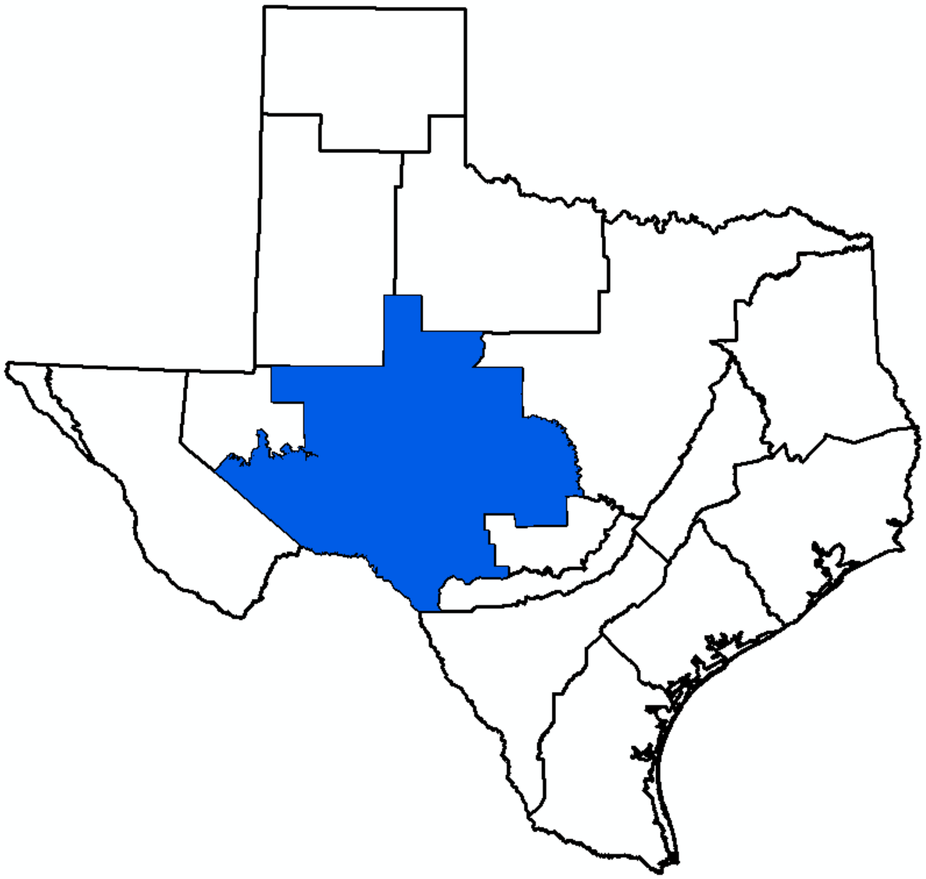
GMA 7 Explanatory Report - Final

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



Prepared for:

Groundwater Management Area 7

Prepared by:

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November 22, 2016

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

Geoscientist and Engineering Seal

This report documents the work and supervision of work of the following licensed Texas Professional Geoscientist and licensed Texas Professional Engineers:

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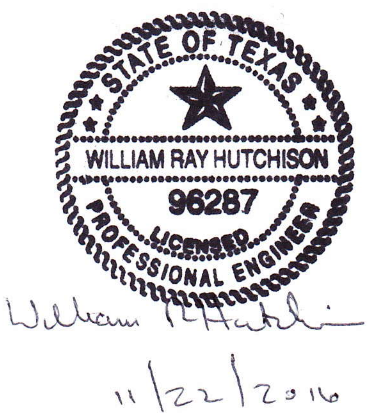
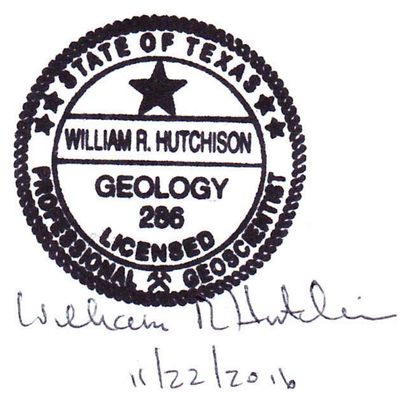
Dr. Hutchison completed the analyses and model simulations described in this report, and was the principal author of the final report.





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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).

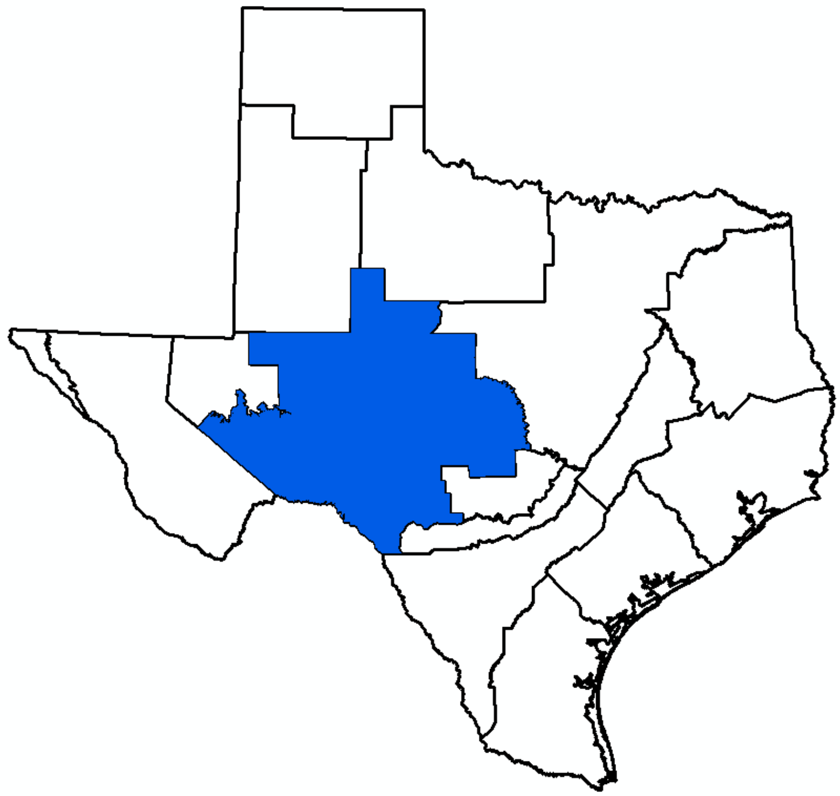

Figure 1. Groundwater Management Area 7

Groundwater Management Area 3 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).

