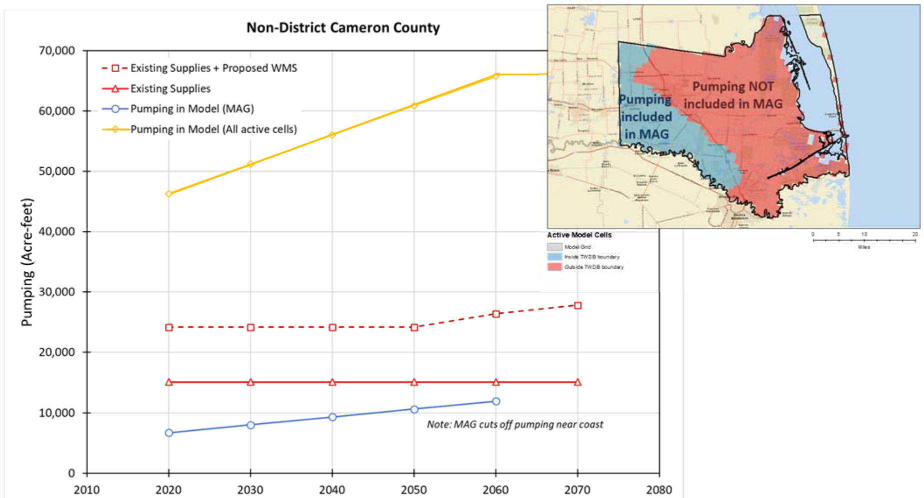
Connection between Regional Water Planning & GMA



*Cameron County (Region M) could not suggest additional WMS because MAG did not include all pumping

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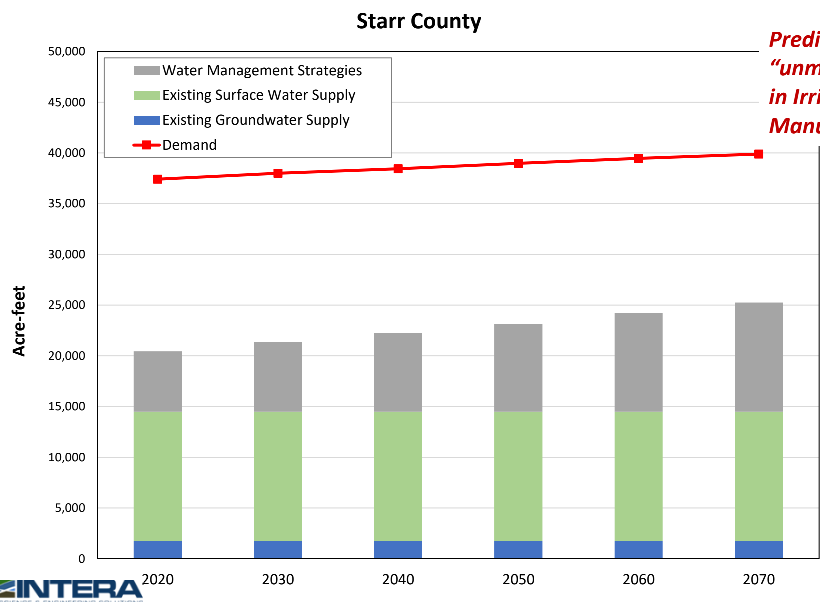
Starr County GCD



Predicted "unmet needs" in Irrigation & Manufacturing

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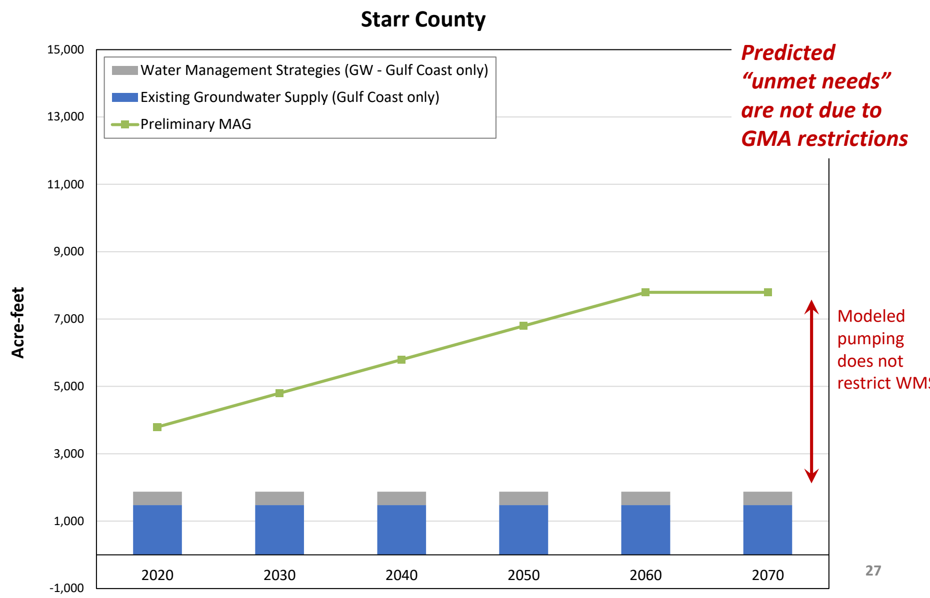
Starr County GCD



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Explanatory Report

DFC Explanatory Report for Groundwater Management Area 16

5.6 Socioeconomic Impacts

The Texas Water Development Board prepared reports on the socioeconomic impacts of not meeting the water needs identified for each of the Regional Water Planning Groups. The socioeconomic impact reports were prepared to support the development of the 2011 Regional Water Plans. The GMA considered the socioeconomic impact reports in developing the DFC. GMA 16 evaluated the development of a DFC in the context of potentially not meeting the identified needs in Regions N and M because certain recommended water management strategies may not be possible.

