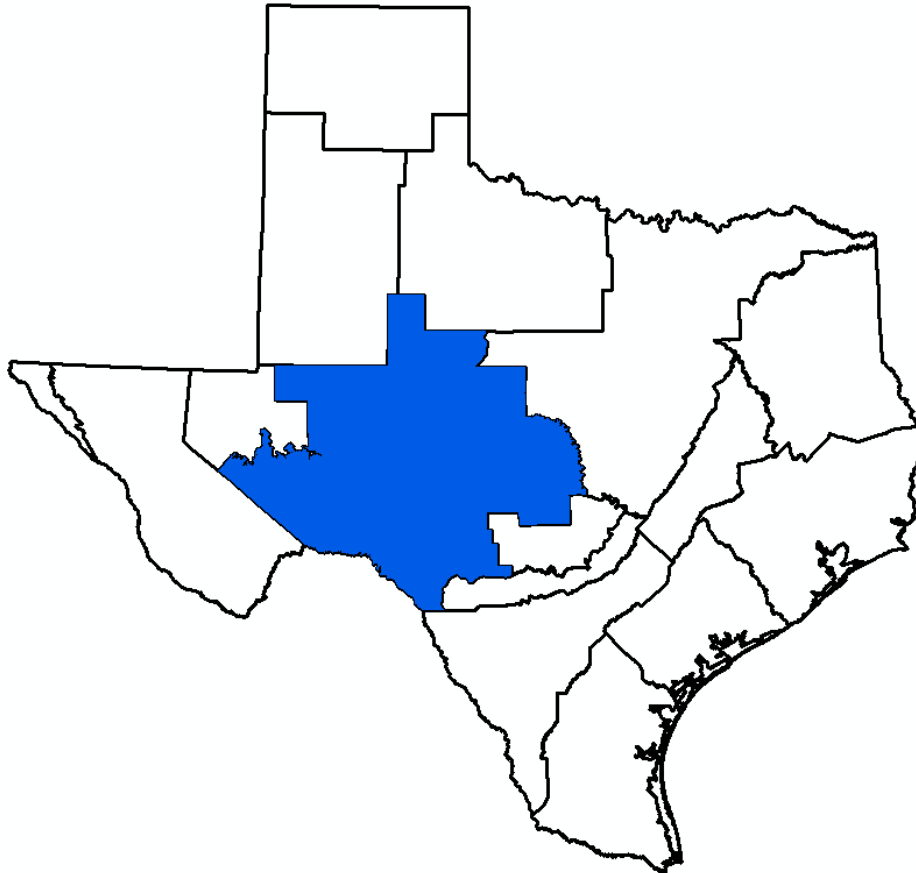# *GMA 7 Explanatory Report - Final*

Aquifers of the Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls)

Prepared for:

Groundwater Management Area 7

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August 28, 2021

GMA 7 Explanatory Report - Final
Aquifers of the Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls)
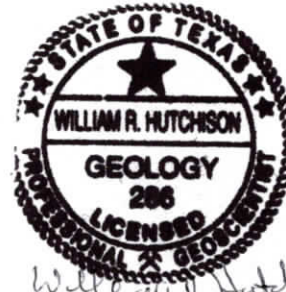
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1.0 Groundwater Management Area 7

Groundwater Management Area 7 is one of sixteen groundwater management areas in Texas and covers that portion of west Texas that is underlain by the Edwards-Trinity (Plateau) Aquifer (Figure 1).
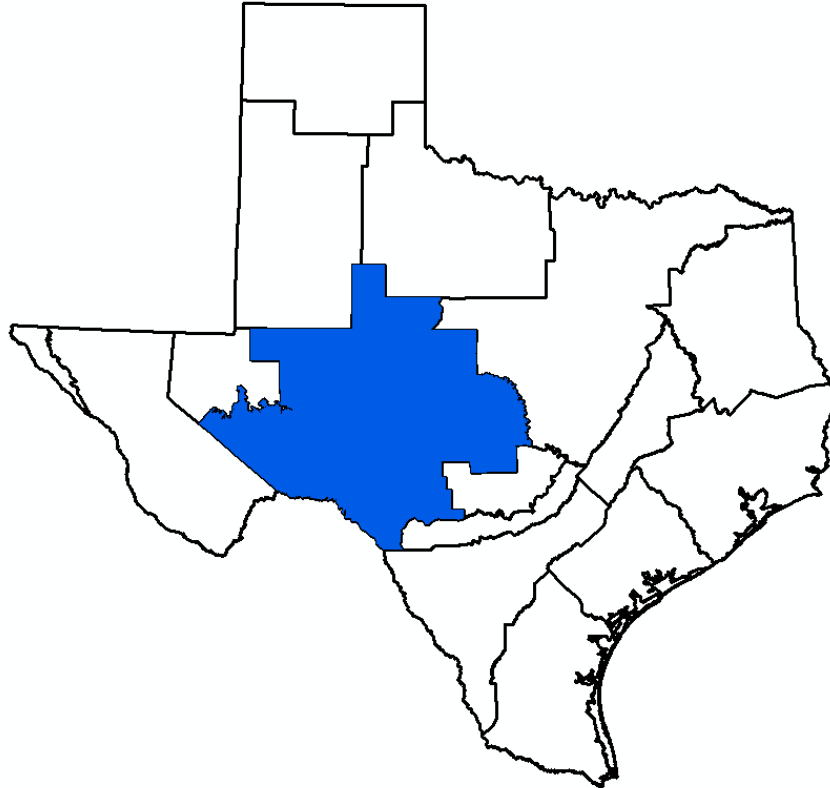
Figure 1. Groundwater Management Area 7

Groundwater Management Area 7 covers all or part of the following counties: Coke, Coleman, Concho, Crockett, Ector, Edwards, Gillespie, Glasscock, Irion, Kimble, Kinney, Llano, Mason, McCulloch, Menard, Midland, Mitchell, Nolan, Pecos, Reagan, Real, Runnels, San Saba, Schleicher, Scurry, Sterling, Sutton, Taylor, Terrell, Tom Green, Upton, and Uvalde (Figure 2).
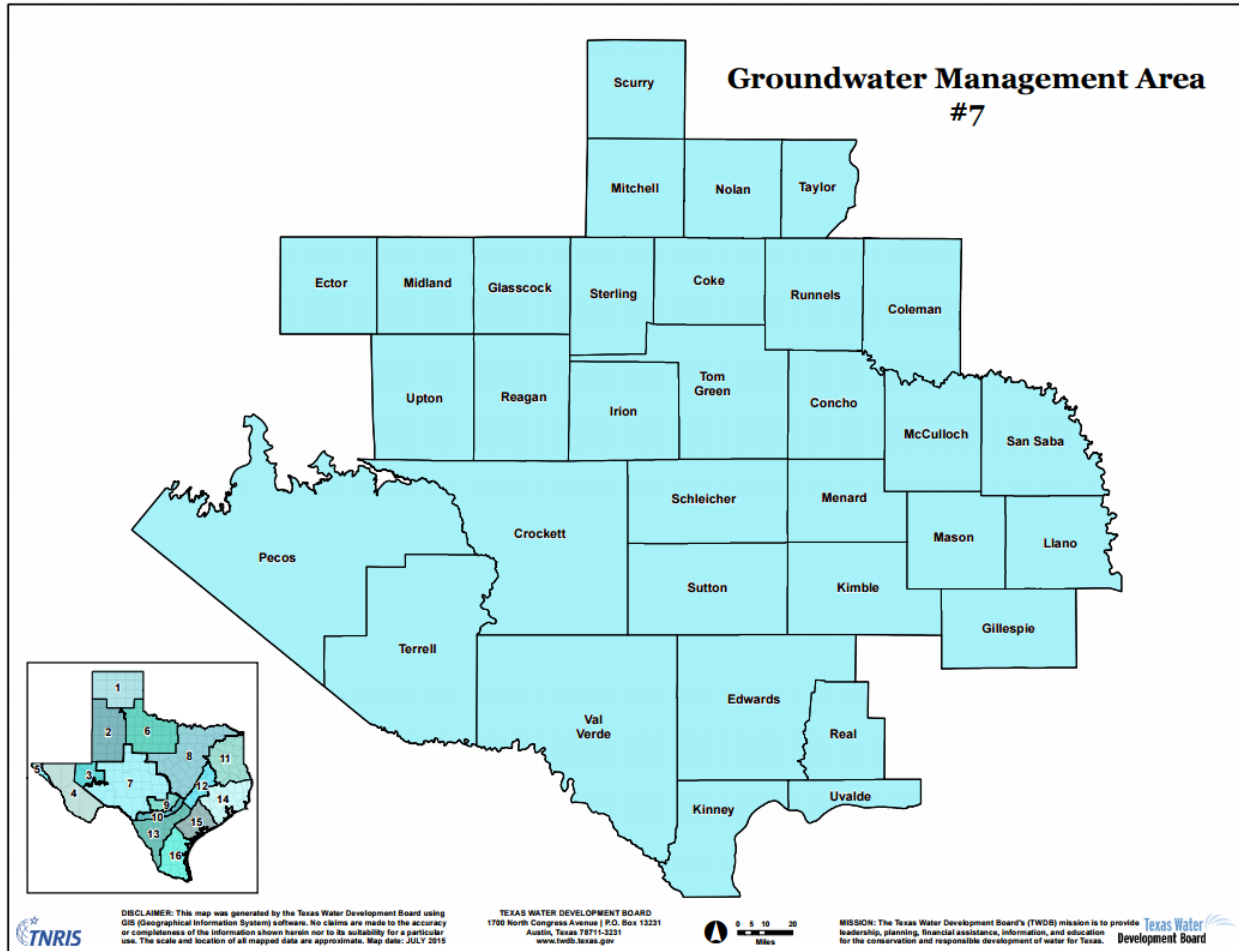
Figure 2. GMA 7 Counties (from TWDB)

There are 20 groundwater conservation districts in Groundwater Management Area 7: Coke County Underground Water Conservation District, Crockett County Groundwater Conservation District, Glasscock Groundwater Conservation District, Hickory Underground Water Conservation District No. 1, Hill County Underground Water Conservation District, Irion County Water Conservation District, Kimble County Groundwater Conservation District, Kinney County Groundwater Conservation District, Lipan-Kickapoo Water Conservation District, Lone Wolf Groundwater Conservation District, Menard County Underground Water District, Middle Pecos Groundwater Conservation District, Plateau Underground Water Conservation and Supply District, Real-Edwards Conservation and Reclamation District Santa Rita Underground Water Conservation District, Sterling County Underground Water Conservation District, Sutton County Underground Water Conservation District, Terrell County Groundwater Conservation District, Uvalde County Underground Water Conservation District, and Wes-Tex Groundwater Conservation District (Figure 3).

The Edwards Aquifer Authority is also partially inside of the boundaries of GMA 7, but are exempt from participation in the joint planning process.
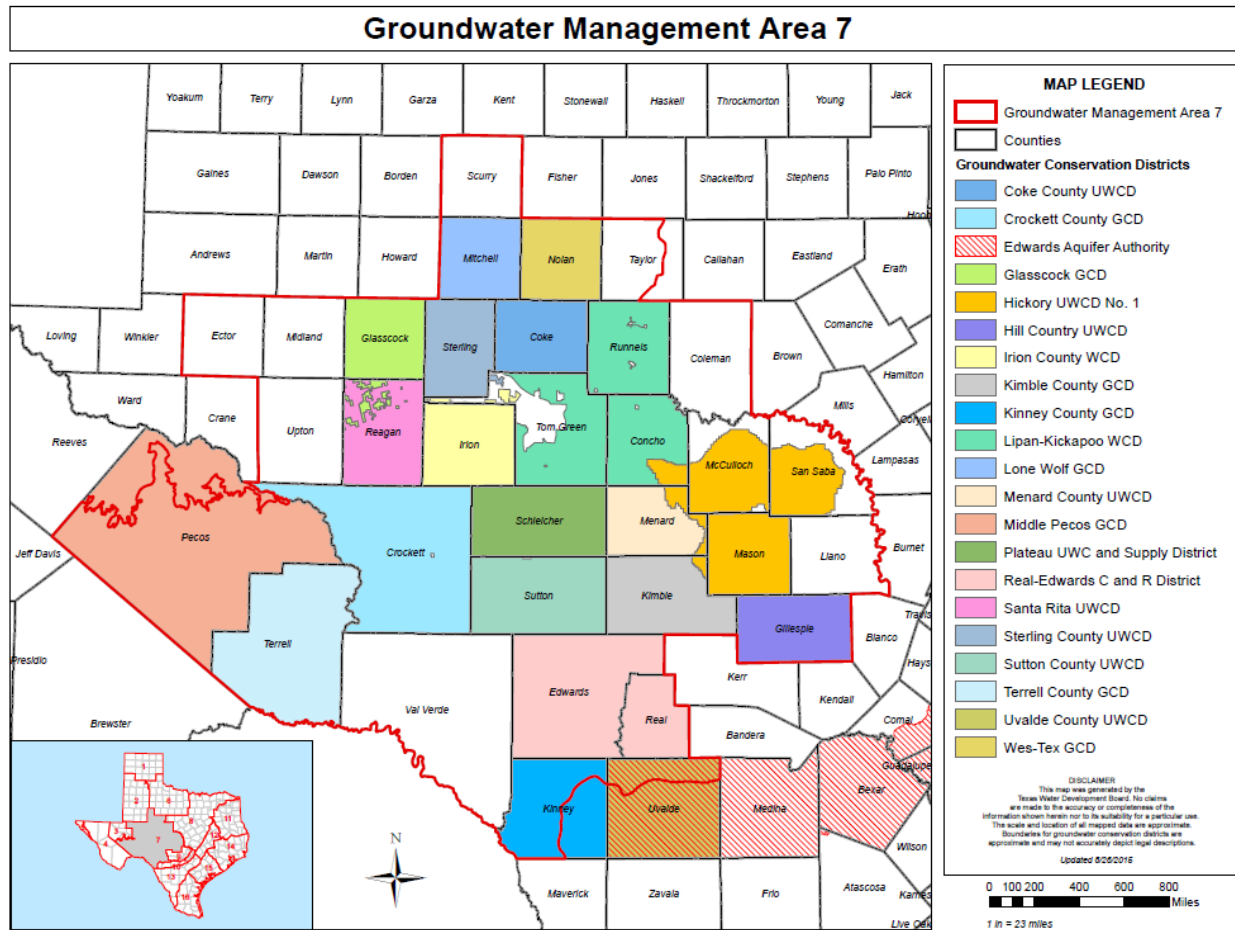
Figure 3. Groundwater Conservation Districts in GMA 7 (from TWDB)

The explanatory report covers the aquifers of the Llano Uplift (Ellenburger-San Saba, Hickory, and Marble Falls). As described in George and others (2011):

> **The Ellenburger–San Saba Aquifer** *is a minor aquifer that is found in parts of 15 counties in the Llano Uplift area of Central Texas. The aquifer consists of the Tanyard, Gorman, and Honeycut formations of the Ellenburger Group and the San Saba Limestone Member of the Wilberns Formation. The aquifer consists of a sequence of limestone and dolomite that crop out in a circular pattern around the Llano Uplift and dip radially into the subsurface away from the center of the uplift to depths of approximately 3,000 feet. Regional block faulting has significantly compartmentalized the aquifer. The maximum thickness of the aquifer is about 2,700 feet. Water is held in fractures, cavities, and solution channels and is commonly under confined conditions. The aquifer is highly permeable in places, as indicated by wells that yield as much as 1,000 gallons per minute and springs that issue from the aquifer, maintaining the base flow of streams in the area. Water produced from the aquifer is inherently hard and usually has less than 1,000 milligrams per liter of total dissolved solids. Fresh to slightly saline water extends downdip to depths of approximately 3,000 feet. Elevated concentrations of radium and radon also occur in the aquifer. Most of the groundwater is used for municipal purposes, and the remainder*

for irrigation and livestock. A large portion of water flowing from San Saba Springs, which is the water supply for the city of San Saba, is thought to be from the Ellenburger–San Saba and Marble Falls aquifers. The regional water planning groups, in their 2006 Regional Water Plans, recommended several water management strategies that use the Ellenburger–San Saba Aquifer, including the development of a new well field in Llano County to supply the city of Llano, additional pumping from existing wells, temporary overdrafts, and the reallocation of supplies from users with surpluses to users with needs.