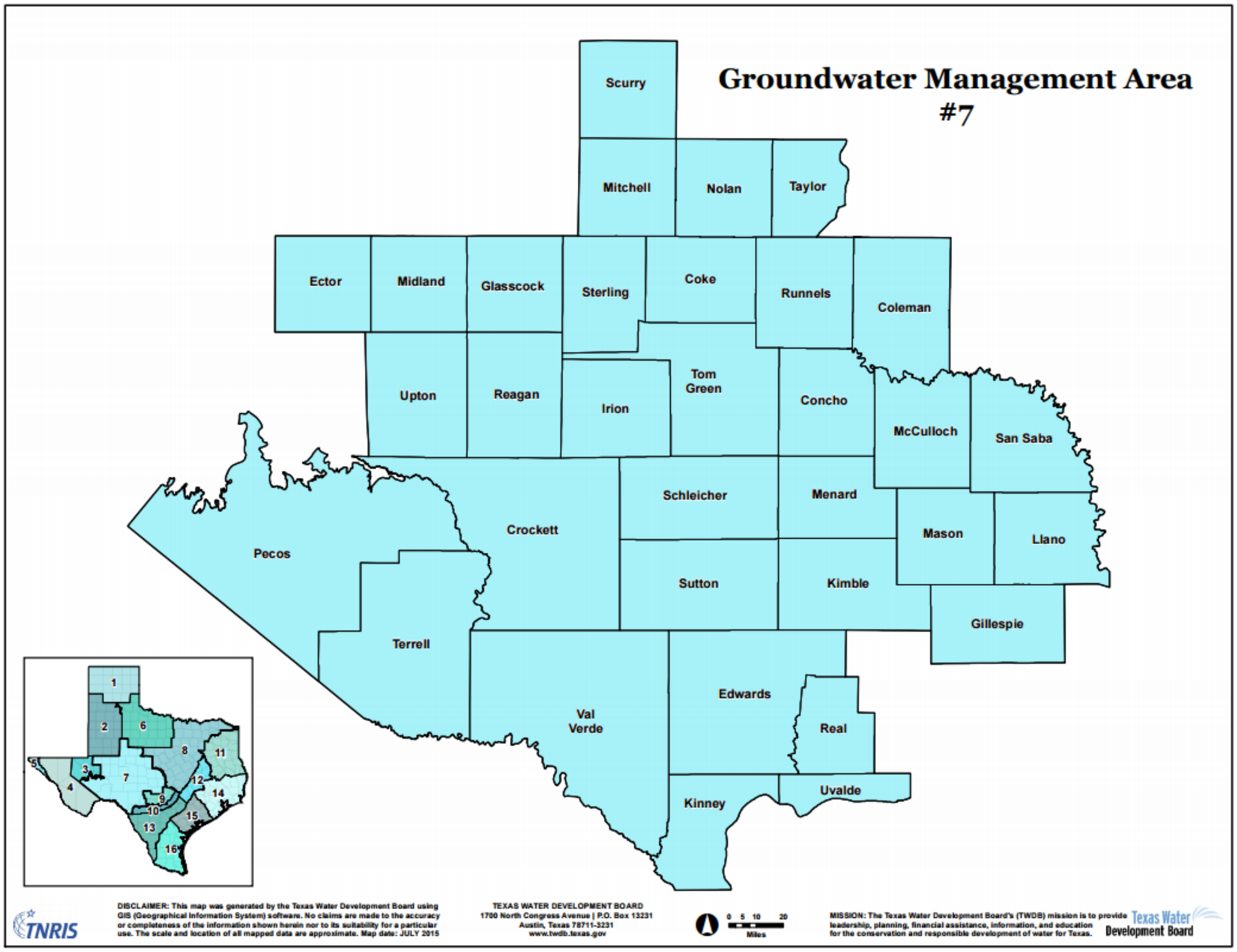

Figure 2. GMA 7 Counties (from TWDB)

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.

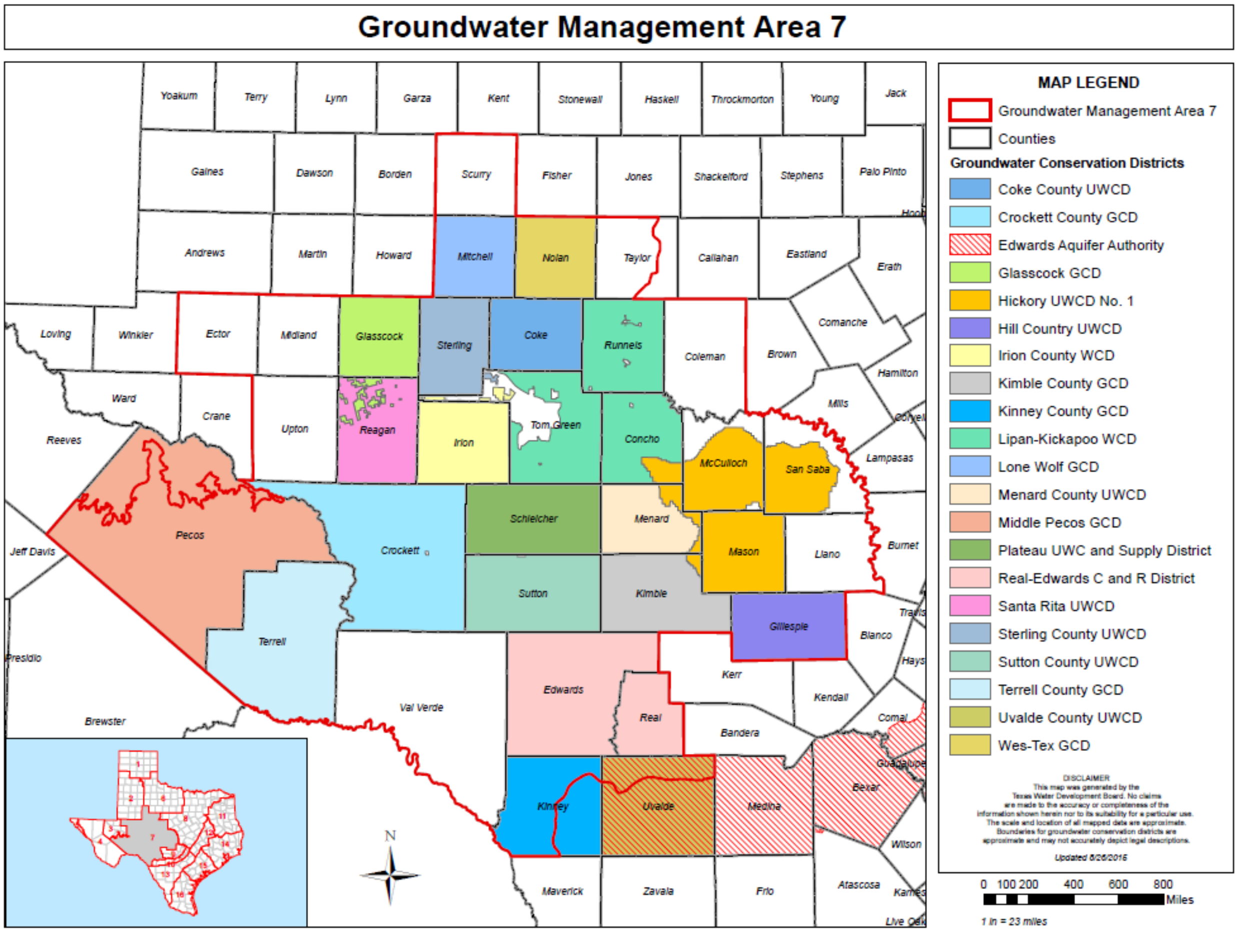

Figure 3. Groundwater Conservation Districts in GMA 7 (from TWDB)

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

2.1 Existing 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 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, 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 Llano Uplift Groundwater Availability Model

In 2016, the Texas Water Development Board released a preliminary version of 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 in Technical Memorandum 16-02.