In general the GMA considered the socioeconomic impacts by projecting future uses of groundwater and incorporating the projections into the development of the DFC. However, the GMA additionally incorporated the Region M water management strategy for groundwater desalination and the Region N water management strategy for groundwater supply development for the City of Alice in the adopted DFC. The approach to simulating the Region M water management strategy for groundwater desalination and the City of Alice groundwater supply development is described in the GAM-run narrative report given in Appendix C.

The socioeconomic impact reports considered by the GCDs of GMA 16 are provided in Appendix G. The information on the Region M water management strategy for groundwater desalination and the City of Alice groundwater supply development considered by GMA 16 is given in Appendix H. These factors were discussed at the public meeting April 22, 2014.

- Explanatory report will briefly summarize this presentation & provide a copy as appendix
- Any District can provide INTERA with more District-specific information or details regarding this topic, if they feel it is necessary
- Deadline for adding District-specific information: next GMA meeting

Previous report (O'Rourke, 2017) will be used as template

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APPENDIX N
PRESENTATION ON CONSIDERATION OF PROPERTY RIGHTS

Groundwater Management Area 16 Joint Planning Cycle: 2019-2022
Consideration of Private Property Rights

Falfurrias, TX
July 28, 2020
Jevon Harding, P.G.
Steve Young, Ph.D., P.G., P.E.

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Joint Planning Requirements

- Balancing Test
  - 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**"

*36.108 (d-2)

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Joint Planning Requirements

- Consideration of 9 "factors" (paraphrased)
  - Aquifer uses or conditions
  - Water supply needs and management strategies
  - *Hydrological conditions*
  - Other environmental impacts
  - Impact on subsidence
  - Socioeconomic impacts
  - **Impact on private property rights**
  - Feasibility of achieving the DFC
  - Any other relevant information

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Chapter 36.108

(d) …the districts shall consider groundwater availability models and other data or information for the management area and shall propose for adoption desired future conditions for the relevant aquifers within the management area. Before voting on the proposed desired future conditions of the aquifers under Subsection (d-2), the districts shall consider:

(1) aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another;

(2) the water supply needs and water management strategies included in the state water plan;

(3) hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge;

(4) other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water;

(5) the impact on subsidence;

(6) socioeconomic impacts reasonably expected to occur;

(7) the impact on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees and assigns in groundwater as recognized under Section 36.002;

(8) the feasibility of achieving the desired future condition; and

(9) any other information relevant to the specific desired future conditions.

4

Chapter 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.

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Chapter 36.002 Ownership of Groundwater (con't)

(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

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Ownership of Groundwater

- Texas now recognizes both Rule of Capture and groundwater ownership as a real property right.
- Therefore, landowners have a statutory right to pump groundwater; although not a correlative right to pump a specific amount of groundwater.
- The tort preclusion aspects of Rule of Capture remain as they do in common law. Therefore, you cannot sue your neighbor for pumping your well dry in most circumstances.
- Recognizes that owners of groundwater rights must comply with groundwater district regulations if they are within the boundaries of a groundwater conservation district.
- Opens the door for a groundwater rights owner to challenge a groundwater district's regulations and/or permits based on constitutional regulatory takings grounds.

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Consideration of Potential DFC Impacts

- "Considerations" by the GMA should analyze how property rights could be impacted.
- Impacts ≠ takings in this process

  - This is NOT a takings impact analysis
- A GMA must consider the rights of all owners of private property, including all owners of groundwater within the GMA. All interests, whether or not they favor highest practicable use or conservation, have property rights under the law.
- Rules adopted by a District to achieve a DFC may have a potential impact on property rights
- Impacts may be viewed as both restricting and enhancing property rights.

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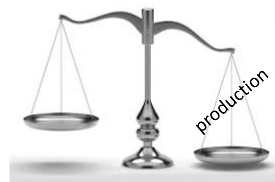
Potential Impacts on Property Rights of DFCs Favoring "Highest Practicable Production"

- Ex. lenient production restrictions that allow existing users to produce more groundwater with less acreage.
- May allow groundwater supply and levels to meet needs.
- May endanger water supply and needs of future users.
- Increased production may increase drainage of groundwater from neighboring landowners.



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Potential Impacts on Property Rights of DFCs Favoring Conservation, Preservation, Protection, and Recharging

- Ex. stricter production limits that require existing users to reduce groundwater production or acquire additional groundwater rights.
- May extend groundwater supply and levels to meet future needs.
- May extend the productive life of the aquifer.
- May minimize interference between groundwater right owners.

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Explanatory Report

- Previous report (O'Rourke, 2017) will be used as template
- Explanatory report will briefly summarize this presentation & provide a copy as appendix
- Any District can provide INTERA with more District-specific information or details regarding this topic, if they feel it is necessary

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