The Hickory Aquifer, *a minor aquifer found in the central part of the state, consists of the water-bearing parts of the Hickory Sandstone Member of the Riley Formation. The Hickory Aquifer reaches a maximum thickness of 480 feet, and freshwater saturated thickness averages about 350 feet. Although the groundwater is generally fresh, with total dissolved solids concentrations of less than 1,000 milligrams per liter, the upper portion of the aquifer typically contains iron in excess of the state's secondary drinking water standards. Of greater concern is naturally occurring radioactivity: gross alpha radiation, radium, and radon are commonly found in excess of the state's primary drinking water standards. The groundwater is used for irrigation throughout its extent and for municipal supply in the cities of Brady, Mason, and Fredericksburg. Slight water level fluctuations occur seasonally in irrigated areas. The regional water planning groups, in their 2006 Regional Water Plans, recommended several water management strategies that use the Hickory Aquifer, including constructing new wells, pumping additional water from existing wells, and maintaining existing supplies through supplemental or replacement wells. In addition, the Region F Regional Water Planning Group recommended treating water from the aquifer and distributing it as drinking water through a bottled water program in Concho and McCulloch counties.*

The Marble Falls Aquifer, *a minor aquifer, occurs in several separated outcrops along the northern and eastern flanks of the Llano Uplift region of Central Texas. The subsurface extent of the aquifer is unknown. Groundwater occurs in fractures, solution cavities, and channels in the limestone of the Marble Falls Formation of the Bend Group. The aquifer is highly permeable in places, as indicated by wells that yield as much as 2,000 gallons per minute. Maximum thickness of the formation is 600 feet. Where underlying beds are thin or absent, the Marble Falls Aquifer may be hydraulically connected to the Ellenburger–San Saba Aquifer. Numerous large springs issue from the aquifer and provide a significant part of the base flow to the San Saba River in McCulloch and San Saba counties and to the Colorado River in San Saba and Lampasas counties. Because the limestone beds composing this aquifer are relatively shallow, the aquifer is susceptible to pollution by surface uses and activities. For example, some wells in Blanco County have produced water with high nitrate concentrations. In the subsurface, groundwater becomes highly mineralized; however, the water produced from this aquifer is suitable for most purposes and generally contains less than 1,000 milligrams per liter of total dissolved solids. Water from the aquifer is used for municipal, agricultural, and industrial uses, and no significant water level declines have occurred in wells measured by the TWDB. The regional water planning groups, in their 2006 Regional Water Plans, recommended drilling new wells in Burnet County as a water management strategy using the Marble Falls Aquifer.*

2.0   Desired Future Condition History

2.1   2010 Desired Future Conditions

GMA 7 adopted a desired future condition for the Ellenburger-San Saba Aquifer on July 29, 2010 as follows:

> *".. through the year 2060:*
>
> *1) Total net decline in water levels within Hickory UWCD No. 1, Hill Country UWCD, Kimble County GCD, and Menard County UWD at the end of the fifty-year period shall not exceed 5 feet below 2010 water levels in the aquifer;*
> *2) The Ellenburger-San Saba Aquifer is not relevant for joint planning purposes in all other areas of GMA 7.*

The desired future condition was developed after considering a water budget analysis was that was completed by the Texas Water Development Board (Thorkildsen and Backhouse, 2010a). A groundwater model of the aquifer was not available at the time of the initial desired future condition.

GMA 7 adopted a desired future condition for the Hickory Aquifer on July 29, 2010 as follows:

> *".. through the year 2060:*
>
> *1) Total net decline in water levels within Hickory UWCD No. 1, Hill Country UWCD, Kimble County GCD, and Menard County UWD, Llano County and the unprotected areas in McCulloch and San Saba counties at the end of the fifty-year period shall not exceed seven (7) feet below 2010 water levels in the aquifer;*
> *2) The Hickory Aquifer is not relevant for joint planning purposes in all other areas of GMA 7.*

The desired future condition was developed after considering a water budget analysis was that was completed by the Texas Water Development Board (Thorkildsen and Backhouse, 2010b). A groundwater model of the aquifer was not available at the time of the initial desired future condition.

GMA 7 adopted a desired future condition for the Marble Falls Aquifer on July 29, 2010 as follows:

> *".. through the year 2060:*
>
> *3) Total net decline in water levels in San Saba County at the end of the fifty-year period shall not exceed seven (7) feet below 2010 water levels in the aquifer;*
> *4) The Marble Falls Aquifer is not relevant for joint planning purposes in all other areas of GMA 7.*

The desired future condition was developed after considering a water budget analysis was that was completed by the Texas Water Development Board (subsequently documented in Wuerch and Backhouse, 2011). A groundwater model of the aquifer was not available at the time of the initial desired future condition.

2.2   2016 Desired Future Conditions

In 2016, the Texas Water Development Board released the groundwater availability model (GAM) for the aquifers of the Llano Uplift region. This model was used as a tool to set the desired future conditions. Documentation of the GAM runs is presented in Technical Memorandum 16-02.

On April 21, 2016, the groundwater conservation districts in Groundwater Management Area 7 voted on proposed desired future conditions for the aquifers of the Llano Uplift region that were based on Scenario 3 in Technical Memorandum 16-02. At a meeting on September 22, 2016, the groundwater conservation districts in Groundwater Management Area 7 voted final approval of these desired future conditions for the aquifers in the Llano Uplift region as follows:

Ellenberger-San Saba Aquifer:

a) Total net drawdowns of aquifer levels shall not exceed drawdowns in 2070, as compared with 2011 aquifer levels, respectively as follows:

County	GCD	Drawdown (feet)
Gillespie	Hill Country UWCD	8
Mason	Hickory UWCD	14
McCulloch	Hickory UWCD	29
Menard	Menard UWD & Hickory UWCD	46
Kimble	Kimble County GCD & Hickory UWCD	18
San Saba	Hickory UWCD	5

(Reference: Scenario 3, GMA 7 Technical Memo 16-02)

b) The Ellenburger-San Saba Aquifer is not relevant for joint planning purposes in all other areas in GMA 7.

Hickory Aquifer:

a) Total net drawdown of aquifer levels shall not exceed drawdowns in 2070, as compared with 2011 aquifer levels, respectively as follows:

County	GCD	Drawdown (feet)
Concho	Hickory UWCD	53
Gillespie	Hill Country UWCD	9
Kimble	Kimble County GCD Hickory UWCD	18
Llano	-	13
Mason	Hickory UWCD	17
McCulloch	Hickory UWCD	29
Menard	Menard UWD and Hickory UWCD	46
San Saba	Hickory UWCD	6

(Reference: Scenario 3 GMA 7 Technical Memo 16-02, 4-14-2016)

b) The Hickory Aquifer is not relevant for joint planning purposes in all areas of GMA 7 outside the boundaries of the Hickory UWCD No.1, Hill Country UWCD, Kimble County GCD, Menard UWD and Llano County.

Marble Falls Aquifer:

After reviewing the results of the model simulations in Technical Memo 16-02, the groundwater conservation districts in Groundwater Management Area 7 classified the Marble Falls Aquifer as not relevant for purposes of joint planning.

2.3 Third Round Desired Future Conditions

After review and discussion, the groundwater conservation districts in Groundwater Management Area 7 found that the desired future conditions approved in 2016 would remain unchanged.

The resolution that documents the adoption of the desired future condition for the Capitan Reef Complex Aquifer is presented in Appendix A and was adopted on August 19, 2021 by a 14-0 vote at a properly noticed meeting of Groundwater Management Area 7.

3.0   Policy Justification

As developed more fully in this report, the proposed desired future condition was adopted after considering:

- Aquifer uses and conditions within Groundwater Management Area 7
- Water supply needs and water management strategies included in the 2012 State Water Plan
- Hydrologic conditions within Groundwater Management Area 7 including total estimated recoverable storage, average annual recharge, inflows, and discharge
- Other environmental impacts, including spring flow and other interactions between groundwater and surface water
- The impact on subsidence
- Socioeconomic impacts reasonably expected to occur
- The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 7 in groundwater as recognized under Texas Water Code Section 36.002
- The feasibility of achieving the desired future condition
- Other information

In addition, the proposed desired future condition provides a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater in Groundwater Management Area 7.

There is no set formula or equation for calculating groundwater availability. This is because an estimate of groundwater availability requires the blending of policy and science. Given that the tools for scientific analysis (groundwater models) contain limitations and uncertainty, policy provides the guidance and defines the bounds that science can use to calculate groundwater availability.

As developed more fully below, many of these factors could only be considered on a qualitative level since the available tools to evaluate these impacts have limitations and uncertainty.

4.0   Technical Justification

The process of using the groundwater model in developing desired future conditions revolves around the concept of incorporating many of the elements of the nine factors (e.g. current uses and water management strategies in the regional plan). For the Llano Uplift region and its associated aquifers (Ellenburger-San Saba, Hickory, and Marble Falls), five scenarios were completed, and the results discussed prior to adopting a desired future condition.

Some critics of the process asserted that the districts were "reverse-engineering" the desired future conditions by specifying pumping (e.g., the modeled available groundwater) and then adopting the resulting drawdown as the desired future condition. However, it must be remembered that among the input parameters for a predictive groundwater model run is pumping, and among the outputs of a predictive groundwater model run is drawdown. Thus, an iterative approach of running several predictive scenarios with models and then evaluating the results is a necessary (and time-consuming) step in the process of developing desired future conditions.

One part of the reverse-engineering critique of the process has been that "science" should be used in the development of desired future conditions. The critique plays on the unfortunate name of the groundwater models in Texas (Groundwater Availability Models) which could suggest that the models yield an availability number. This is simply a mischaracterization of how the models work (i.e. what is a model input and what is a model output).

The critique also relies on a fairly narrow definition of the term *science* and fails to recognize that the adoption of a desired future condition is primarily a policy decision. The call to use science in the development of desired future conditions seems to equate the term *science* with the terms *facts* and *truth*. Although the Latin origin of the word means knowledge, the term *science* also refers to the application of the scientific method. The scientific method is discussed in many textbooks and can be viewed as a means to quantify cause-and-effect relationships and to make useful predictions.

In the case of groundwater management, the scientific method can be used to understand the relationship between groundwater pumping and drawdown, or groundwater pumping and spring flow. A groundwater model is a tool that can be used to run "experiments" to better understand the cause-and-effect relationships within a groundwater system as they relate to groundwater management.

Much of the consideration of the nine statutory factors involves understanding the effects or the impacts of a desired future condition (e.g. groundwater-surface water interaction and property rights). The use of the models in this manner in evaluating the impacts of alternative futures is an effective means of developing information for the groundwater conservation districts as they develop desired future conditions.

5.0   Factor Consideration

Senate Bill 660, adopted by the legislature in 2011, changed the process by which groundwater conservation districts within a groundwater management area develop and adopt desired future conditions. The new process includes nine steps as presented below:

- The groundwater conservation districts within a groundwater management area consider nine factors outlined in the statute.
- The groundwater conservation districts adopt a "proposed" desired future condition
- The "proposed" desired future condition is sent to each groundwater conservation district for a 90-day comment period, which includes a public hearing by each district
- After the comment period, each district compiles a summary report that summarizes the relevant comments and includes suggested revisions. This summary report is then submitted to the groundwater management area.
- The groundwater management area then meets to vote on a desired future condition.
- The groundwater management area prepares an "explanatory report".
- The desired future condition resolution and the explanatory report are then submitted to the Texas Water Development Board and the groundwater conservation districts within the groundwater management area.
- Districts then adopt desired future conditions that apply to that district.

The nine factors that must be considered before adopting a proposed desired future condition are:

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 (of the Texas Water Development Board), 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 (of the Texas Water Code).
8. The feasibility of achieving the desired future condition.
9. Any other information relevant to the specific desired future condition.

In addition to these nine factors, statute requires that the desired future condition 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.

5.1   Groundwater Demands and Uses

County-level groundwater demands and uses from 2000 to 2012 for the aquifers in the Llano Uplift region are presented in Appendix B. Data were obtained from the Texas Water Development Board historic pumping database:

http://www.twdb.state.tx.us/waterplanning/waterusesurvey/historical-pumpage.asp

These data, and a comparison to current modeled available groundwater numbers were discussed at the GMA 7 meeting of December 18, 2014 in San Angelo, Texas, and reviewed again at the GMA 7 meeting of January 19, 2020.

5.2   Groundwater Supply Needs and Strategies

The 2016 Region F Plan lists county-by-county shortages and strategies. Shortages are identified when current supplies (e.g. existing wells) cannot meet future demands. Strategies are then recommended (e.g. new wells) to meet the future demands. Of note is the strategy associated with the new Hickory Aquifer wells for the City of San Angelo. As documented in Technical Memorandum 16-02, pumping from these wells was specifically included in the simulations.

5.3   Hydrologic Conditions, including Total Estimated Recoverable Storage

The groundwater budget for the Ellenburger-San Saba Aquifer for the calibration period of the model (1981 to 2010) is presented alongside the groundwater budget for Scenario 3 from 2011 to 2070 in Table 1.