2.3 Desired Future Condition

As presented in the Resolutions for the desired future condition (Appendix A), the following was adopted:

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.

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.

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.

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 2011 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	August 3, 2016	None
Hill Country UWCD	July 22, 2016	None
Kimble County GCD	July 18, 2016	None
Menard County UWD	July 12, 2016	None

No comments were received on the desired future conditions for the Ellenburger-San Saba and Hickory aquifers.

8.0 References

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Wuerch, D., and Backhouse, S., 2011. GTA Aquifer Assessment 10-12MAG. Groundwater Management Area 7, Marble Falls Aquifer, Modeled Available Groundwater Estimates. Texas Water Development Board, Groundwater Technical Assistance Section, November 1, 2011, August 31, 2010, 10p.

Appendix A

Desired Future Conditions Resolution

STATE OF TEXAS §

RESOLUTION # 09-22-2016-5

GROUNDWATER §
MANAGEMENT AREA 7 §

Resolution Adopting Desired Future Conditions for the Ellenburger-San Saba Aquifer 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 §36.108, Texas Water Code since September 2011; and

WHEREAS, the GMA 7 committee has received and considered Groundwater Availability Model runs and other technical advice regarding local aquifers, hydrology, geology, recharge characteristics, the nine factors set forth in §36.108(d) of the Texas Water Code, local groundwater demands and usage, population projections, total water supply and quality of water supply available 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 April 21, 2016 at the Hill Country University located at 2818 E U.S. Highway 290, Fredericksburg, Texas, to vote to adopt proposed Desired Future Conditions for the Ellenburger-San Saba Aquifer within the boundaries of GMA 7; and

WHEREAS, the member GCDs in which the Ellenburger-San Saba Aquifer is relevant for joint planning purposes held open meetings within each said district between May 13, 2016 and August 11, 2016 to take public comment on the proposed DFCs for that district; and

WHEREAS on this day of September 22, 2016, at an open meeting duly noticed and held in accordance with law at the Texas A & M Agrilife Research and Extension Center, 7887 U. S. Highway 87 North, San Angelo, Texas , the GCDs within GMA 7, having considered at this meeting comments submitted to the individual districts during the comment period and at this meeting, have voted, 20 districts in favor, 0 districts against, to adopt the DFCs for the Ellenburger-San Saba Aquifer in the following counties and districts through the year 2070 as follows:

a) Total net drawdowns of aquifer levels in 2070, as compared with 2010 aquifer levels, shall not exceed the number of feet set forth below, respectively, for the following counties and districts:

County	GCD	Drawdown in 2070 (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, 4-14-2016

a) The Ellenburger-San Saba Aquifer is not relevant for joint planning purposes in all other areas in 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 Ellenburger-San Saba Aquifer which were adopted by vote of the following Designated Representatives of Groundwater Conservation Districts present and voting on September 22, 2016:

Ayes:

DESIGNATED REPRESENTATIVE - COKE COUNTY UWCD

DESIGNATED REPRESENTATIVE - CROCKETT COUNTY GCD

DESIGNATED REPRESENTATIVE - GLASSCOCK GCD

DESIGNATED REPRESENTATIVE - HICKORY UWCD #1

DESIGNATED REPRESENTATIVE - HILL COUNTRY UWCD

DESIGNATED REPRESENTATIVE - IRION COUNTY WCD

DESIGNATED REPRESENTATIVE - KIMBLE COUNTY GCD

DESIGNATED REPRESENTATIVE - KINNEY COUNTY GCD

DESIGNATED REPRESENTATIVE- LIPAN-KICKAPOO WCD

DESIGNATED REPRESENTATIVE - LONE WOLF GCD

DESIGNATED REPRESENTATIVE - MENARD COUNTY UWD

DESIGNATED REPRESENTATIVE - MIDDLE PECOS GCD

DESIGNATED REPRESENTATIVE - PLATEAU UWC & SD

DESIGNATED REPRESENTATIVE - REAL-EDWARDS CON & REC DIST

DESIGNATED REPRESENTATIVE - SANTA RITA UWCD

DESIGNATED REPRESENTATIVE - STERLING COUNTY UWCD

DESIGNATED REPRESENTATIVE - SUTTON COUNTY UWCD

DESIGNATED REPRESENTATIVE - UVALDE COUNTY WCD

DESIGNATED REPRESENTATIVE - WES-TEX GCD

DESIGNATED REPRESENTATIVE – TERRELL COUNTY GCD

Nays:

DESIGNATED REPRESENTATIVE -

DESIGNATED REPRESENTATIVE -

STATE OF TEXAS §

RESOLUTION # 09-22-2016-6

GROUNDWATER §
MANAGEMENT AREA 7 §

Resolution Adopting Desired Future Conditions for the Hickory Aquifer 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.l08, 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 §36.l08, Texas Water Code since September 2011; and

WHEREAS, the GMA 7 committee has received and considered Groundwater Availability Model runs and other technical advice regarding local aquifers, hydrology, geology, recharge characteristics, the nine factors set forth in §36.108(d) of the Texas Water Code, local groundwater demands and usage, population projections, total water supply and quality of water supply available 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 April 21, 2016 at the Hill Country University located at 2818 E U.S. Highway 290, Fredericksburg, Texas, to vote to adopt proposed Desired Future Conditions for the Hickory Aquifer within the boundaries of GMA 7; and

WHEREAS, the member GCDs in which the Hickory Aquifer is relevant for joint planning purposes held open meetings within each said district between May 13, 2016 and August 11, 2016 to take public comment on the proposed DFCs for that district; and

WHEREAS on this 22nd day of September, 2016, at an open meeting duly noticed and held in accordance with law at the Texas A & M Agrilife Research and Extension Center, 7887 U. S. Highway 87 North, San Angelo, Texas , the GCDs within GMA 7, having considered at this meeting comments submitted to the individual districts during the comment period and at this meeting, have voted, 20 districts for, 0 districts against, to adopt the following DFCs through the year 2017 for the Hickory Aquifer:

a) Total net drawdowns of aquifer levels in 2070, as compared with 2010 aquifer levels, shall not exceed the number of feet set forth below, respectively, for the following counties and districts:

County	GCD	Drawdown in 2070 (feet)
Concho	Hickory UWCD	53
Gillespie	Hill Country UWCD	9
Mason	Hickory UWCD	17
McCulloch	Hickory UWCD	29
Menard	Menard UWD and Hickory UWCD	46
Kimble	Kimble County GCD and Hickory UWCD	18
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 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 Hickory Aquifer which were adopted by vote of the following Designated Representatives of Groundwater Conservation Districts present and voting on September 22, 2016:

Ayes:

DESIGNATED REPRESENTATIVE - COKE COUNTY UWCD

DESIGNATED REPRESENTATIVE - CROCKETT COUNTY GCD

DESIGNATED REPRESENTATIVE - GLASSCOCK GCD

DESIGNATED REPRESENTATIVE - HICKORY UWCD #1

DESIGNATED REPRESENTATIVE - HILL COUNTRY UWCD

DESIGNATED REPRESENTATIVE - IRION COUNTY WCD

DESIGNATED REPRESENTATIVE - KIMBLE COUNTY GCD

DESIGNATED REPRESENTATIVE -KINNEY COUNTY GCD

DESIGNATED REPRESENTATIVE- LIPAN-KICKAPOO WCD

DESIGNATED REPRESENTATIVE - LONE WOLF GCD

DESIGNATED REPRESENTATIVE - MENARD COUNTY UWD

DESIGNATED REPRESENTATIVE - MIDDLE PECOS GCD

DESIGNATED REPRESENTATIVE - PLATEAU UWC & SD

DESIGNATED REPRESENTATIVE - REAL-EDWARDS CON & REC DIST

DESIGNATED REPRESENTATIVE - SANTA RITA UWCD

DESIGNATED REPRESENTATIVE - STERLING COUNTY UWCD

DESIGNATED REPRESENTATIVE - SUTTON COUNTY UWCD

DESIGNATED REPRESENTATIVE - UVALDE COUNTY WCD

DESIGNATED REPRESENTATIVE - WES-TEX GCD

DESIGNATED REPRESENTATIVE – TERRELL COUNTY GCD

Nays:

DESIGNATED REPRESENTATIVE -

DESIGNATED REPRESENTATIVE -

STATE OF TEXAS	§	
	§	**RESOLUTION # 09-22-2016-1**
GROUNDWATER	§	
MANAGEMENT AREA 7	§	

Declaration that the Blaine, Igneous, Lipan, Marble Falls and Seymour Aquifers are Not Relevant For Joint Planning Purposes 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.l08, 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.l08, Texas Water Code since September 2011 and;

WHEREAS, the GMA 7 Districts have received and considered technical advice regarding local aquifers, hydrology, geology, recharge characteristics, local groundwater demands and usage, population projections, other factors set forth in 36.108 (d-) and other considerations that affect groundwater condition in the Blaine, Igneous, and Seymour Aquifers through the year 2060; and

WHEREAS on this day of September 22, 2016, at an open meeting duly noticed and held in accordance with law at the Texas A & M Agrilife Research and Extension Center, 7887 U. S. Highway 87 North, San Angelo, Texas ,and voted to adopt proposed Desired Future Conditions for the aquifers of GMA; and

WHEREAS at said meeting held on September 22, 2016, the GCDs within GMA 7 voted, upon motion made and seconded, 20 districts in favor, 0 districts opposed, to declare the Blaine, Igneous, Lipan, Marble Falls and Seymour Aquifers not relevant for joint planning purposes pursuant to Section 36.108 of the Texas Water Code and therefore not requiring establishment of DFCs by GMA 7 nor determination by the Texas Water Development Board (TWDB) of Modeled Available Groundwater (MAGs) for those aquifers within GMA 7,

NOW THEREFORE BE IT RESOLVED, that Groundwater Management Area 7 does hereby record, and confirm the above declaration that the **Blaine, Igneous, Lipan, Marble Falls and Seymour Aquifers are not relevant for Section 36.108 joint planning purposes within the boundaries of Groundwater Management Area 7**, therefore not requiring establishment of Desired Future Conditions by GMA 7 Districts nor determination of Managed Available Groundwater by the Texas Water Development Board for said aquifers within GMA 7, approved by the following votes of the Designated Representatives of Groundwater Conservation Districts present and voting on April 21, 2016:

Ayes:

DESIGNATED REPRESENTATIVE - COKE COUNTY UWCD

DESIGNATED REPRESENTATIVE - CROCKETT COUNTY GCD

DESIGNATED REPRESENTATIVE - GLASSCOCK GCD

DESIGNATED REPRESENTATIVE - HICKORY UWCD #1

DESIGNATED REPRESENTATIVE - HILL COUNTRY UWCD

DESIGNATED REPRESENTATIVE - IRION COUNTY WCD

DESIGNATED REPRESENTATIVE - KIMBLE COUNTY GCD

DESIGNATED REPRESENTATIVE - KINNEY COUNTY GCD

DESIGNATED REPRESENTATIVE - LIPAN-KICKAPOO WCD

DESIGNATED REPRESENTATIVE - LONE WOLF GCD

DESIGNATED REPRESENTATIVE - MENARD COUNTY UWD

DESIGNATED REPRESENTATIVE - MIDDLE PECOS GCD

DESIGNATED REPRESENTATIVE - PLATEAU UWC & SD

DESIGNATED REPRESENTATIVE - REAL-EDWARDS CON & REC DIST

DESIGNATED REPRESENTATIVE - SANTA RITA UWCD

DESIGNATED REPRESENTATIVE - STERLING COUNTY UWCD

DESIGNATED REPRESENTATIVE - SUTTON COUNTY UWCD

DESIGNATED REPRESENTATIVE – TERRELL COUNTY GCD

DESIGNATED REPRESENTATIVE - UVALDE COUNTY WCD

DESIGNATED REPRESENTATIVE - WES-TEX GCD

Nays:

DESIGNATED REPRESENTATIVE -

DESIGNATED REPRESENTATIVE -

Appendix B

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

Appendix B

TWDB Pumping Estimates

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

Appendix B
TWDB Pumping Estimates

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

Appendix B
TWDB Pumping Estimates

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

Appendix B

TWDB Pumping Estimates

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

TEXAS WATER DEVELOPMENT BOARD

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July 22, 2010

Mr. John Grant
Chairman, Region F Regional Water Planning Group
c/o Colorado River Municipal Water District
P.O. Box 869
Big Spring, Texas 79721-0869

Re: Socioeconomic Impact Analysis of Not Meeting Water Needs for the 2011 Region F Regional Water Plan

Dear Chairman Grant:

We have received your request for technical assistance to complete the socioeconomic impact analysis of not meeting water needs. In response, enclosed is a report that describes our methodology and presents the results. Section 1 provides an overview of the methodology. Section 2 presents results at the regional level, and Appendix 2 show results for individual water user groups.

If you have any questions or comments, please feel free to contact me at (512) 463-7928 or by email at stuart.norvell@twdb.state.tx.us.

Sincerely,

Stuart D. Norvell
Manager, Water Planning Research and Analysis
Water Resources Planning Division

SN/ao

Enclosure

c. Angela Kennedy, TWDB
S. Doug Shaw, TWDB

Economic Impacts of Projected Water Shortages for the Region F Regional Water Planning Area

Prepared in Support of the 2011 Region F Regional Water Plan

Stuart D. Norvell, Managing Economist
Water Resources Planning Division
Texas Water Development Board
Austin, Texas

S. Doug Shaw, Agricultural Economist
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Texas Water Development Board
Austin, Texas

July 2010

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Introduction

Water shortages during drought would likely curtail or eliminate economic activity in business and industries reliant on water. For example, without water farmers cannot irrigate; refineries cannot produce gasoline, and paper mills cannot make paper. Unreliable water supplies would not only have an immediate and real impact on existing businesses and industry, but they could also adversely affect economic development in Texas. From a social perspective, water supply reliability is critical as well. Shortages would disrupt activity in homes, schools and government and could adversely affect public health and safety. For all of the above reasons, it is important to analyze and understand how restricted water supplies during drought could affect communities throughout the state.