The groundwater budget for the Hickory Aquifer for the calibration period of the model (1981 to 2010) is presented alongside the groundwater budget for Scenario 3 from 2011 to 2070 in Table 2.

The total estimated recoverable storage estimates from the TWDB (Jones and others, 2013) are summarized as follows:

- Table 3: Ellenburger-San Saba Aquifer
- Table 4: Hickory Aquifer
- Table 5: Marble Falls Aquifer

Table 1. Groundwater Budget for Ellenburger-San Saba Aquifer

	1980-2010	2011-2070	Difference
Inflow			
Recharge from Rainfall	80,410	81,865	1,455
Inflow from Overlying Formations	40,448	43,944	3,496
Total Inflow	120,858	125,810	4,951
Outflow			
Pumping	16,008	19,021	3,013
Spring Discharge	11	9	-2
Discharge to Surface Water	35,714	24,803	-10,911
Outflow to Underlying Formations	57,987	68,828	10,842
Outflow to GMA 8	9,269	9,791	522
Outflow to GMA 9	3,879	3,552	-327
	122,867	126,004	3,137
Inflow-Outflow	-2,008	-194	1,814
Model Estimated Storage Change	-2,008	-183	1,825
Model Error	0	-11	-11

Table 2. Groundwater Budget of Hickory Uplift Aquifers in GMA 7
All Values in AF/yr except as noted

	1981 to 2010	2010 to 2070	Difference
Inflow			
Recharge from Rainfall	15,397	14,415	-982
Inflow from Overlying Formations	55,683	65,905	10,222
Total	71,081	80,321	9,240
Outflow			
Pumping	29,222	37,783	8,561
Springs and Discharge to Surface Water	20,802	20,118	-684
Outflow to Underlying Formations	13,083	13,337	254
Outflow to GMA 8	1,737	1,727	-10
Outflow to GMA 9	7,170	6,748	-422
Total	72,015	79,714	7,698
Inflow - Outflow	-935	607	1,542
Model Estimate of Storage Change	-935	607	1,542
Model Error	0	0	0

Table 3. Total Estimated Recoverable Storage – Ellenburger-San Saba Aquifer

County	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Coleman	1,400,000	350,000	1,050,000
Concho	62,000	15,500	46,500
Gillespie	6,500,000	1,625,000	4,875,000
Kimble	6,000,000	1,500,000	4,500,000
Llano	350,000	87,500	262,500
Mason	1,900,000	475,000	1,425,000
McCulloch	16,000,000	4,000,000	12,000,000
Menard	1,600,000	400,000	1,200,000
San Saba	20,000,000	5,000,000	15,000,000
Total	53,812,000	13,453,000	40,359,000

Table 4. Total Estimated Recoverable Storage – Hickory Aquifer

County	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Coleman	1,500,000	375,000	1,125,000
Concho	2,800,000	700,000	2,100,000
Gillespie	7,200,000	1,800,000	5,400,000
Kimble	5,900,000	1,475,000	4,425,000
Llano	1,000,000	250,000	750,000
Mason	5,400,000	1,350,000	4,050,000
McCulloch	8,500,000	2,125,000	6,375,000
Menard	4,500,000	1,125,000	3,375,000
San Saba	7,500,000	1,875,000	5,625,000
Total	44,300,000	11,075,000	33,225,000

Table 5. Total Estimated Recoverable Storage – Marble Falls Aquifer

County	Total Storage (acre-feet)	25 percent of Total Storage (acre-feet)	75 percent of Total Storage (acre-feet)
Kimble	2,400	600	1,800
Llano	2,100	525	1,575
Mason	5,300	1,325	3,975
McCulloch	33,000	8,250	24,750
San Saba	144,000	36,000	108,000
Total	186,800	46,693	140,078

5.4   Other Environmental Impacts, including Impacts on Spring Flow and Surface Water

Tables 1, 2, 3 above includes groundwater budget estimates of spring flow and surface water impacts for each aquifer.

5.5   Subsidence

Subsidence is not an issue in any of the aquifers of the Llano Uplift region in GMA 7. Applying the maximum drawdown to the recently released subsidence tool on the Texas Water Development board website, the Total Weighted Risk for the Ellenburger-San Saba Aquifer is 2.66 and is 3.44 for the Hickory Aquifer. As noted in the tool, a risk score of 0 is low risk and a risk score of 10 is high risk. Predicted subsidence using the tool is 0.02 feet for the Hickory Aquifer and 0.00 feet for the Ellenburger-San Saba Aquifer from 2010 to 2070.

5.6   Socioeconomic Impacts

The Texas Water Development Board prepared reports on the socioeconomic impacts of not meeting water needs for each of the Regional Planning Groups during development of the 2021 Regional Water Plans. Because the development of this desired future condition used the State Water Plan demands and water management strategies as an important foundation, it is reasonable to conclude that the socioeconomic impacts associated with this proposed desired future condition can be evaluated in the context of not meeting the listed water management strategies. Groundwater Management Area 3 is covered by Regional Planning Group F. The socioeconomic impact report for Regions F is included in Appendix C.

5.7   Impact on Private Property Rights

The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 3 in groundwater is recognized under Texas Water Code Section 36.002.

The desired future conditions adopted by GMA 7 are consistent with protecting property rights of landowners who are currently pumping groundwater and landowners who have chosen to conserve groundwater by not pumping. All current and projected uses (as defined in the 2015 Region F plan) can be met based on the simulations. In addition, the pumping associated with achieving the desired future condition (the modeled available groundwater) will cause impacts to exiting well owners and to surface water. However, as required by Chapter 36 of the Water Code, GMA 7 considered these impacts and balanced them with the increasing demand of water in the GMA 7 area, and concluded that, on balance and with appropriate monitoring and project specific review during the permitting process, the desired future condition is consistent with protection of private property rights.

5.8   Feasibility of Achieving the Desired Future Condition

Groundwater levels are routinely monitored by the districts and by the TWDB in GMA 7. Evaluating the monitoring data is a routine task for the districts, and the comparison of these data with the model results that were used to develop the DFCs is covered in each district's management plan. These comparisons will be useful to guide the update of the DFCs that are required every five years.

5.9   Other Information

GMA 7 did not consider any other information in developing these DFCs.

6.0   Discussion of Other Desired Future Conditions Considered

There were 5 GAM scenarios completed that included a range of future pumping scenarios. Results of these scenarios were originally presented at the GMA 7 meeting of March 17, 2016. The model results were summarized in GMA 7 Technical Memorandum 16-02. In addition, the details of the analysis contained in Technical Memorandum 16-02 were presented at the Hickory UWCD No. 1 Board meeting on April 14, 2016.

After review and discussion, the groundwater conservation districts found that Scenario 3, which includes all San Angelo pumping in the Hickory Aquifer was a reasonable scenario as a basis for the desired future condition.

7.0   Discussion of Other Recommendations

Public comments were invited, and each district held a public hearing on the proposed desired future condition for aquifers within their boundaries. The four GCDs in GMA 7 that had DFCs proposed in the Ellenburger-San Saba and Hickory aquifers held public hearings as follows:

Groundwater Conservation District	Date of Public Hearing	Number of Comments Received
Hickory UWCD No. 1	6/10/2021	None
Hill Country UWCD	6/8/2021	None
Kimble County GCD	3/22/2021	None
Menard County UWD	4/14/2021	None

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Appendix A

Desired Future Conditions Resolution

STATE OF TEXAS   §

§   **RESOLUTION # 08-19-2021-4**

GROUNDWATER   §

MANAGEMENT AREA 7   §

Resolution Adopting Desired Future Conditions for the Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls) in Groundwater Management Area 7

WHEREAS, Groundwater Conservation Districts (GCDs) located within or partially within Groundwater Management Area 7 (GMA 7) are required under Chapter §36.108, Texas Water Code to conduct joint planning and designate the Desired Future Conditions of aquifers within GMA 7 and;

WHEREAS, the Board Presidents or their Designated Representatives of GCDs in GMA 7 have met in various meetings and conducted joint planning in accordance with Chapter §36.108, Texas Water Code since October 2019 and;

WHEREAS, the GMA 7 Districts have received and considered Groundwater Availability Model runs and other technical advice regarding local aquifers, hydrology, geology, recharge characteristics, local groundwater demands and usage, population projections, other factors set forth in §36.108(d) of the Texas Water Code, from all aquifers within the respective GCDs, ground and surface water inter-relationships, that affect groundwater conditions through the year 2070; and

WHEREAS, the member GCDs of GMA 7, having given proper and timely notice, held an open meeting on March 18, 2021 at the Sutton County Civic Center, 1700 N Crockett, Sonora, Texas, and voted to adopt proposed Desired Future Conditions for the Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls) Aquifers within the boundaries of GMA 7, noting these proposed DFCs are unchanged from the previously adopted DFCs; and

WHEREAS, the member GCDs in which the Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls) Aquifers is relevant for joint planning purposes held open meetings within each said district between March 22, 2021 and July 22, 2021 to take public comment on the proposed DFCs for that district; and

WHEREAS, on this day of August 19, 2021, at an open meeting duly noticed and held in accordance with law, at the Sutton County Civic Center, 1700 N Crockett, Sonora, Texas, the GCDs within GMA 7 voted, upon motion made and seconded, __14__ districts in favor, __0__ districts opposed, to adopt the following DFCs for Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls) Aquifers in the following counties and districts through the year 2070:

Ellenburger-San Saba Aquifer:
   a) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed **8 feet in Gillespie County** in 2070 as compared with 2010 aquifer levels.
   b) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed **18 foot in Kimble County** in 2070 as compared with 2010 aquifer levels.
   c) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed **14 foot in Mason County** in 2070 as compared with 2010 aquifer levels.

d) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed **29 feet in McCulloch County** in 2070 as compared with 2010 aquifer levels.

e) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed **46 feet in Menard County** in 2070 as compared with 2010 aquifer levels.

f) Total net drawdown of the Ellenburger-San Saba Aquifer not to exceed **5 feet in San Saba County** in 2070 as compared with 2010 aquifer levels.

Hickory Aquifer:

g) Total net drawdown of the Hickory Aquifer not to exceed **53 feet in Concho County** in 2070 as compared with 2010 aquifer levels.

h) Total net drawdown of the Hickory Aquifer not to exceed **9 feet in Gillespie County** in 2070 as compared with 2010 aquifer levels.

i) Total net drawdown of the Hickory Aquifer not to exceed **18 feet in Kimble County** in 2070 as compared with 2010 aquifer levels.

j) Total net drawdown of the Hickory Aquifer not to exceed **17 feet in Mason County** in 2070 as compared with 2010 aquifer levels.

k) Total net drawdown of the Hickory Aquifer not to exceed **29 feet in McColloch County** in 2070 as compared with 2010 aquifer levels.

l) Total net drawdown of the Hickory Aquifer not to exceed **46 feet in Menard County** in 2070 as compared with 2010 aquifer levels.

m) Total net drawdown of the Hickory Aquifer not to exceed **6 feet in San Saba County** in 2070 as compared with 2010 aquifer levels.
   (Reference items a) through m): Scenario 3, GMA 7 Technical Memorandum 16-02)

n) The Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls) Aquifers are not relevant for joint planning purposes in all other areas of GMA 7.

NOW THEREFORE BE IT RESOLVED, that Groundwater Management Area 7 does hereby document, record, and confirm the above-described Desired Future Conditions for the **Llano Uplift Region (Ellenburger-San Saba, Hickory, Marble Falls) Aquifers** which were adopted by vote of the following Designated Representatives of Groundwater Conservation Districts present and voting on August 19, 2021:

AYES:

[signature]
DESIGNATED REPRESENTATIVE – Coke County Underground Water Conservation District

[signature]
DESIGNATED REPRESENTATIVE – Crockett County Groundwater Conservation District

_____
DESIGNATED REPRESENTATIVE – Glasscock Groundwater Conservation District

_____
DESIGNATED REPRESENTATIVE – Hickory Underground Water Conservation District No. 1

_____
DESIGNATED REPRESENTATIVE – Hill Country Underground Water Conservation District

[signature]
DESIGNATED REPRESENTATIVE - Irion County Water Conservation District

[signature: Meredith E Allen]
DESIGNATED REPRESENTATIVE – Kimble County Groundwater Conservation District

[signature]
DESIGNATED REPRESENTATIVE - Kinney County Groundwater Conservation District

[signature]
DESIGNATED REPRESENTATIVE - Lipan-Kickapoo Water Conservation District

_____
DESIGNATED REPRESENTATIVE - Lone Wolf Groundwater Conservation District

[signature: Meredith E. Allen]
DESIGNATED REPRESENTATIVE – Menard County Underground Water District

[signature]
DESIGNATED REPRESENTATIVE – Middle Pecos Groundwater Conservation District

[signature: Jon Cart..]
DESIGNATED REPRESENTATIVE - Plateau Underground Water Conservation and Supply District

[signature: Brian L..]
DESIGNATED REPRESENTATIVE - Real-Edwards Conservation and Reclamation District

_____
DESIGNATED REPRESENTATIVE - Santa Rita Underground Water Conservation District

[signature]
DESIGNATED REPRESENTATIVE - Sterling County Underground Water Conservation District

[signature: Meredith E Allen]
DESIGNATED REPRESENTATIVE – Sutton County Underground Water Conservation District

[signature: Debbie Deaton]
DESIGNATED REPRESENTATIVE - Terrell County Groundwater Conservation District

[signature]
DESIGNATED REPRESENTATIVE - Uvalde County Underground Water Conservation District

_____
DESIGNATED REPRESENTATIVE - Wes-Tex Groundwater Conservation District

NAYES:

_____
DESIGNATED REPRESENTATIVE – Coke County Underground Water Conservation District

_____
DESIGNATED REPRESENTATIVE – Crockett County Groundwater Conservation District

_____
DESIGNATED REPRESENTATIVE – Glasscock Groundwater Conservation District

_____
DESIGNATED REPRESENTATIVE – Hickory Underground Water Conservation District No. 1

_____
DESIGNATED REPRESENTATIVE – Hill Country Underground Water Conservation District

_____
DESIGNATED REPRESENTATIVE - Irion County Water Conservation District

_____
DESIGNATED REPRESENTATIVE – Kimble County Groundwater Conservation District

_____
DESIGNATED REPRESENTATIVE - Kinney County Groundwater Conservation District

_____
DESIGNATED REPRESENTATIVE - Lipan-Kickapoo Water Conservation District

_____
DESIGNATED REPRESENTATIVE - Lone Wolf Groundwater Conservation District

_____
DESIGNATED REPRESENTATIVE – Menard County Underground Water District

_____
DESIGNATED REPRESENTATIVE – Middle Pecos Groundwater Conservation District
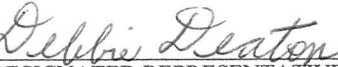
_____
DESIGNATED REPRESENTATIVE - Plateau Underground Water Conservation and Supply District

_____
DESIGNATED REPRESENTATIVE - Real-Edwards Conservation and Reclamation District

_____
DESIGNATED REPRESENTATIVE - Santa Rita Underground Water Conservation District

_____
DESIGNATED REPRESENTATIVE - Sterling County Underground Water Conservation District

_____
DESIGNATED REPRESENTATIVE – Sutton County Underground Water Conservation District

_____
DESIGNATED REPRESENTATIVE - Terrell County Groundwater Conservation District

_____
DESIGNATED REPRESENTATIVE - Uvalde County Underground Water Conservation District

_____
DESIGNATED REPRESENTATIVE - Wes-Tex Groundwater Conservation District

Groundwater Management Area # 7
Joint Planning Meeting

Notice is hereby given that on Thursday, **August 19, 2021 at 10:00 a.m.** that one or more members of the Board of Directors and/or the designated representative of said boards of Groundwater Conservation Districts within the Texas Water Development Board-designated **Groundwater Management Area # 7** of the State of Texas will meet at the **Sutton County Civic Center, 1700 North Crockett Street, Sonora, TX 76950,** for the purposes of conducting joint planning in compliance with the requirements of Section 36.108 of the Texas Water Code.

Agenda

1. Call to Order and Invocation
2. Introduction of Member Districts and other persons in attendance
3. Public Comment
4. Consider and Possible Action on Minutes of the March 18, 2021 meeting
5. Update from the Texas Water Development Board
6. Review of public comments received during 90-day period
7. Presentation by Dr. Bill Hutchison on draft responses to public comments on proposed DFCs
8. Consider and Possible Action on Adoption of Resolution to declare the Blaine, Igneous, Lipan, Marble Falls, Seymour, and Cross Timbers aquifers not relevant for joint planning purposes within GMA 7 and consequently not requiring adoption of a proposed Desired Future Condition or development of Managed Available Groundwater numbers by the Texas Water Development Board.
9. Consider and Possible Action on Adoption of Resolutions for proposed DFCs for the following aquifers within boundaries of GMA 7:
    a. Capitan Reef Complex Aquifer
    b. Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers.
    c. Llano Uplift region (Ellenburger-San Saba, Hickory, Marble Falls aquifers)
    d. Ogallala and Dockum aquifers
    e. Rustler Aquifer
10. Next steps in Joint Planning Process
11. Other Matters to come before the membership
12. Set date and preliminary agenda for next meeting
13. Adjourn

Groundwater Conservation Districts located partially or wholly within
Groundwater Management Area # 7 are:

Coke County UWCD; Crockett County GCD; Glasscock GCD; Hickory UWCD No. 1; Hill Country UWCD; Irion County WCD; Kimble County GCD; Kinney County GCD; Lipan-Kickapoo WCD; Lone Wolf GCD; Menard County UWD; Middle Pecos GCD; Plateau UWC&SD; Real-Edwards C&RD; Santa Rita UWCD; Sterling County UWCD; Sutton County UWCD; Terrell County GCD; Uvalde County UWCD; Wes-Tex GCD

Requests for additional information and comments may be submitted to:
Meredith Allen
GMA # 7 Coordinator
Sutton County Underground Water Conservation District
301 S. Crockett Ave, Sonora, Texas 76950
Telephone: 325-226-9093 / Fax: 325-387-5737
e-mail: manager@suttoncountyuwcd.org

Appendix B

TWDB Pumping Estimates – Ellenburger-San Saba, Hickory, and Marble Falls Aquifers

Year	County	Aquifer	Municipal	Manufacturing	Mining	Irrigation	Livestock	Total
2000	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	1	1
2001	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	1	1
2002	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	1	1
2003	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	1	1
2004	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	1	1
2005	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	0	0
2006	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	0	0
2007	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	0	0
2008	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	0	0
2009	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	0	0
2010	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	0	0
2011	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	0	0
2012	COLEMAN	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	0	0
2000	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	3,388	6	0	406	29	3,829
2001	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	3,428	6	0	465	28	3,927
2002	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	3,324	6	0	465	27	3,822
2003	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	3,118	6	0	465	26	3,615
2004	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	3,103	6	0	492	66	3,667
2005	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	3,440	6	0	400	101	3,947
2006	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	2,950	6	0	438	101	3,495
2007	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	2,872	6	0	37	105	3,020
2008	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	2,936	6	0	407	115	3,464
2009	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	2,923	6	0	396	108	3,433
2010	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	2,923	6	0	264	187	3,380
2011	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	3,603	14	0	652	193	4,462
2012	GILLESPIE	ELLENBURGER-SAN SABA AQUIFER	3,568	14	0	402	91	4,075
2000	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	6	6
2001	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	6	6
2002	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	6	6
2003	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	5	5
2004	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	5	5
2005	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	5	5
2006	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	5	0	0	0	4	9
2007	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	5	0	0	0	5	10
2008	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	5	0	0	0	4	9
2009	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	5	0	0	0	4	9
2010	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	5	0	0	0	5	10
2011	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	6	0	0	0	5	11
2012	KIMBLE	ELLENBURGER-SAN SABA AQUIFER	6	0	0	0	3	9
2000	LLANO	ELLENBURGER-SAN SABA AQUIFER	129	0	0	0	51	180
2001	LLANO	ELLENBURGER-SAN SABA AQUIFER	160	0	0	0	51	211
2002	LLANO	ELLENBURGER-SAN SABA AQUIFER	258	0	0	0	51	309
2003	LLANO	ELLENBURGER-SAN SABA AQUIFER	266	0	0	0	49	315
2004	LLANO	ELLENBURGER-SAN SABA AQUIFER	264	0	0	0	42	306
2005	LLANO	ELLENBURGER-SAN SABA AQUIFER	275	0	0	0	21	296
2006	LLANO	ELLENBURGER-SAN SABA AQUIFER	484	0	0	0	20	504
2007	LLANO	ELLENBURGER-SAN SABA AQUIFER	473	0	0	0	22	495
2008	LLANO	ELLENBURGER-SAN SABA AQUIFER	661	0	0	0	21	682
2009	LLANO	ELLENBURGER-SAN SABA AQUIFER	486	0	0	0	24	510
2010	LLANO	ELLENBURGER-SAN SABA AQUIFER	191	0	0	0	21	212
2011	LLANO	ELLENBURGER-SAN SABA AQUIFER	128	0	0	0	21	149
2012	LLANO	ELLENBURGER-SAN SABA AQUIFER	173	0	0	0	17	190
2000	MASON	ELLENBURGER-SAN SABA AQUIFER	4	0	0	45	72	121
2001	MASON	ELLENBURGER-SAN SABA AQUIFER	4	0	0	42	82	128
2002	MASON	ELLENBURGER-SAN SABA AQUIFER	2	0	0	43	67	112

Year	County	Aquifer	Municipal	Manufacturing	Mining	Irrigation	Livestock	Total
2003	MASON	ELLENBURGER-SAN SABA AQUIFER	5	0	0	41	106	152
2004	MASON	ELLENBURGER-SAN SABA AQUIFER	0	0	0	42	38	80
2005	MASON	ELLENBURGER-SAN SABA AQUIFER	0	0	0	37	55	92
2006	MASON	ELLENBURGER-SAN SABA AQUIFER	8	0	0	30	69	107
2007	MASON	ELLENBURGER-SAN SABA AQUIFER	6	0	0	15	54	75
2008	MASON	ELLENBURGER-SAN SABA AQUIFER	7	0	0	24	54	85
2009	MASON	ELLENBURGER-SAN SABA AQUIFER	13	0	0	30	48	91
2010	MASON	ELLENBURGER-SAN SABA AQUIFER	19	0	0	17	31	67
2011	MASON	ELLENBURGER-SAN SABA AQUIFER	21	0	0	25	50	96
2012	MASON	ELLENBURGER-SAN SABA AQUIFER	20	0	0	23	45	88
2000	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	0	0	0	33	361	394
2001	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	0	0	0	24	261	285
2002	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	0	0	0	25	316	341
2003	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	0	0	0	42	241	283
2004	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	0	0	0	38	231	269
2005	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	0	0	0	38	253	291
2006	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	4	0	0	35	229	268
2007	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	4	0	0	22	239	265
2008	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	4	0	0	9	244	257
2009	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	15	0	0	40	265	320
2010	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	27	0	0	29	436	492
2011	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	29	0	0	29	232	290
2012	MCCULLOCH	ELLENBURGER-SAN SABA AQUIFER	25	0	0	25	196	246
2000	MENARD	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	4	4
2001	MENARD	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	5	5
2002	MENARD	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	4	4
2003	MENARD	ELLENBURGER-SAN SABA AQUIFER	1	0	0	0	5	6
2004	MENARD	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	4	4
2005	MENARD	ELLENBURGER-SAN SABA AQUIFER	1	0	0	0	4	5
2006	MENARD	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	4	4
2007	MENARD	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	4	4
2008	MENARD	ELLENBURGER-SAN SABA AQUIFER	0	0	0	0	4	4
2009	MENARD	ELLENBURGER-SAN SABA AQUIFER	1	0	0	0	4	5
2010	MENARD	ELLENBURGER-SAN SABA AQUIFER	2	0	0	0	3	5
2011	MENARD	ELLENBURGER-SAN SABA AQUIFER	2	0	0	0	3	5
2012	MENARD	ELLENBURGER-SAN SABA AQUIFER	2	0	0	0	3	5
2000	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	6	0	0	138	348	492
2001	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	5	0	0	106	321	432
2002	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	5	0	0	110	321	436
2003	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	5	0	0	226	317	548
2004	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	514	0	0	326	509	1,349
2005	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	5	0	0	320	241	566
2006	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	91	0	0	269	210	570
2007	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	75	0	0	430	291	796
2008	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	83	0	0	75	210	368
2009	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	104	0	0	938	210	1,252
2010	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	212	0	0	429	198	839
2011	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	220	0	0	914	198	1,332
2012	SAN SABA	ELLENBURGER-SAN SABA AQUIFER	207	0	0	1,080	170	1,457
2000	CONCHO	HICKORY AQUIFER	449	0	0	0	3	452
2001	CONCHO	HICKORY AQUIFER	385	0	0	0	3	388
2002	CONCHO	HICKORY AQUIFER	471	0	0	0	3	474
2003	CONCHO	HICKORY AQUIFER	447	0	0	0	2	449
2004	CONCHO	HICKORY AQUIFER	465	0	0	0	3	468
2005	CONCHO	HICKORY AQUIFER	594	0	0	0	2	596

Year	County	Aquifer	Municipal	Manufacturing	Mining	Irrigation	Livestock	Total
2006	CONCHO	HICKORY AQUIFER	447	0	0	0	2	449
2007	CONCHO	HICKORY AQUIFER	328	0	0	0	2	330
2008	CONCHO	HICKORY AQUIFER	371	0	0	0	2	373
2009	CONCHO	HICKORY AQUIFER	313	0	0	0	2	315
2010	CONCHO	HICKORY AQUIFER	313	0	0	0	2	315
2011	CONCHO	HICKORY AQUIFER	447	0	0	0	2	449
2012	CONCHO	HICKORY AQUIFER	337	0	0	0	1	338
2000	GILLESPIE	HICKORY AQUIFER	74	0	0	440	24	538
2001	GILLESPIE	HICKORY AQUIFER	67	0	0	503	23	593
2002	GILLESPIE	HICKORY AQUIFER	67	0	0	503	23	593
2003	GILLESPIE	HICKORY AQUIFER	63	0	0	503	21	587
2004	GILLESPIE	HICKORY AQUIFER	61	0	0	533	29	623
2005	GILLESPIE	HICKORY AQUIFER	66	0	0	434	44	544
2006	GILLESPIE	HICKORY AQUIFER	178	0	0	474	44	696
2007	GILLESPIE	HICKORY AQUIFER	155	0	0	40	46	241
2008	GILLESPIE	HICKORY AQUIFER	168	0	0	441	50	659
2009	GILLESPIE	HICKORY AQUIFER	168	0	0	429	47	644
2010	GILLESPIE	HICKORY AQUIFER	169	0	0	286	81	536
2011	GILLESPIE	HICKORY AQUIFER	183	0	0	707	84	974
2012	GILLESPIE	HICKORY AQUIFER	177	0	0	435	39	651
2000	KIMBLE	HICKORY AQUIFER	0	0	0	3	0	3
2001	KIMBLE	HICKORY AQUIFER	0	0	0	4	0	4
2002	KIMBLE	HICKORY AQUIFER	0	0	0	4	0	4
2003	KIMBLE	HICKORY AQUIFER	0	0	0	4	0	4
2004	KIMBLE	HICKORY AQUIFER	0	0	0	6	0	6
2005	KIMBLE	HICKORY AQUIFER	0	0	0	12	0	12
2006	KIMBLE	HICKORY AQUIFER	2	0	0	2	0	4
2007	KIMBLE	HICKORY AQUIFER	2	0	0	33	0	35
2008	KIMBLE	HICKORY AQUIFER	2	0	0	13	0	15
2009	KIMBLE	HICKORY AQUIFER	2	0	0	55	0	57
2010	KIMBLE	HICKORY AQUIFER	2	0	0	38	0	40
2011	KIMBLE	HICKORY AQUIFER	2	0	0	22	0	24
2012	KIMBLE	HICKORY AQUIFER	2	0	0	28	0	30
2000	LLANO	HICKORY AQUIFER	16	2	0	739	51	808
2001	LLANO	HICKORY AQUIFER	13	2	0	634	51	700
2002	LLANO	HICKORY AQUIFER	18	2	0	865	51	936
2003	LLANO	HICKORY AQUIFER	19	2	0	636	49	706
2004	LLANO	HICKORY AQUIFER	18	3	0	672	363	1,056
2005	LLANO	HICKORY AQUIFER	15	3	0	437	186	641
2006	LLANO	HICKORY AQUIFER	143	3	0	668	176	990
2007	LLANO	HICKORY AQUIFER	119	3	0	318	191	631
2008	LLANO	HICKORY AQUIFER	133	3	0	73	180	389
2009	LLANO	HICKORY AQUIFER	143	3	0	0	209	355
2010	LLANO	HICKORY AQUIFER	160	3	0	17	180	360
2011	LLANO	HICKORY AQUIFER	143	3	0	400	179	725
2012	LLANO	HICKORY AQUIFER	137	3	0	740	145	1,025
2000	MASON	HICKORY AQUIFER	803	0	0	9,910	141	10,854
2001	MASON	HICKORY AQUIFER	739	0	0	9,208	160	10,107
2002	MASON	HICKORY AQUIFER	807	0	0	9,564	132	10,503
2003	MASON	HICKORY AQUIFER	645	0	0	8,992	208	9,845
2004	MASON	HICKORY AQUIFER	484	0	0	9,269	385	10,138
2005	MASON	HICKORY AQUIFER	609	0	0	8,119	555	9,283
2006	MASON	HICKORY AQUIFER	801	0	0	6,568	687	8,056
2007	MASON	HICKORY AQUIFER	563	0	0	3,210	545	4,318
2008	MASON	HICKORY AQUIFER	725	0	0	5,278	542	6,545