Administrative rules require that regional water planning groups evaluate the impacts of not meeting water needs as part of the regional water planning process, and rules direct TWDB staff to provide technical assistance: "*The executive administrator shall provide available technical assistance to the regional water planning groups, upon request, on water supply and demand analysis, including methods to evaluate the social and economic impacts of not meeting needs*" [(§357.7 (4)(A)]. Staff of the TWDB's Water Resources Planning Division designed and conducted this report in support of the Region F Regional Water Planning Group.

This document summarizes the results of our analysis and discusses the methodology used to generate the results. Section 1 outlines the overall methodology and discusses approaches and assumptions specific to each water use category (i.e., irrigation, livestock, mining, steam-electric, municipal and manufacturing). Section 2 presents the results for each category where shortages are reported at the regional planning area level and river basin level. Results for individual water user groups are not presented, but are available upon request.

1. Methodology

Section 1 provides a general overview of how economic and social impacts were measured. In addition, it summarizes important clarifications, assumptions and limitations of the study.

1.1 Economic Impacts of Water Shortages

1.1.1 General Approach

Economic analysis as it relates to water resources planning generally falls into two broad areas. Supply side analysis focuses on costs and alternatives of developing new water supplies or implementing programs that provide additional water from current supplies. Demand side analysis concentrates on impacts or benefits of providing water to people, businesses and the environment. Analysis in this report focuses strictly on demand side impacts. When analyzing the economic impacts of water shortages as defined in Texas water planning, three potential scenarios are possible:

1) Scenario 1 involves situations where there are physical shortages of raw surface or groundwater due to drought of record conditions. For example, City A relies on a reservoir with average conservation storage of 500 acre-feet per year and a firm yield of 100 acre feet. In 2010, the city uses about 50 acre-feet per year, but by 2030 their demands are expected to increase to 200 acre-feet. Thus, in 2030 the reservoir would not have enough water to meet the city's demands,

and people would experience a shortage of 100 acre-feet assuming drought of record conditions. Under normal or average climatic conditions, the reservoir would likely be able to provide reliable water supplies well beyond 2030.

2) Scenario 2 is a situation where despite drought of record conditions, water supply sources can meet existing use requirements; however, limitations in water infrastructure would preclude future water user groups from accessing these water supplies. For example, City B relies on a river that can provide 500 acre-feet per year during drought of record conditions and other constraints as dictated by planning assumptions. In 2010, the city is expected to use an estimated 100 acre-feet per year and by 2060 it would require no more than 400 acre-feet. But the intake and pipeline that currently transfers water from the river to the city's treatment plant has a capacity of only 200 acre-feet of water per year. Thus, the city's water supplies are adequate even under the most restrictive planning assumptions, but their conveyance system is too small. This implies that at some point – perhaps around 2030 - infrastructure limitations would constrain future population growth and any associated economic activity or impacts.

3) Scenario 3 involves water user groups that rely primarily on aquifers that are being depleted. In this scenario, projected and in some cases existing demands may be unsustainable as groundwater levels decline. Areas that rely on the Ogallala aquifer are a good example. In some communities in the region, irrigated agriculture forms a major base of the regional economy. With less irrigation water from the Ogallala, population and economic activity in the region could decline significantly assuming there are no offsetting developments.

Assessing the social and economic effects of each of the above scenarios requires various levels and methods of analysis and would generate substantially different results for a number of reasons; the most important of which has to do with the time frame of each scenario. Scenario 1 falls into the general category of static analysis. This means that models would measure impacts for a small interval of time such as a drought. Scenarios 2 and 3, on the other hand imply a dynamic analysis meaning that models are concerned with changes over a much longer time period.

Since administrative rules specify that planning analysis be evaluated under drought of record conditions (a static and random event), socioeconomic impact analysis developed by the TWDB for the state water plan is based on assumptions of Scenario 1. Estimated impacts under scenario 1 are point estimates for years in which needs are reported (2010, 2020, 2030, 2040, 2050 and 2060). They are independent and distinct "what if" scenarios for a particular year and shortages are assumed to be temporary events resulting from drought of record conditions. Estimated impacts measure what would happen if water user groups experience water shortages for a period of one year.

The TWDB recognize that dynamic models may be more appropriate for some water user groups; however, combining approaches on a statewide basis poses several problems. For one, it would require a complex array of analyses and models, and might require developing supply and demand forecasts under "normal" climatic conditions as opposed to drought of record conditions. Equally important is the notion that combining the approaches would produce inconsistent results across regions resulting in a so-called "apples to oranges" comparison.

A variety tools are available to estimate economic impacts, but by far, the most widely used today are input-output models (IO models) combined with social accounting matrices (SAMs). Referred to as IO/SAM models, these tools formed the basis for estimating economic impacts for agriculture (irrigation and livestock water uses) and industry (manufacturing, mining, steam-electric and commercial business activity for municipal water uses).

Since the planning horizon extends through 2060, economic variables in the baseline are adjusted in accordance with projected changes in demographic and economic activity. Growth rates for municipal water use sectors (i.e., commercial, residential and institutional) are based on TWDB population forecasts. Future values for manufacturing, agriculture, and mining and steam-electric activity are based on the same underlying economic forecasts used to estimate future water use for each category.

The following steps outline the overall process.

Step 1*: Generate IO/SAM Models and Develop Economic Baseline*

IO/SAM models were estimated using propriety software known as IMPLAN PRO™ (Impact for Planning Analysis). IMPLAN is a modeling system originally developed by the U.S. Forestry Service in the late 1970s. Today, the Minnesota IMPLAN Group (MIG Inc.) owns the copyright and distributes data and software. It is probably the most widely used economic impact model in existence. IMPLAN comes with databases containing the most recently available economic data from a variety of sources.[1] Using IMPLAN software and data, transaction tables conceptually similar to the one discussed previously were estimated for each county in the region and for the region as a whole. Each transaction table contains 528 economic sectors and allows one to estimate a variety of economic statistics including:

- **total sales -** total production measured by sales revenues;
- **intermediate sales -** sales to other businesses and industries within a given region;
- **final sales –** sales to end users in a region and exports out of a region**;**
- **employment -** number of full and part-time jobs (annual average) required by a given industry including self-employment;
- **regional income -** total payroll costs (wages and salaries plus benefits) paid by industries, corporate income, rental income and interest payments; and
- **business taxes -** sales, excise, fees, licenses and other taxes paid during normal operation of an industry (does not include income taxes).

TWDB analysts developed an economic baseline containing each of the above variables using year 2000 data. Since the planning horizon extends through 2060, economic variables in the baseline were allowed to change in accordance with projected changes in demographic and economic activity. Growth rates for municipal water use sectors (i.e., commercial, residential and institutional) are based on TWDB population forecasts. Projections for manufacturing, agriculture, and mining and steam-electric activity are based on the same underlying economic forecasts used to estimate future water use for each category. Monetary impacts in future years are reported in constant year 2006 dollars.