Year	County	Aquifer	Municipal	Manufacturing	Mining	Irrigation	Livestock	Total
2009	MASON	HICKORY AQUIFER	772	0	0	6,519	477	7,768
2010	MASON	HICKORY AQUIFER	755	0	0	3,735	313	4,803
2011	MASON	HICKORY AQUIFER	887	0	0	5,471	499	6,857
2012	MASON	HICKORY AQUIFER	713	0	313	5,044	446	6,516
2000	MCCULLOCH	HICKORY AQUIFER	2,921	0	637	2,723	249	6,530
2001	MCCULLOCH	HICKORY AQUIFER	2,366	0	670	1,990	181	5,207
2002	MCCULLOCH	HICKORY AQUIFER	2,267	33	490	2,029	219	5,038
2003	MCCULLOCH	HICKORY AQUIFER	2,421	36	705	3,383	166	6,711
2004	MCCULLOCH	HICKORY AQUIFER	2,407	38	734	3,074	201	6,454
2005	MCCULLOCH	HICKORY AQUIFER	2,668	33	743	3,074	221	6,739
2006	MCCULLOCH	HICKORY AQUIFER	2,907	33	2,417	2,872	199	8,428
2007	MCCULLOCH	HICKORY AQUIFER	2,752	25	2,268	1,751	208	7,004
2008	MCCULLOCH	HICKORY AQUIFER	1,763	0	2,268	750	213	4,994
2009	MCCULLOCH	HICKORY AQUIFER	1,477	0	791	3,280	231	5,779
2010	MCCULLOCH	HICKORY AQUIFER	1,365	0	2,414	2,370	380	6,529
2011	MCCULLOCH	HICKORY AQUIFER	2,147	0	2,788	2,384	202	7,521
2012	MCCULLOCH	HICKORY AQUIFER	1,876	0	3,058	2,013	170	7,117
2000	MENARD	HICKORY AQUIFER	0	0	0	74	0	74
2001	MENARD	HICKORY AQUIFER	0	0	0	84	0	84
2002	MENARD	HICKORY AQUIFER	0	0	0	84	0	84
2003	MENARD	HICKORY AQUIFER	0	0	0	37	0	37
2004	MENARD	HICKORY AQUIFER	0	0	0	28	0	28
2005	MENARD	HICKORY AQUIFER	0	0	0	43	0	43
2006	MENARD	HICKORY AQUIFER	0	0	0	312	0	312
2007	MENARD	HICKORY AQUIFER	0	0	0	212	0	212
2008	MENARD	HICKORY AQUIFER	0	0	0	0	0	0
2009	MENARD	HICKORY AQUIFER	0	0	0	162	0	162
2010	MENARD	HICKORY AQUIFER	0	0	0	171	0	171
2011	MENARD	HICKORY AQUIFER	0	0	0	66	0	66
2012	MENARD	HICKORY AQUIFER	0	0	0	201	0	201
2000	SAN SABA	HICKORY AQUIFER	134	0	0	308	294	736
2001	SAN SABA	HICKORY AQUIFER	141	0	0	237	270	648
2002	SAN SABA	HICKORY AQUIFER	109	0	0	247	271	627
2003	SAN SABA	HICKORY AQUIFER	137	0	0	504	267	908
2004	SAN SABA	HICKORY AQUIFER	4,958	0	0	734	284	5,976
2005	SAN SABA	HICKORY AQUIFER	143	0	0	721	135	999
2006	SAN SABA	HICKORY AQUIFER	135	0	0	604	117	856
2007	SAN SABA	HICKORY AQUIFER	231	0	0	967	163	1,361
2008	SAN SABA	HICKORY AQUIFER	120	0	0	168	117	405
2009	SAN SABA	HICKORY AQUIFER	125	0	0	2,111	117	2,353
2010	SAN SABA	HICKORY AQUIFER	156	0	0	966	111	1,233
2011	SAN SABA	HICKORY AQUIFER	165	0	0	2,057	111	2,333
2012	SAN SABA	HICKORY AQUIFER	145	0	0	2,430	95	2,670
2006	GILLESPIE	MARBLE FALLS AQUIFER	10	0	0	0	0	10
2007	GILLESPIE	MARBLE FALLS AQUIFER	8	0	0	0	0	8
2008	GILLESPIE	MARBLE FALLS AQUIFER	9	0	0	0	0	9
2009	GILLESPIE	MARBLE FALLS AQUIFER	9	0	0	0	0	9
2010	GILLESPIE	MARBLE FALLS AQUIFER	9	0	0	0	0	9
2011	GILLESPIE	MARBLE FALLS AQUIFER	10	0	0	0	0	10
2012	GILLESPIE	MARBLE FALLS AQUIFER	10	0	0	0	0	10
2000	MASON	MARBLE FALLS AQUIFER	4	0	0	0	69	73
2001	MASON	MARBLE FALLS AQUIFER	4	0	0	0	78	82
2002	MASON	MARBLE FALLS AQUIFER	2	0	0	0	65	67
2003	MASON	MARBLE FALLS AQUIFER	5	0	0	0	102	107
2000	MCCULLOCH	MARBLE FALLS AQUIFER	0	0	0	33	15	48

Year	County	Aquifer	Municipal	Manufacturing	Mining	Irrigation	Livestock	Total
2001	MCCULLOCH	MARBLE FALLS AQUIFER	0	0	0	24	11	35
2002	MCCULLOCH	MARBLE FALLS AQUIFER	0	0	0	25	14	39
2003	MCCULLOCH	MARBLE FALLS AQUIFER	0	0	0	42	10	52
2004	MCCULLOCH	MARBLE FALLS AQUIFER	0	0	0	38	7	45
2005	MCCULLOCH	MARBLE FALLS AQUIFER	0	0	0	38	7	45
2006	MCCULLOCH	MARBLE FALLS AQUIFER	1	0	0	35	7	43
2007	MCCULLOCH	MARBLE FALLS AQUIFER	1	0	0	22	7	30
2008	MCCULLOCH	MARBLE FALLS AQUIFER	1	0	0	9	7	17
2009	MCCULLOCH	MARBLE FALLS AQUIFER	3	0	0	40	8	51
2010	MCCULLOCH	MARBLE FALLS AQUIFER	5	0	0	29	12	46
2011	MCCULLOCH	MARBLE FALLS AQUIFER	6	0	0	29	7	42
2012	MCCULLOCH	MARBLE FALLS AQUIFER	5	0	0	25	6	36
2000	SAN SABA	MARBLE FALLS AQUIFER	1,192	0	24	7	235	1,458
2001	SAN SABA	MARBLE FALLS AQUIFER	1,176	0	24	5	215	1,420
2002	SAN SABA	MARBLE FALLS AQUIFER	1,074	0	24	6	215	1,319
2003	SAN SABA	MARBLE FALLS AQUIFER	1,034	0	7	11	213	1,265
2004	SAN SABA	MARBLE FALLS AQUIFER	421	0	7	0	24	452
2005	SAN SABA	MARBLE FALLS AQUIFER	1,065	0	2	0	11	1,078
2006	SAN SABA	MARBLE FALLS AQUIFER	1,070	0	0	0	10	1,080
2007	SAN SABA	MARBLE FALLS AQUIFER	841	0	0	0	14	855
2008	SAN SABA	MARBLE FALLS AQUIFER	1,082	0	8	0	10	1,100
2009	SAN SABA	MARBLE FALLS AQUIFER	1,061	0	5	0	10	1,076
2010	SAN SABA	MARBLE FALLS AQUIFER	25	0	5	0	9	39
2011	SAN SABA	MARBLE FALLS AQUIFER	68	0	4	0	9	81
2012	SAN SABA	MARBLE FALLS AQUIFER	375	8	0	0	8	391

Appendix C

Region F Socioeconomic Impact Reports from TWDB

Socioeconomic Impacts of Projected Water Shortages

for the Region F Regional Water Planning Area

Prepared in Support of the 2021 Region F Regional Water Plan

Texas Water
Development Board

Dr. John R. Ellis
Water Use, Projections, & Planning Division
Texas Water Development Board

November 2021

Table of Contents

Executive Summary

Evaluating the social and economic impacts of not meeting identified water needs is a required analysis in the regional water planning process. The Texas Water Development Board (TWDB) estimates these impacts for regional water planning groups (RWPGs) and summarizes the impacts in the state water plan. The analysis presented is for the Region F Regional Water Planning Group (Region F).

Based on projected water demands and existing water supplies, Region F identified water needs (potential shortages) that could occur within its region under a repeat of the drought of record for six water use categories (irrigation, livestock, manufacturing, mining, municipal and steam-electric power). The TWDB then estimated the annual socioeconomic impacts of those needs—if they are not met—for each water use category and as an aggregate for the region.

This analysis was performed using an economic impact modeling software package, IMPLAN (Impact for Planning Analysis), as well as other economic analysis techniques, and 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. 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 (i.e., summing up expected impacts from today up to the decade noted), but are simply snapshots of the estimated annual socioeconomic impacts should a drought of record occur in each particular decade based on anticipated water supplies and demands for that same decade.

For regional economic impacts, income losses and job losses are estimated within each planning decade (2020 through 2070). The income losses represent an approximation of gross domestic product (GDP) that would be foregone if water needs are not met.

The analysis also provides estimates of financial transfer impacts, which include tax losses (state, local, and utility tax collections); water trucking costs; and utility revenue losses. In addition, social impacts are estimated, encompassing lost consumer surplus (a welfare economics measure of consumer wellbeing); as well as population and school enrollment losses.

IMPLAN data reported that Region F generated more than $50 billion in gross domestic product (GDP) (2018 dollars) and supported more than 424,000 jobs in 2016. The Region F estimated total population was approximately 686,000 in 2016.

It is estimated that not meeting the identified water needs in Region F would result in an annually combined lost income impact of approximately $19.6 billion in 2020 and $6.4 billion in 2070 (Table ES-1). It is also estimated that the region would lose approximately 98,000 jobs in 2020 and 39,000 in 2070.

All impact estimates are in year 2018 dollars and were calculated using a variety of data sources and tools including the use of a region-specific IMPLAN model, data from TWDB annual water use

estimates, the U.S. Census Bureau, Texas Agricultural Statistics Service, and the Texas Municipal League.

Table ES-1 Region F socioeconomic impact summary

Regional Economic Impacts	2020	2030	2040	2050	2060	2070
Income losses ($ millions)*	$19,624	$19,720	$17,058	$13,443	$7,750	$6,356
Job losses	98,208	100,186	88,685	71,444	43,995	38,833
Financial Transfer Impacts	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Tax losses on production and imports ($ millions)*	$2,644	$2,647	$2,266	$1,749	$937	$725
Water trucking costs ($ millions)*	$29	$29	$29	$30	$31	$32
Utility revenue losses ($ millions)*	$56	$82	$111	$139	$172	$207
Utility tax revenue losses ($ millions)*	$1	$1	$2	$3	$3	$4
Social Impacts	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Consumer surplus losses ($ millions)*	$87	$93	$149	$183	$227	$286
Population losses	18,031	18,394	16,283	13,117	8,078	7,130
School enrollment losses	3,449	3,518	3,115	2,509	1,545	1,364

* Year 2018 dollars, rounded. Entries denoted by a dash (-) indicate no estimated economic impact. Entries denoted by a zero ($0) indicate estimated income losses less than $500,000.

1 Introduction

Water shortages during a repeat of the drought of record would likely curtail or eliminate certain economic activity in businesses and industries that rely heavily on water. Insufficient water supplies could not only have an immediate and real impact on the regional economy in the short term, but they could also adversely and chronically affect economic development in Texas. From a social perspective, water supply reliability is critical as well. Shortages could disrupt activity in homes, schools and government, and could adversely affect public health and safety. For these reasons, it is important to evaluate and understand how water supply shortages during drought could impact communities throughout the state.

As part of the regional water planning process, RWPGs must evaluate the social and economic impacts of not meeting water needs (31 Texas Administrative Code §357.33 (c)). Due to the complexity of the analysis and limited resources of the planning groups, the TWDB has historically performed this analysis for the RWPGs upon their request. Staff of the TWDB's Water Use, Projections, & Planning Division designed and conducted this analysis in support of Region F, and those efforts for this region as well as the other 15 regions allow consistency and a degree of comparability in the approach.

This document summarizes the results of the analysis and discusses the methodology used to generate the results. Section 1 provides a snapshot of the region's economy and summarizes the identified water needs in each water use category, which were calculated based on the RWPG's water supply and demand established during the regional water planning process. Section 2 defines each of ten impact assessment measures used in this analysis. Section 3 describes the methodology for the impact assessment and the approaches and assumptions specific to each water use category (i.e., irrigation, livestock, manufacturing, mining, municipal, and steam-electric power). Section 4 presents the impact estimates for each water use category with results summarized for the region as a whole. Appendix A presents a further breakdown of the socioeconomic impacts by county.

1.1 Regional Economic Summary

The Region F Regional Water Planning Area generated more than $50 billion in GDP (2018 dollars) and supported roughly 424,000 jobs in 2016, according to the IMPLAN dataset utilized in this socioeconomic analysis. This activity accounted for 3 percent of the state's total GDP of 1.73 trillion dollars for the year based on IMPLAN. Table 1-1 lists all economic sectors ranked by the total value-added to the economy in Region F. The mining sector (including oil and gas extraction) generated close to 40 percent of the region's total value-added and was also a significant source of tax revenue. The top employers in the region were in the mining, public administration, and retail trade sectors. Region F's estimated total population was roughly 686,000 in 2016, approximately 2.5 percent of the state's total.