It is important to stress that employment, income and business taxes are the most useful variables when comparing the relative contribution of an economic sector to a regional economy. Total sales as reported in IO/SAM models are less desirable and can be misleading because they include sales to other industries in the region for use in the production of other goods. For example, if a mill buys grain from local farmers and uses it to produce feed, sales of both the processed feed and raw corn are counted as "output" in an IO model. Thus, total sales double-count or overstate the true economic value of goods

[1]The IMPLAN database consists of national level technology matrices based on benchmark input-output accounts generated by the U.S. Bureau of Economic Analysis and estimates of final demand, final payments, industry output and employment for various economic sectors. IMPLAN regional data (i.e. states, a counties or groups of counties within a state) are divided into two basic categories: 1) data on an industry basis including value-added, output and employment, and 2) data on a commodity basis including final demands and institutional sales. State-level data are balanced to national totals using a matrix ratio allocation system and county data are balanced to state totals.

and services produced in an economy. They are not consistent with commonly used measures of output such as Gross National Product (GNP), which counts only final sales.

Another important distinction relates to terminology. Throughout this report, the term *sector* refers to economic subdivisions used in the IMPLAN database and resultant input-output models (528 individual sectors based on Standard Industrial Classification Codes). In contrast, the phrase *water use category* refers to water user groups employed in state and regional water planning including irrigation, livestock, mining, municipal, manufacturing and steam electric. Each IMPLAN sector was assigned to a specific water use category.

Step 2: *Estimate Direct and Indirect Economic Impacts of Water Needs*

Direct impacts are reductions in output by sectors experiencing water shortages. For example, without adequate cooling and process water a refinery would have to curtail or cease operation, car washes may close, or farmers may not be able to irrigate and sales revenues fall. Indirect impacts involve changes in inter-industry transactions as supplying industries respond to decreased demands for their services, and how seemingly non-related businesses are affected by decreased incomes and spending due to direct impacts. For example, if a farmer ceases operations due to a lack of irrigation water, they would likely reduce expenditures on supplies such as fertilizer, labor and equipment, and businesses that provide these goods would suffer as well.

Direct impacts accrue to immediate businesses and industries that rely on water and without water industrial processes could suffer. However, output responses may vary depending upon the severity of shortages. A small shortage relative to total water use would likely have a minimal impact, but large shortages could be critical. For example, farmers facing small shortages might fallow marginally productive acreage to save water for more valuable crops. Livestock producers might employ emergency culling strategies, or they may consider hauling water by truck to fill stock tanks. In the case of manufacturing, a good example occurred in the summer of 1999 when Toyota Motor Manufacturing experienced water shortages at a facility near Georgetown, Kentucky.[2] As water levels in the Kentucky River fell to historic lows due to drought, plant managers sought ways to curtail water use such as reducing rinse operations to a bare minimum and recycling water by funneling it from paint shops to boilers. They even considered trucking in water at a cost of 10 times what they were paying. Fortunately, rains at the end of the summer restored river levels, and Toyota managed to implement cutbacks without affecting production, but it was a close call. If rains had not replenished the river, shortages could have severely reduced output.[3]

To account for uncertainty regarding the relative magnitude of impacts to farm and business operations, the following analysis employs the concept of elasticity. Elasticity is a number that shows how a change in one variable will affect another. In this case, it measures the relationship between a percentage reduction in water availability and a percentage reduction in output. For example, an elasticity of 1.0 indicates that a 1.0 percent reduction in water availability would result in a 1.0 percent reduction in economic output. An elasticity of 0.50 would indicate that for every 1.0 percent of unavailable water, output is reduced by 0.50 percent and so on. Output elasticities used in this study are:[4]

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[2] Royal, W. "*High And Dry - Industrial Centers Face Water Shortages*." in Industry Week, Sept, 2000.

[3] The efforts described above are not planned programmatic or long-term operational changes. They are emergency measures that individuals might pursue to alleviate what they consider a temporary condition. Thus, they are not characteristic of long-term management strategies designed to ensure more dependable water supplies such as capital investments in conservation technology or development of new water supplies.

[4] Elasticities are based on one of the few empirical studies that analyze potential relationships between economic output and water shortages in the United States. The study, conducted in California, showed that a significant number of industries would suffer reduced output during water shortages. Using a survey based approach researchers posed two scenarios to different industries. In

- if water needs are 0 to 5 percent of total water demand, no corresponding reduction in output is assumed;

- if water needs are 5 to 30 percent of total water demand, for each additional one percent of water need that is not met, there is a corresponding 0.50 percent reduction in output;

- if water needs are 30 to 50 percent of total water demand, for each additional one percent of water need that is not met, there is a corresponding 0.75 percent reduction in output; and

- if water needs are greater than 50 percent of total water demand, for each additional one percent of water need that is not met, there is a corresponding 1.0 percent (i.e., a proportional reduction).

In some cases, elasticities are adjusted depending upon conditions specific to a given water user group.

Once output responses to water shortages were estimated, direct impacts to total sales, employment, regional income and business taxes were derived using regional level economic multipliers estimating using IO/SAM models. The formula for a given IMPLAN sector is:

$D_{i,t} = Q_{i,t} *_{,} S_{i,t} * E_Q * RFD_i * DM_{i(Q, L, I, T)}$

where:

$D_{i,t}$ = direct economic impact to sector *i* in period *t*

$Q_{i,t}$ = total sales for sector *i* in period *t* in an affected county

$RFD_{i,}$ = ratio of final demand to total sales for sector *i* for a given region

$S_{i,t}$ = water shortage as percentage of total water use in period *t*

E_Q = elasticity of output and water use

$DM_{i(L, I, T)}$ = direct output multiplier coefficients for labor (L), income (I) and taxes (T) for sector *i*.

Secondary impacts were derived using the same formula used to estimate direct impacts; however, indirect multiplier coefficients are used. Methods and assumptions specific to each water use sector are discussed in Sections 1.1.2 through 1.1.4.

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the first scenario, they asked how a 15 percent cutback in water supply lasting one year would affect operations. In the second scenario, they asked how a 30 percent reduction lasting one year would affect plant operations. In the case of a 15 percent shortage, reported output elasticities ranged from 0.00 to 0.76 with an average value of 0.25. For a 30 percent shortage, elasticities ranged from 0.00 to 1.39 with average of 0.47. For further information, see, California Urban Water Agencies, "*Cost of Industrial Water Shortages,*" Spectrum Economics, Inc. November, 1991.

General Assumptions and Clarification of the Methodology

As with any attempt to measure and quantify human activities at a societal level, assumptions are necessary and every model has limitations. Assumptions are needed to maintain a level of generality and simplicity such that models can be applied on several geographic levels and across different economic sectors. In terms of the general approach used here several clarifications and cautions are warranted:

1. Shortages as reported by regional planning groups are the starting point for socioeconomic analyses.

2. Estimated impacts are point estimates for years in which needs are reported (i.e., 2010, 2020, 2030, 2040, 2050 and 2060).They are independent and distinct "what if" scenarios for each particular year and water shortages are assumed to be temporary events resulting from severe drought conditions combined with infrastructure limitations. In other words, growth occurs and future shocks are imposed on an economy at 10-year intervals and resultant impacts are measured. Given, that reported figures are not cumulative in nature, it is inappropriate to sum impacts over the entire planning horizon. Doing so, would imply that the analysis predicts that drought of record conditions will occur every ten years in the future, which is not the case. Similarly, authors of this report recognize that in many communities needs are driven by population growth, and in the future total population will exceed the amount of water available due to infrastructure limitations, regardless of whether or not there is a drought. This implies that infrastructure limitations would constrain economic growth. However, since needs as defined by planning rules are based upon water supply and demand under the assumption of drought of record conditions, it improper to conduct economic analysis that focuses on growth related impacts over the planning horizon. Figures generated from such an analysis would presume a 50-year drought of record, which is unrealistic. Estimating lost economic activity related to constraints on population and commercial growth due to lack of water would require developing water supply and demand forecasts under "normal" or "most likely" future climatic conditions.