This represents a snapshot of the regional economy as a whole, and it is important to note that not all economic sectors were included in the TWDB socioeconomic impact analysis. Data considerations prompted use of only the more water-intensive sectors within the economy because
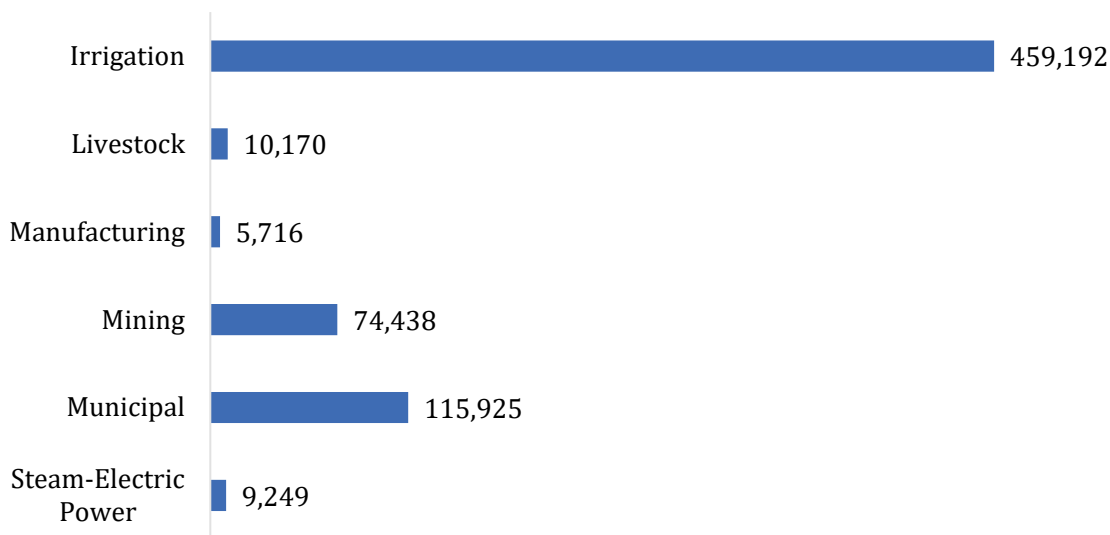
damage estimates could only be calculated for those economic sectors which had both reliable income and water use estimates.

Table 1-1 Region F regional economy by economic sector*

Economic sector	Value-added ($ millions)	Tax ($ millions)	Jobs
Mining, Quarrying, and Oil and Gas Extraction	$19,711.6	$2,458.8	67,722
Public Administration	$4,274.8	$(23.0)	53,420
Real Estate and Rental and Leasing	$3,831.9	$556.6	14,285
Wholesale Trade	$3,199.8	$496.7	16,901
Manufacturing	$3,091.3	$95.4	18,614
Construction	$2,650.8	$33.3	30,015
Retail Trade	$2,203.5	$542.9	39,778
Health Care and Social Assistance	$1,743.9	$25.6	30,056
Finance and Insurance	$1,513.5	$66.2	16,366
Utilities	$1,350.0	$174.2	2,089
Accommodation and Food Services	$1,346.2	$196.9	32,131
Professional, Scientific, and Technical Services	$1,256.2	$37.8	18,165
Other Services (except Public Administration)	$1,229.4	$124.4	21,836
Transportation and Warehousing	$1,011.8	$97.2	15,793
Administrative and Support and Waste Management and Remediation Services	$719.3	$26.4	14,728
Information	$695.5	$208.0	3,546
Agriculture, Forestry, Fishing and Hunting	$412.7	$15.9	16,847
Management of Companies and Enterprises	$394.9	$9.5	3,372
Arts, Entertainment, and Recreation	$187.6	$33.8	5,317
Educational Services	$92.6	$5.4	3,175
Grand Total	**$50,917.2**	**$5,182.1**	**424,156**

*Source: 2016 IMPLAN for 536 sectors aggregated by 2-digit NAICS (North American Industry Classification System)

While the mining sector led the region in economic output, the majority (68 percent) of water use in 2016 occurred in irrigated agriculture. Notably, more than 44 percent of the state's mining water use occurred within Region F. Figure 1-1 illustrates Region F's breakdown of the 2016 water use estimates by TWDB water use category.

Figure 1-1 Region F 2016 water use estimates by water use category (in acre-feet)

Category	Value
Irrigation	459,192
Livestock	10,170
Manufacturing	5,716
Mining	74,438
Municipal	115,925
Steam-Electric Power	9,249

Source: TWDB Annual Water Use Estimates (all values in acre-feet)

1.2 Identified Regional Water Needs (Potential Shortages)

As part of the regional water planning process, the TWDB adopted water demand projections for water user groups (WUG) in Region F with input from the planning group. WUG-level demand projections were established for utilities that provide more than 100 acre-feet of annual water supply, combined rural areas (designated as county-other), and county-wide water demand projections for five non-municipal categories (irrigation, livestock, manufacturing, mining and steam-electric power). The RWPG then compared demands to the existing water supplies of each WUG to determine potential shortages, or needs, by decade.

Table 1-2 summarizes the region's identified water needs in the event of a repeat of the drought of record. Demand management, such as conservation, or the development of new infrastructure to increase supplies, are water management strategies that may be recommended by the planning group to address those needs. This analysis assumes that no strategies are implemented, and that the identified needs correspond to future water shortages. Note that projected water needs generally increase over time, primarily due to anticipated population growth, economic growth, or declining supplies. To provide a general sense of proportion, total projected needs as an overall percentage of total demand by water use category are also presented in aggregate in Table 1-2. Projected needs for individual water user groups within the aggregate can vary greatly and may reach 100% for a given WUG and water use category. A detailed summary of water needs by WUG and county appears in Chapter 4 of the 2021 Region F Regional Water Plan.

Table 1-2 Regional water needs summary by water use category

Water Use Category		2020	2030	2040	2050	2060	2070
Irrigation	water needs (acre-feet per year)	13,528	17,957	18,618	19,676	22,157	24,740
	% of the category's total water demand	3%	4%	4%	4%	5%	5%
Livestock	water needs (acre-feet per year)	9	17	25	39	50	60
	% of the category's total water demand	0%	0%	0%	0%	0%	1%
Manufacturing	water needs (acre-feet per year)	1,137	1,226	1,269	1,461	1,664	1,851
	% of the category's total water demand	10%	10%	10%	12%	13%	15%
Mining	water needs (acre-feet per year)	23,009	22,916	19,702	15,080	7,993	5,880
	% of the category's total water demand	21%	21%	22%	23%	17%	17%
Municipal*	water needs (acre-feet per year)	16,030	24,159	33,381	42,081	52,530	63,829
	% of the category's total water demand	12%	16%	21%	25%	29%	34%
Steam-electric power	water needs (acre-feet per year)	12,746	12,793	12,850	12,945	13,042	13,129
	% of the category's total water demand	70%	71%	71%	72%	72%	73%
Total water needs (acre-feet per year)		**66,459**	**79,068**	**85,845**	**91,282**	**97,436**	**109,489**

* Municipal category consists of residential and non-residential (commercial and institutional) subcategories.

2   Impact Assessment Measures

A required component of the regional and state water plans is to estimate the potential economic and social impacts of potential water shortages during a repeat of the drought of record. Consistent with previous water plans, ten impact measures were estimated and are described in Table 2-1.

Table 2-1 Socioeconomic impact analysis measures

Regional economic impacts	Description
Income losses - value-added	The value of output less the value of intermediate consumption; it is a measure of the contribution to gross domestic product (GDP) made by an individual producer, industry, sector, or group of sectors within a year. Value-added measures used in this report have been adjusted to include the direct, indirect, and induced monetary impacts on the region.
Income losses - electrical power purchase costs	Proxy for income loss in the form of additional costs of power as a result of impacts of water shortages.
Job losses	Number of part-time and full-time jobs lost due to the shortage. These values have been adjusted to include the direct, indirect, and induced employment impacts on the region.
Financial transfer impacts	**Description**
Tax losses on production and imports	Sales and excise taxes not collected due to the shortage, in addition to customs duties, property taxes, motor vehicle licenses, severance taxes, other taxes, and special assessments less subsidies. These values have been adjusted to include the direct, indirect and induced tax impacts on the region.
Water trucking costs	Estimated cost of shipping potable water.
Utility revenue losses	Foregone utility income due to not selling as much water.
Utility tax revenue losses	Foregone miscellaneous gross receipts tax collections.
Social impacts	**Description**
Consumer surplus losses	A welfare measure of the lost value to consumers accompanying restricted water use.
Population losses	Population losses accompanying job losses.
School enrollment losses	School enrollment losses (K-12) accompanying job losses.

2.1 Regional Economic Impacts

The two key measures used to assess regional economic impacts are income losses and job losses. The income losses presented consist of the sum of value-added losses and the additional purchase costs of electrical power.

Income Losses - Value-added Losses

Value-added is the value of total output less the value of the intermediate inputs also used in the production of the final product. Value-added is similar to GDP, a familiar measure of the productivity of an economy. The loss of value-added due to water shortages is estimated by input-output analysis using the IMPLAN software package, and includes the direct, indirect, and induced monetary impacts on the region. The indirect and induced effects are measures of reduced income as well as reduced employee spending for those input sectors which provide resources to the water shortage impacted production sectors.

Income Losses - Electric Power Purchase Costs

The electrical power grid and market within the state is a complex interconnected system. The industry response to water shortages, and the resulting impact on the region, are not easily modeled using traditional input/output impact analysis and the IMPLAN model. Adverse impacts on the region will occur and are represented in this analysis by estimated additional costs associated with power purchases from other generating plants within the region or state. Consequently, the analysis employs additional power purchase costs as a proxy for the value-added impacts for the steam-electric power water use category, and these are included as a portion of the overall income impact for completeness.

For the purpose of this analysis, it is assumed that power companies with insufficient water will be forced to purchase power on the electrical market at a projected higher rate of 5.60 cents per kilowatt hour. This rate is based upon the average day-ahead market purchase price of electricity in Texas that occurred during the recent drought period in 2011. This price is assumed to be comparable to those prices which would prevail in the event of another drought of record.

Job Losses

The number of jobs lost due to the economic impact is estimated using IMPLAN output associated with each TWDB water use category. Because of the difficulty in predicting outcomes and a lack of relevant data, job loss estimates are not calculated for the steam-electric power category.

2.2 Financial Transfer Impacts

Several impact measures evaluated in this analysis are presented to provide additional detail concerning potential impacts on a portion of the economy or government. These financial transfer impact measures include lost tax collections (on production and imports), trucking costs for imported water, declines in utility revenues, and declines in utility tax revenue collected by the

state. These measures are not solely adverse, with some having both positive and negative impacts. For example, cities and residents would suffer if forced to pay large costs for trucking in potable water. Trucking firms, conversely, would benefit from the transaction. Additional detail for each of these measures follows.

Tax Losses on Production and Imports

Reduced production of goods and services accompanying water shortages adversely impacts the collection of taxes by state and local government. The regional IMPLAN model is used to estimate reduced tax collections associated with the reduced output in the economy. Impact estimates for this measure include the direct, indirect, and induced impacts for the affected sectors.

Water Trucking Costs

In instances where water shortages for a municipal water user group are estimated by RWPGs to exceed 80 percent of water demands, it is assumed that water would need to be trucked in to support basic consumption and sanitation needs. For water shortages of 80 percent or greater, a fixed, maximum of $35,000[1] per acre-foot of water applied as an economic cost. This water trucking cost was utilized for both the residential and non-residential portions of municipal water needs.

Utility Revenue Losses

Lost utility income is calculated as the price of water service multiplied by the quantity of water not sold during a drought shortage. Such estimates are obtained from utility-specific pricing data provided by the Texas Municipal League, where available, for both water and wastewater. These water rates are applied to the potential water shortage to estimate forgone utility revenue as water providers sold less water during the drought due to restricted supplies.

Utility Tax Losses

Foregone utility tax losses include estimates of forgone miscellaneous gross receipts taxes. Reduced water sales reduce the amount of utility tax that would be collected by the State of Texas for water and wastewater service sales.

2.3   Social Impacts

Consumer Surplus Losses for Municipal Water Users

Consumer surplus loss is a measure of impact to the wellbeing of municipal water users when their water use is restricted. Consumer surplus is the difference between how much a consumer is willing and able to pay for a commodity (i.e., water) and how much they actually have to pay. The

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[1] Based on staff survey of water hauling firms and historical data concerning transport costs for potable water in the recent drought in California for this estimate. There are many factors and variables that would determine actual water trucking costs including distance to, cost of water, and length of that drought.

difference is a benefit to the consumer's wellbeing since they do not have to pay as much for the commodity as they would be willing to pay. Consumer surplus may also be viewed as an estimate of how much consumers would be willing to pay to keep the original quantity of water which they used prior to the drought. Lost consumer surplus estimates within this analysis only apply to the residential portion of municipal demand, with estimates being made for reduced outdoor and indoor residential use. Lost consumer surplus estimates varied widely by location and degree of water shortage.

Population and School Enrollment Losses

Population loss due to water shortages, as well as the associated decline in school enrollment, are based upon the job loss estimates discussed in Section 2.1. A simplified ratio of job and net population losses are calculated for the state as a whole based on a recent study of how job layoffs impact the labor market population.[2] For every 100 jobs lost, 18 people were assumed to move out of the area. School enrollment losses are estimated as a proportion of the population lost based upon public school enrollment data from the Texas Education Agency concerning the age K-12 population within the state (approximately 19%).

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[2] Foote, Andrew, Grosz, Michel, Stevens, Ann. "Locate Your Nearest Exit: Mass Layoffs and Local Labor Market Response." University of California, Davis. April 2015, http://paa2015.princeton.edu/papers/150194. The study utilized Bureau of Labor Statistics data regarding layoffs between 1996 and 2013, as well as Internal Revenue Service data regarding migration, to model the change in the population as the result of a job layoff event. The study found that layoffs impact both out-migration and in-migration into a region, and that a majority of those who did move following a layoff moved to another labor market rather than an adjacent county.

3   Socioeconomic Impact Assessment Methodology

This portion of the report provides a summary of the methodology used to estimate the potential economic impacts of future water shortages. The general approach employed in the analysis was to obtain estimates for income and job losses on the smallest geographic level that the available data would support, tie those values to their accompanying historic water use estimate, and thereby determine a maximum impact per acre-foot of shortage for each of the socioeconomic measures. The calculations of economic impacts are based on the overall composition of the economy divided into many underlying economic sectors. Sectors in this analysis refer to one or more of the 536 specific production sectors of the economy designated within IMPLAN, the economic impact modeling software used for this assessment. Economic impacts within this report are estimated for approximately 330 of these sectors, with the focus on the more water-intensive production sectors. The economic impacts for a single water use category consist of an aggregation of impacts to multiple, related IMPLAN economic sectors.

3.1   Analysis Context

The context of this socioeconomic impact analysis involves situations where there are physical shortages of groundwater or surface water due to a recurrence of drought of record conditions. Anticipated shortages for specific water users may be nonexistent in earlier decades of the planning horizon, yet population growth or greater industrial, agricultural or other sector demands in later decades may result in greater overall demand, exceeding the existing supplies. Estimated socioeconomic impacts measure what would happen if water user groups experience water shortages for a period of one year. Actual socioeconomic impacts would likely become larger as drought of record conditions persist for periods greater than a single year.

3.2   IMPLAN Model and Data

Input-Output analysis using the IMPLAN software package was the primary means of estimating the value-added, jobs, and tax related impact measures. This analysis employed regional level models to determine key economic impacts. IMPLAN is an economic impact model, originally developed by the U.S. Forestry Service in the 1970's to model economic activity at varying geographic levels. The model is currently maintained by the Minnesota IMPLAN Group (MIG Inc.) which collects and sells county and state specific data and software. The year 2016 version of IMPLAN, employing data for all 254 Texas counties, was used to provide estimates of value-added, jobs, and taxes on production for the economic sectors associated with the water user groups examined in the study. IMPLAN uses 536 sector-specific Industry Codes, and those that rely on water as a primary input were assigned to their appropriate planning water user categories (irrigation, livestock, manufacturing, mining, and municipal). Estimates of value-added for a water use category were obtained by summing value-added estimates across the relevant IMPLAN sectors associated with that water use category. These calculations were also performed for job losses as well as tax losses on production and imports.

The adjusted value-added estimates used as an income measure in this analysis, as well as the job and tax estimates from IMPLAN, include three components:

- **_Direct effects_** representing the initial change in the industry analyzed;
- **_Indirect effects_** that are changes in inter-industry transactions as supplying industries respond to reduced demands from the directly affected industries; and,
- **_Induced effects_** that reflect changes in local spending that result from reduced household income among employees in the directly and indirectly affected industry sectors.

Input-output models such as IMPLAN only capture backward linkages and do not include forward linkages in the economy.

3.3 Elasticity of Economic Impacts

The economic impact of a water need is based on the size of the water need relative to the total water demand for each water user group. Smaller water shortages, for example, less than 5 percent, are generally anticipated to result in no initial negative economic impact because water users are assumed to have a certain amount of flexibility in dealing with small shortages. As a water shortage intensifies, however, such flexibility lessens and results in actual and increasing economic losses, eventually reaching a representative maximum impact estimate per unit volume of water. To account for these characteristics, an elasticity adjustment function is used to estimate impacts for the income, tax and job loss measures. Figure 3-1 illustrates this general relationship for the adjustment functions. Negative impacts are assumed to begin accruing when the shortage reaches the lower bound 'b1' (5 percent in Figure 3-1), with impacts then increasing linearly up to the 100 percent impact level (per unit volume) once the upper bound reaches the 'b2' level shortage (40 percent in Figure 3-1).

To illustrate this, if the total annual value-added for manufacturing in the region was $2 million and the reported annual volume of water used in that industry is 10,000 acre-feet, the estimated economic measure of the water shortage would be $200 per acre-foot. The economic impact of the shortage would then be estimated using this value-added amount as the maximum impact estimate ($200 per acre-foot) applied to the anticipated shortage volume and then adjusted by the elasticity function. Using the sample elasticity function shown in Figure 3-1, an approximately 22 percent shortage in the livestock category would indicate an economic impact estimate of 50% of the original $200 per acre-foot impact value (i.e., $100 per acre-foot).

Such adjustments are not required in estimating consumer surplus, utility revenue losses, or utility tax losses. Estimates of lost consumer surplus rely on utility-specific demand curves with the lost consumer surplus estimate calculated based on the relative percentage of the utility's water shortage. Estimated changes in population and school enrollment are indirectly related to the elasticity of job losses.

Assumed values for the lower and upper bounds 'b1' and 'b2' vary by water use category and are presented in Table 3-1.

Figure 3-1 Example economic impact elasticity function (as applied to a single water user's shortage)
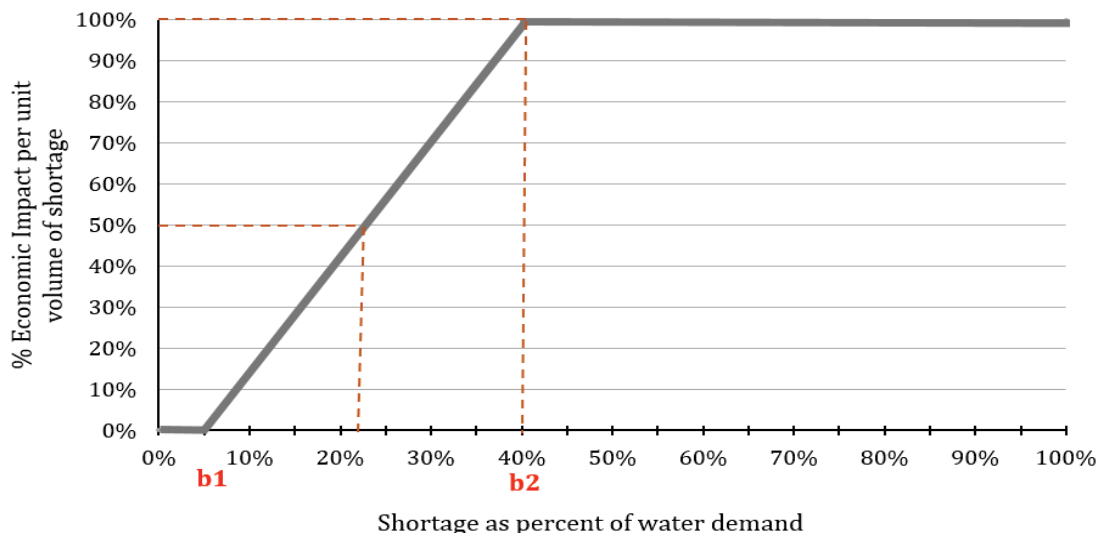
Table 3-1 Economic impact elasticity function lower and upper bounds

Water use category	Lower bound (b1)	Upper bound (b2)
Irrigation	5%	40%
Livestock	5%	10%
Manufacturing	5%	40%
Mining	5%	40%
Municipal (non-residential water intensive subcategory)	5%	40%
Steam-electric power	N/A	N/A

3.4 Analysis Assumptions and Limitations

The modeling of complex systems requires making many assumptions and acknowledging the model's uncertainty and limitations. This is particularly true when attempting to estimate a wide range of socioeconomic impacts over a large geographic area and into future decades. Some of the key assumptions and limitations of this methodology include:

1. The foundation for estimating the socioeconomic impacts of water shortages resulting from a drought are the water needs (potential shortages) that were identified by RWPGs as part of the

regional water planning process. These needs have some uncertainty associated with them but serve as a reasonable basis for evaluating the potential impacts of a drought of record event.

2. All estimated socioeconomic impacts are snapshots for years in which water needs were identified (i.e., 2020, 2030, 2040, 2050, 2060, and 2070). The estimates are independent and distinct "what if" scenarios for each particular year, and water shortages are assumed to be temporary events resulting from a single year recurrence of drought of record conditions. The evaluation assumed that no recommended water management strategies are implemented. In other words, growth occurs and future shocks are imposed on an economy at 10-year intervals, and the resulting impacts are estimated. Note that the estimates presented are not cumulative (i.e., summing up expected impacts from today up to the decade noted), but are simply snapshots of the estimated annual socioeconomic impacts should a drought of record occur in each particular decade based on anticipated water supplies and demands for that same decade.

3. Input-output models such as IMPLAN rely on a static profile of the structure of the economy as it appears today. This presumes that the relative contributions of all sectors of the economy would remain the same, regardless of changes in technology, availability of limited resources, and other structural changes to the economy that may occur in the future. Changes in water use efficiency will undoubtedly take place in the future as supplies become more stressed. Use of the static IMPLAN structure was a significant assumption and simplification considering the 50-year time period examined in this analysis. To presume an alternative future economic makeup, however, would entail positing many other major assumptions that would very likely generate as much or more error.

4. This is not a form of cost-benefit analysis. That approach to evaluating the economic feasibility of a specific policy or project employs discounting future benefits and costs to their present value dollars using some assumed discount rate. The methodology employed in this effort to estimate the economic impacts of future water shortages did not use any discounting methods to weigh future costs differently through time.

5. All monetary values originally based upon year 2016 IMPLAN and other sources are reported in constant year 2018 dollars to be consistent with the water management strategy requirements in the State Water Plan.

6. IMPLAN based loss estimates (income-value-added, jobs, and taxes on production and imports) are calculated only for those IMPLAN sectors for which the TWDB's Water Use Survey (WUS) data was available and deemed reliable. Every effort is made in the annual WUS effort to capture all relevant firms who are significant water users. Lack of response to the WUS, or omission of relevant firms, impacts the loss estimates.

7. Impacts are annual estimates. The socioeconomic analysis does not reflect the full extent of impacts that might occur as a result of persistent water shortages occurring over an extended duration. The drought of record in most regions of Texas lasted several years.

8. Value-added estimates are the primary estimate of the economic impacts within this report. One may be tempted to add consumer surplus impacts to obtain an estimate of total adverse economic impacts to the region, but the consumer surplus measure represents the change to the wellbeing of households (and other water users), not an actual change in the flow of dollars through the economy. The two measures (value-added and consumer surplus) are both valid impacts but ideally should not be summed.

9. The value-added, jobs, and taxes on production and import impacts include the direct, indirect and induced effects to capture backward linkages in the economy described in Section 2.1. Population and school enrollment losses also indirectly include such effects as they are based on the associated losses in employment. The remaining measures (consumer surplus, utility revenue, utility taxes, additional electrical power purchase costs, and potable water trucking costs), however, do not include any induced or indirect effects.

10. The majority of impacts estimated in this analysis may be more conservative (i.e., smaller) than those that might actually occur under drought of record conditions due to not including impacts in the forward linkages in the economy. Input-output models such as IMPLAN only capture backward linkages on suppliers (including households that supply labor to directly affected industries). While this is a common limitation in this type of economic modeling effort, it is important to note that forward linkages on the industries that use the outputs of the directly affected industries can also be very important. A good example is impacts on livestock operators. Livestock producers tend to suffer substantially during droughts, not because there is not enough water for their stock, but because reductions in available pasture and higher prices for purchased hay have significant economic effects on their operations. Food processors could be in a similar situation if they cannot get the grains or other inputs that they need. These effects are not captured in IMPLAN, resulting in conservative impact estimates.

11. The model does not reflect dynamic economic responses to water shortages as they might occur, nor does the model reflect economic impacts associated with a recovery from a drought of record including:
    a. The likely significant economic rebound to some industries immediately following a drought, such as landscaping;
    b. The cost and time to rebuild liquidated livestock herds (a major capital investment in that industry);
    c. Direct impacts on recreational sectors (i.e., stranded docks and reduced tourism); or,
    d. Impacts of negative publicity on Texas' ability to attract population and business in the event that it was not able to provide adequate water supplies for the existing economy.

12. Estimates for job losses and the associated population and school enrollment changes may exceed what would actually occur. In practice, firms may be hesitant to lay off employees, even in difficult economic times. Estimates of population and school enrollment changes are based on regional evaluations and therefore do not necessarily reflect what might occur on a statewide basis.

13. **The results must be interpreted carefully. It is the general and relative magnitudes of impacts as well as the changes of these impacts over time that should be the focus rather than the absolute numbers.** Analyses of this type are much better at predicting relative percent differences brought about by a shock to a complex system (i.e., a water shortage) than the precise size of an impact. To illustrate, assuming that the estimated economic impacts of a drought of record on the manufacturing and mining water user categories are $2 and $1 million, respectively, one should be more confident that the economic impacts on manufacturing are twice as large as those on mining and that these impacts will likely be in the millions of dollars. But one should have less confidence that the actual total economic impact experienced would be $3 million.

14. The methodology does not capture "spillover" effects between regions – or the secondary impacts that occur outside of the region where the water shortage is projected to occur.

15. The methodology that the TWDB has developed for estimating the economic impacts of unmet water needs, and the assumptions and models used in the analysis, are specifically designed to estimate potential economic effects at the regional and county levels. Although it may be tempting to add the regional impacts together in an effort to produce a statewide result, the TWDB cautions against that approach for a number of reasons. The IMPLAN modeling (and corresponding economic multipliers) are all derived from regional models – a statewide model of Texas would produce somewhat different multipliers. As noted in point 14 within this section, the regional modeling used by TWDB does not capture spillover losses that could result in other regions from unmet needs in the region analyzed, or potential spillover gains if decreased production in one region leads to increases in production elsewhere. The assumed drought of record may also not occur in every region of Texas at the same time, or to the same degree.

4   Analysis Results

This section presents estimates of potential economic impacts that could reasonably be expected in the event of water shortages associated with a drought of record and if no recommended water management strategies were implemented. Projected economic impacts for the six water use categories (irrigation, livestock, manufacturing, mining, municipal, and steam-electric power) are reported by decade.

4.1   Impacts for Irrigation Water Shortages

Nine of the 32 counties in the region are projected to experience water shortages in the irrigated agriculture water use category for one or more decades within the planning horizon. Estimated impacts to this water use category appear in Table 4-1. Note that tax collection impacts were not estimated for this water use category. IMPLAN data indicates a negative tax impact (i.e., increased tax collections) for the associated production sectors, primarily due to past subsidies from the federal government. However, it was not considered realistic to report increasing tax revenues during a drought of record.

Table 4-1 Impacts of water shortages on irrigation in Region F

Impact measure	2020	2030	2040	2050	2060	2070
Income losses ($ millions)*	$4	$6	$6	$7	$8	$8
Job losses	98	137	148	170	187	200

* Year 2018 dollars, rounded. Entries denoted by a dash (-) indicate no estimated economic impact. Entries denoted by a zero ($0) indicate estimated income losses less than $500,000.

4.2   Impacts for Livestock Water Shortages

One of the 32 counties in the region are projected to experience water shortages in the livestock water use category for one or more decades within the planning horizon. Estimated impacts to this water use category appear in Table 4-2.

Table 4-2 Impacts of water shortages on livestock in Region F

Impact measure	2020	2030	2040	2050	2060	2070
Income losses ($ millions)*	$-	$0	$1	$1	$1	$1
Jobs losses	-	11	26	41	52	63
Tax losses on production and imports ($ millions)*	$-	$0	$0	$0	$0	$0

* Year 2018 dollars, rounded. Entries denoted by a dash (-) indicate no estimated economic impact. Entries denoted by a zero ($0) indicate estimated income losses less than $500,000.

4.3   Impacts of Manufacturing Water Shortages

Manufacturing water shortages in the region are projected to occur in seven of the 32 counties in the region for at least one decade of the planning horizon. Estimated impacts to this water use category appear in Table 4-3.

Table 4-3 Impacts of water shortages on manufacturing in Region F

Impacts measure	2020	2030	2040	2050	2060	2070
Income losses ($ millions)*	$457	$535	$576	$684	$821	$982
Job losses	1,241	1,771	2,121	2,927	3,933	5,043
Tax losses on production and Imports ($ millions)*	$28	$33	$35	$42	$50	$60

* Year 2018 dollars, rounded. Entries denoted by a dash (-) indicate no estimated economic impact. Entries denoted by a zero ($0) indicate estimated income losses less than $500,000.