3. While useful for planning purposes, this study is not a benefit-cost analysis. Benefit cost analysis is a tool widely used to evaluate the economic feasibility of specific policies or projects as opposed to estimating economic impacts of unmet water needs. Nevertheless, one could include some impacts measured in this study as part of a benefit cost study if done so properly. Since this is not a benefit cost analysis, future impacts are not weighted differently. In other words, estimates are not discounted. If used as a measure of economic benefits, one should incorporate a measure of uncertainty into the analysis. In this type of analysis, a typical method of discounting future values is to assign probabilities of the drought of record recurring again in a given year, and weight monetary impacts accordingly. This analysis assumes a probability of one.

4. IO multipliers measure the strength of backward linkages to supporting industries (i.e., those who sell inputs to an affected sector). However, multipliers say nothing about forward linkages consisting of businesses that purchase goods from an affected sector for further processing. For example, ranchers in many areas sell most of their animals to local meat packers who process animals into a form that consumers ultimately see in grocery stores and restaurants. Multipliers do not capture forward linkages to meat packers, and since meat packers sell livestock purchased from ranchers as "final sales," multipliers for the ranching sector do fully account for all losses to a region's economy. Thus, as mentioned previously, in some cases closely linked sectors were moved from one water use category to another.

5. Cautions regarding interpretations of direct and secondary impacts are warranted. IO/SAM multipliers are based on "fixed-proportion production functions," which basically means that input use - including labor - moves in lockstep fashion with changes in levels of output. In a

scenario where output (i.e., sales) declines, losses in the immediate sector or supporting sectors could be much less than predicted by an IO/SAM model for several reasons. For one, businesses will likely expect to continue operating so they might maintain spending on inputs for future use; or they may be under contractual obligations to purchase inputs for an extended period regardless of external conditions. Also, employers may not lay-off workers given that experienced labor is sometimes scarce and skilled personnel may not be readily available when water shortages subside. Lastly people who lose jobs might find other employment in the region. As a result, direct losses for employment and secondary losses in sales and employment should be considered an upper bound. Similarly, since projected population losses are based on reduced employment in the region, they should be considered an upper bound as well.

6. IO models are static. Models and resultant multipliers are based upon the structure of the U.S. and regional economies in 2006. In contrast, water shortages are projected to occur well into the future. Thus, the analysis assumes that the general structure of the economy remains the same over the planning horizon, and the farther out into the future we go, this assumption becomes less reliable.

7. Impacts are annual estimates. If one were to assume that conditions persisted for more than one year, figures should be adjusted to reflect the extended duration. The drought of record in most regions of Texas lasted several years.

8. Monetary figures are reported in constant year 2006 dollars.

1.1.2 Impacts to Agriculture

Irrigated Crop Production

The first step in estimating impacts to irrigation required calculating gross sales for IMPLAN crop sectors. Default IMPLAN data do not distinguish irrigated production from dry-land production. Once gross sales were known other statistics such as employment and income were derived using IMPLAN direct multiplier coefficients. Gross sales for a given crop are based on two data sources:

1) county-level statistics collected and maintained by the TWDB and the USDA Farm Services Agency (FSA) including the number of irrigated acres by crop type and water application per acre, and

2) regional-level data published by the Texas Agricultural Statistics Service (TASS) including prices received for crops (marketing year averages), crop yields and crop acreages.

Crop categories used by the TWDB differ from those used in IMPLAN datasets. To maintain consistency, sales and other statistics are reported using IMPLAN crop classifications. Table 1 shows the TWDB crops included in corresponding IMPLAN sectors, and Table 2 summarizes acreage and estimated annual water use for each crop classification (five-year average from 2003-2007). Table 3 displays average (2003-2007) gross revenues per acre for IMPLAN crop categories.

Table 1: Crop Classifications Used in TWDB Water Use Survey and Corresponding IMPLAN Crop Sectors	
IMPLAN Category	**TWDB Category**
Oilseeds	Soybeans and “other oil crops”
Grains	Grain sorghum, corn, wheat and “other grain crops”
Vegetable and melons	“Vegetables” and potatoes
Tree nuts	Pecans
Fruits	Citrus, vineyard and other orchard
Cotton	Cotton
Sugarcane and sugar beets	Sugarcane and sugar beets
All “other” crops	“Forage crops”, peanuts, alfalfa, hay and pasture, rice and “all other crops”

Table 2: Summary of Irrigated Crop Acreage and Water Demand for the Region F Water Planning Area (average 2003-2007)

Sector	Acres (1000s)	Distribution of acres	Water use (1000s of AF)	Distribution of water use
Oilseeds	<1	<1%	<1	<1%
Grains	45	20%	62	17%
Vegetable and melons	5	2%	9	<1%
Tree nuts	6	3%	13	<1%
Fruits	<1	<1%	1	<1%
Cotton	104	47%	154	42%
All “other” crops	61	28%	123	34%
Total	221	100%	363	100%

Source: Water demand figures are a 5- year average (2003-2007) of the TWDB’s annual Irrigation Water Use Estimates. Statistics for irrigated crop acreage are based upon annual survey data collected by the TWDB and the Farm Service Agency. Values do not include acreage or water use for the TWDB categories classified by the Farm Services Agency as “failed acres,” “golf course” or “waste water.”

Table 3: Average Gross Sales Revenues per Acre for Irrigated Crops for the Region F Water Planning Area (2003-2007)		
IMPLAN Sector	**Gross revenues per acre**	**Crops included in estimates**
Oilseeds	$177	Irrigated figure is based on five-year (2003-2007) average weighted by acreage for “irrigated soybeans” and “irrigated ‘other’ oil crops.”
Grains	$199	Based on five-year (2003-2007) average weighted by acreage for “irrigated grain sorghum,” “irrigated corn”, “irrigated wheat” and “irrigated ‘other’ grain crops.”
Vegetable and melons	$6,053	Based on five-year (2003-2007) average weighted by acreage for “irrigated shallow and deep root vegetables”, “irrigated Irish potatoes” and “irrigated melons.”
Tree nuts	$3,451	Based on five-year (2003-2007) average weighted by acreage for “irrigated pecans.”
Fruits	$5,902	Based on five-year (2003-2007) average weighted by acreage for “irrigated citrus”, “irrigated vineyards” and “irrigated ‘other’ orchard.”
Cotton	$488	Based on five-year (2003-2007) average weighted by acreage for “irrigated cotton.”
All other crops	$335	Irrigated figure is based on five-year (2003-2007) average weighted by acreage for “irrigated ‘forage’ crops”, “irrigated peanuts”, “irrigated alfalfa”, “irrigated ‘hay’ and pasture” and “irrigated ‘all other’ crops.”