4.4   Impacts of Mining Water Shortages

Mining water shortages in the region are projected to occur in seven of the 32 counties in the region for one or more decades within the planning horizon. Estimated impacts to this water use type appear in Table 4-4.

Table 4-4 Impacts of water shortages on mining in Region F

Impacts measure	2020	2030	2040	2050	2060	2070
Income losses ($ millions)*	$18,617	$18,533	$15,686	$11,894	$5,970	$4,291
Job losses	94,650	94,226	79,758	60,489	30,375	21,842
Tax losses on production and Imports ($ millions)*	$2,604	$2,592	$2,194	$1,663	$834	$599

* Year 2018 dollars, rounded. Entries denoted by a dash (-) indicate no estimated economic impact. Entries denoted by a zero ($0) indicate estimated income losses less than $500,000.

4.5   Impacts for Municipal Water Shortages

Nineteen of the 32 counties in the region are projected to experience water shortages in the municipal water use category for one or more decades within the planning horizon.

Impact estimates were made for two sub-categories within municipal water use: residential and non-residential. Non-residential municipal water use includes commercial and institutional users, which are further divided into non-water-intensive and water-intensive subsectors including car wash, laundry, hospitality, health care, recreation, and education. Lost consumer surplus estimates were made only for needs in the residential portion of municipal water use. Available IMPLAN and TWDB Water Use Survey data for the non-residential, water-intensive portion of municipal demand allowed these sectors to be included in income, jobs, and tax loss impact estimate.

Trucking cost estimates, calculated for shortages exceeding 80 percent, assumed a fixed, maximum cost of $35,000 per acre-foot to transport water for municipal use. The estimated impacts to this water use category appear in Table 4-5.

Table 4-5 Impacts of water shortages on municipal water users in Region F

Impacts measure	2020	2030	2040	2050	2060	2070
Income losses[1] ($ millions)*	$121	$220	$362	$426	$515	$637
Job losses[1]	2,219	4,041	6,632	7,817	9,448	11,685
Tax losses on production and imports[1] ($ millions)*	$12	$23	$37	$44	$53	$65
Trucking costs ($ millions)*	$29	$29	$29	$30	$31	$32
Utility revenue losses ($ millions)*	$56	$82	$111	$139	$172	$207
Utility tax revenue losses ($ millions)*	$1	$1	$2	$3	$3	$4

[1] Estimates apply to the water-intensive portion of non-residential municipal water use.
* Year 2018 dollars, rounded. Entries denoted by a dash (-) indicate no estimated economic impact. Entries denoted by a zero ($0) indicate estimated income losses less than $500,000.

4.6 Impacts of Steam-Electric Water Shortages

Steam-electric water shortages in the region are projected to occur in four of the 32 counties in the region for one or more decades within the planning horizon. Estimated impacts to this water use category appear in Table 4-6.

Note that estimated economic impacts to steam-electric water users:

- Are reflected as an income loss proxy in the form of estimated additional purchasing costs for power from the electrical grid to replace power that could not be generated due to a shortage;
- Do not include estimates of impacts on jobs. Because of the unique conditions of power generators during drought conditions and lack of relevant data, it was assumed that the industry would retain, perhaps relocating or repurposing, their existing staff in order to manage their ongoing operations through a severe drought.
- Do not presume a decline in tax collections. Associated tax collections, in fact, would likely increase under drought conditions since, historically, the demand for electricity increases during times of drought, thereby increasing taxes collected on the additional sales of power.

Table 4-6 Impacts of water shortages on steam-electric power in Region F

Impacts measure	2020	2030	2040	2050	2060	2070
Income Losses ($ millions)*	$424	$426	$428	$431	$434	$437

* Year 2018 dollars, rounded. Entries denoted by a dash (-) indicate no estimated economic impact. Entries denoted by a zero ($0) indicate estimated income losses less than $500,000.

4.7   Regional Social Impacts

Projected changes in population, based upon several factors (household size, population, and job loss estimates), as well as the accompanying change in school enrollment, were also estimated and are summarized in Table 4-7.

Table 4-7 Region-wide social impacts of water shortages in Region F

Impacts measure	2020	2030	2040	2050	2060	2070
Consumer surplus losses ($ millions)*	$87	$93	$149	$183	$227	$286
Population losses	18,031	18,394	16,283	13,117	8,078	7,130
School enrollment losses	3,449	3,518	3,115	2,509	1,545	1,364

* Year 2018 dollars, rounded. Entries denoted by a dash (-) indicate no estimated economic impact. Entries denoted by a zero ($0) indicate estimated income losses less than $500,000.

Appendix A - County Level Summary of Estimated Economic Impacts for Region F

County level summary of estimated economic impacts of not meeting identified water needs by water use category and decade (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)

County	Water Use Category	Income losses (Million $)*						Job losses					
		2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
ANDREWS	IRRIGATION	$0.07	$1.55	$1.98	$2.84	$3.51	$3.86	2	40	51	73	91	100
ANDREWS	LIVESTOCK	-	$0.24	$0.57	$0.88	$1.13	$1.36	-	11	26	41	52	63
ANDREWS	MANUFACTURING	$0.74	$18.63	$54.78	$155.00	$279.33	$417.54	5	117	343	970	1,748	2,613
ANDREWS	MINING	$2,415.23	$2,211.91	$1,774.79	$1,228.20	$754.04	$299.20	12,260	11,228	9,009	6,234	3,828	1,519
ANDREWS	MUNICIPAL	$0.00	$0.49	$1.84	$6.40	$13.72	$24.41	0	9	34	117	251	448
ANDREWS Total		$2,416.05	$2,232.81	$1,833.97	$1,393.32	$1,051.73	$746.38	12,266	11,404	9,463	7,436	5,970	4,741
BORDEN	IRRIGATION	-	-	$0.00	$0.01	$0.01	$0.02	-	-	0	0	0	0
BORDEN Total		-	-	$0.00	$0.01	$0.01	$0.02	-	-	0	0	0	0
BROWN	IRRIGATION	$1.14	$1.15	$1.14	$1.15	$1.14	$1.14	27	28	28	28	28	28
BROWN	MINING	$21.21	$21.98	$21.89	$22.23	$21.61	$21.54	142	147	146	149	144	144
BROWN	MUNICIPAL	$0.12	$0.12	$0.11	$0.11	$0.11	$0.11	2	2	2	2	2	2
BROWN Total		$22.46	$23.24	$23.14	$23.48	$22.86	$22.79	171	177	176	178	174	174
COKE	MUNICIPAL	$2.68	$2.64	$2.62	$2.61	$2.61	$2.61	49	48	48	48	48	48
COKE Total		$2.68	$2.64	$2.62	$2.61	$2.61	$2.61	49	48	48	48	48	48
COLEMAN	IRRIGATION	$0.17	$0.17	$0.17	$0.17	$0.17	$0.17	5	5	5	5	5	5
COLEMAN	MANUFACTURING	$1.22	$1.22	$1.22	$1.22	$1.22	$1.22	10	10	10	10	10	10
COLEMAN	MUNICIPAL	$7.62	$7.53	$7.34	$7.29	$7.28	$7.28	140	138	135	134	133	133
COLEMAN Total		$9.01	$8.91	$8.72	$8.67	$8.66	$8.66	155	153	149	148	148	148
CONCHO	MUNICIPAL	$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	1	1	1	1	1	1
CONCHO Total		$0.07	$0.07	$0.07	$0.08	$0.08	$0.08	1	1	1	1	1	1
ECTOR	MUNICIPAL	$1.42	$1.55	$2.77	$5.68	$22.92	$57.07	26	28	51	104	420	1,046
ECTOR	STEAM ELECTRIC POWER	$2.16	$3.83	$5.72	$8.75	$11.35	$13.61	-	-	-	-	-	-

County	Water Use Category	Income losses (Million $)*						Job losses					
		2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
ECTOR Total		$3.58	$5.38	$8.50	$14.44	$34.27	$70.68	26	28	51	104	420	1,046
HOWARD	MANUFACTURING	-	-	-	-	$4.53	$18.06	-	-	-	-	15	59
HOWARD	MUNICIPAL	$0.98	-	-	$1.07	$8.98	$22.90	18	-	-	20	165	420
HOWARD	STEAM ELECTRIC POWER	$0.10	-	-	$0.13	$0.77	$1.40	-	-	-	-	-	-
HOWARD Total		$1.08	-	-	$1.21	$14.27	$42.36	18	-	-	20	179	479
IRION	IRRIGATION	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09	3	3	3	3	3	3
IRION	MINING	$1,381.50	$1,374.78	$94.20	-	-	-	7,023	6,988	479	-	-	-
IRION Total		$1,381.59	$1,374.87	$94.29	$0.09	$0.09	$0.09	7,025	6,991	482	3	3	3
KIMBLE	IRRIGATION	$0.26	$0.26	$0.26	$0.26	$0.26	$0.26	8	8	8	8	8	8
KIMBLE	MANUFACTURING	$104.49	$121.99	$121.99	$121.99	$121.99	$121.99	312	364	364	364	364	364
KIMBLE	MUNICIPAL	$4.77	$4.72	$4.64	$4.61	$4.60	$4.60	87	87	85	85	84	84
KIMBLE Total		$109.52	$126.97	$126.89	$126.86	$126.85	$126.85	407	459	457	457	457	457
LOVING	MINING	$3,202.78	$3,202.78	$2,463.99	$1,202.04	$427.69	$571.91	16,281	16,281	12,525	6,110	2,174	2,907
LOVING Total		$3,202.78	$3,202.78	$2,463.99	$1,202.04	$427.69	$571.91	16,281	16,281	12,525	6,110	2,174	2,907
MARTIN	IRRIGATION	-	-	-	-	-	$0.18	-	-	-	-	-	4
MARTIN	MUNICIPAL	$0.04	$0.08	$0.19	$0.57	$1.11	$1.75	1	1	3	10	20	32
MARTIN Total		$0.04	$0.08	$0.19	$0.57	$1.11	$1.93	1	1	3	10	20	36
MASON	MUNICIPAL	$7.47	$7.37	$7.28	$7.23	$7.22	$7.22	137	135	133	132	132	132
MASON Total		$7.47	$7.37	$7.28	$7.23	$7.22	$7.22	137	135	133	132	132	132
MCCULLOCH	MUNICIPAL	$13.32	$13.60	$13.43	$13.50	$13.52	$13.54	244	249	246	248	248	248
MCCULLOCH Total		$13.32	$13.60	$13.43	$13.50	$13.52	$13.54	244	249	246	248	248	248
MENARD	MUNICIPAL	$1.68	$1.62	$1.57	$1.56	$1.56	$1.56	31	30	29	29	29	29
MENARD Total		$1.68	$1.62	$1.57	$1.56	$1.56	$1.56	31	30	29	29	29	29
MIDLAND	MUNICIPAL	$0.03	$111.77	$233.17	$267.70	$302.87	$341.40	0	2,049	4,275	4,908	5,553	6,259
MIDLAND Total		$0.03	$111.77	$233.17	$267.70	$302.87	$341.40	0	2,049	4,275	4,908	5,553	6,259
MITCHELL	IRRIGATION	$0.10	$0.15	$0.13	$0.11	$0.10	$0.08	2	3	2	2	2	1
MITCHELL	MUNICIPAL	-	$0.49	$0.62	$0.76	$0.94	$1.16	-	9	11	14	17	21
MITCHELL	STEAM ELECTRIC POWER	$343.68	$343.68	$343.68	$343.68	$343.68	$343.68	-	-	-	-	-	-
MITCHELL Total		$343.78	$344.32	$344.43	$344.55	$344.71	$344.92	2	12	14	16	19	23

County	Water Use Category	Income losses (Million $)*						Job losses					
		2020	2030	2040	2050	2060	2070	2020	2030	2040	2050	2060	2070
PECOS	MANUFACTURING	$156.91	$148.60	$148.60	$148.60	$148.60	$148.60	352	334	334	334	334	334
PECOS	MINING	$2,869.87	$2,869.87	$2,869.87	$2,869.87	-	-	14,588	14,588	14,588	14,588	-	-
PECOS Total		$3,026.79	$3,018.47	$3,018.47	$3,018.47	$148.60	$148.60	14,940	14,922	14,922	14,922	334	334
REEVES	MINING	$8,527.63	$8,527.63	$8,117.65	$6,313.72	$4,591.80	$3,279.86	43,348	43,348	41,264	32,094	23,341	16,672
REEVES	MUNICIPAL	$0.45	$0.50	$0.55	$0.58	$0.60	$0.62	8	9	10	11	11	11
REEVES Total		$8,528.08	$8,528.13	$8,118.19	$6,314.30	$4,592.40	$3,280.48	43,356	43,357	41,274	32,105	23,352	16,684
RUNNELS	MUNICIPAL	$4.00	$3.77	$3.59	$3.56	$3.59	$3.77	73	69	66	65	66	69
RUNNELS Total		$4.00	$3.77	$3.59	$3.56	$3.59	$3.77	73	69	66	65	66	69
SCURRY	IRRIGATION	$2.67	$2.68	$2.68	$2.68	$2.68	$2.68	51	51	51	51	51	51
SCURRY	MANUFACTURING	$187.78	$225.33	$225.33	$225.33	$225.33	$225.33	415	498	498	498	498	498
SCURRY	MINING	$198.43	$323.89	$343.57	$258.29	$174.65	$118.07	1,009	1,646	1,746	1,313	888	600
SCURRY	MUNICIPAL	$1.81	$1.60	$1.73	$2.36	$5.62	$11.66	33	29	32	43	103	214
SCURRY Total		$390.68	$553.50	$573.31	$488.66	$408.28	$357.74	1,508	2,225	2,327	1,905	1,540	1,363
TOM GREEN	MANUFACTURING	$6.18	$18.84	$24.06	$31.54	$40.49	$48.95	147	449	573	751	964	1,166
TOM GREEN	MUNICIPAL	$74.57	$62.49	$80.20	$100.73	$116.86	$134.43	1,367	1,146	1,470	1,847	2,142	2,465
TOM GREEN Total		$80.75	$81.33	$104.26	$132.27	$157.35	$183.38	1,514	1,594	2,043	2,598	3,107	3,630
WARD	MUNICIPAL	-	-	-	-	$1.19	$1.22	-	-	-	-	22	22
WARD	STEAM ELECTRIC POWER	$78.28	$78.28	$78.28	$78.28	$78.28	$78.28	-	-	-	-	-	-
WARD Total		$78.28	$78.28	$78.28	$78.28	$79.47	$79.50	-	-	-	-	22	22
REGION F Total		$19,623.72	$19,719.90	$17,058.36	$13,443.46	$7,749.80	$6,356.45	98,208	100,186	88,685	71,444	43,995	38,833