*Figures are rounded. Source: Based on data from the Texas Agricultural Statistics Service, Texas Water Development Board, and Texas A&M University.

An important consideration when estimating impacts to irrigation was determining which crops are affected by water shortages. One approach is the so-called rationing model, which assumes that farmers respond to water supply cutbacks by fallowing the lowest value crops in the region first and the highest valued crops last until the amount of water saved equals the shortage.[5] For example, if farmer A grows vegetables (higher value) and farmer B grows wheat (lower value) and they both face a proportionate cutback in irrigation water, then farmer B will sell water to farmer A. Farmer B will fallow her irrigated acreage before farmer A fallows anything. Of course, this assumes that farmers can and do transfer enough water to allow this to happen. A different approach involves constructing farm-level profit maximization models that conform to widely-accepted economic theory that farmers make decisions based on marginal net returns. Such models have good predictive capability, but data requirements and complexity are high. Given that a detailed analysis for each region would require a substantial amount of farm-level data and analysis, the following investigation assumes that projected shortages are distributed equally across predominant crops in the region. Predominant in this case are crops that comprise at least one percent of total acreage in the region.

The following steps outline the overall process used to estimate direct impacts to irrigated agriculture:

1. *Distribute shortages across predominant crop types in the region*. Again, unmet water needs were distributed equally across crop sectors that constitute one percent or more of irrigated acreage.

2. *Estimate associated reductions in output for affected crop sectors*. Output reductions are based on elasticities discussed previously and on estimated values per acre for different crops. Values per acre stem from the same data used to estimate output for the year 2006 baseline. Using multipliers, we then generate estimates of forgone income, jobs, and tax revenues based on reductions in gross sales and final demand.

Livestock

The approach used for the livestock sector is basically the same as that used for crop production. As is the case with crops, livestock categorizations used by the TWDB differ from those used in IMPLAN datasets, and TWDB groupings were assigned to a given IMPLAN sector (Table 4). Then we:

1) *Distribute projected water needs equally among predominant livestock sectors and estimate lost output*: As is the case with irrigation, shortages are assumed to affect all livestock sectors equally; however, the category of "other" is not included given its small size. If water needs were small relative to total demands, we assume that producers would haul in water by truck to fill stock tanks. The cost per acre-foot ($24,000) is based on 2008 rates charged by various water haulers in Texas, and assumes that the average truck load is 6,500 gallons at a hauling distance of 60 miles.

3) *Estimate reduced output in forward processors for livestock sectors*. Reductions in output for livestock sectors are assumed to have a proportional impact on forward processors in the region such as meat packers. In other words, if the cows were gone, meat-packing plants or fluid milk manufacturers) would likely have little to process. This is not an unreasonable premise. Since the

[5] The rationing model was initially proposed by researchers at the University of California at Berkeley, and was then modified for use in a study conducted by the U.S. Environmental Protection Agency that evaluated how proposed water supply cutbacks recommended to protect water quality in the Bay/Delta complex in California would affect farmers in the Central Valley. See, Zilberman, D., Howitt, R. and Sunding, D. "*Economic Impacts of Water Quality Regulations in the San Francisco Bay and Delt*a." Western Consortium for Public Health. May 1993.

1950s, there has been a major trend towards specialized cattle feedlots, which in turn has decentralized cattle purchasing from livestock terminal markets to direct sales between producers and slaughterhouses. Today, the meat packing industry often operates large processing facilities near high concentrations of feedlots to increase capacity utilization.[6] As a result, packers are heavily dependent upon nearby feedlots. For example, a recent study by the USDA shows that on average meat packers obtain 64 percent of cattle from within 75 miles of their plant, 82 percent from within 150 miles and 92 percent from within 250 miles.[7]

Table 4: Description of Livestock Sectors

IMPLAN Category	TWDB Category
Cattle ranching and farming	Cattle, cow calf, feedlots and dairies
Poultry and egg production	Poultry production.
Other livestock	Livestock other than cattle and poultry (i.e., horses, goats, sheep, hogs)
Milk manufacturing	Fluid milk manufacturing, cheese manufacturing, ice cream manufacturing etc.
Meat packing	Meat processing present in the region from slaughter to final processing

1.1.3 Impacts to Municipal Water User Groups

Disaggregation of Municipal Water Demands

Estimating the economic impacts for the municipal water user groups is complicated for a number of reasons. For one, municipal use comprises a range of consumers including commercial businesses, institutions such as schools and government and households. However, reported water needs are not distributed among different municipal water users. In other words, how much of a municipal need is commercial and how much is residential (domestic)?

The amount of commercial water use as a percentage of total municipal demand was estimated based on "GED" coefficients (gallons per employee per day) published in secondary sources.[8] For example, if year 2006 baseline data for a given economic sector (e.g., amusement and recreation services) shows employment at 30 jobs and the GED coefficient is 200, then average daily water use by that sector is (30 x 200 = 6,000 gallons) or 6.7 acre-feet per year. Water not attributed to commercial use is considered

[6] Ferreira, W.N. "*Analysis of the Meat Processing Industry in the United States*." Clemson University Extension Economics Report ER211, January 2003.

[7] Ward, C.E. "*Summary of Results from USDA's Meatpacking Concentration Study*." Oklahoma Cooperative Extension Service, OSU Extension Facts WF-562.

[8] Sources for GED coefficients include: Gleick, P.H., Haasz, D., Henges-Jeck, C., Srinivasan, V., Wolff, G. Cushing, K.K., and Mann, A. "*Waste Not, Want Not*: *The Potential for Urban Water Conservation in California*." Pacific Institute. November 2003. U.S. Bureau of the Census. 1982 Census of Manufacturers: Water Use in Manufacturing. USGPO, Washington D.C. See also: "*U.S. Army Engineer Institute for Water Resources, IWR Report 88-R-6.*," Fort Belvoir, VA. See also, Joseph, E. S., 1982, "*Municipal and Industrial Water Demands of the Western United States*." Journal of the Water Resources Planning and Management Division, Proceedings of the American Society of Civil Engineers, v. 108, no. WR2, p. 204-216. See also, Baumann, D. D., Boland, J. J., and Sims, J. H., 1981, "*Evaluation of Water Conservation for Municipal and Industrial Water Supply*." U.S. Army Corps of Engineers, Institute for Water Resources, Contract no. 82-C1.

domestic, which includes single and multi-family residential consumption, institutional uses and all use designated as “county-other.” Based on our analysis, commercial water use is about 5 to 35 percent of municipal demand. Less populated rural counties occupy the lower end of the spectrum, while larger metropolitan counties are at the higher end.

After determining the distribution of domestic versus commercial water use, we developed methods for estimating impacts to the two groups.

Domestic Water Uses

Input output models are not well suited for measuring impacts of shortages for domestic water uses, which make up the majority of the municipal water use category. To estimate impacts associated with domestic water uses, municipal water demand and needs are subdivided into residential, and commercial and institutional use. Shortages associated with residential water uses are valued by estimating proxy demand functions for different water user groups allowing us to estimate the marginal value of water, which would vary depending upon the level of water shortages. The more severe the water shortage, the more costly it becomes. For instance, a 2 acre-foot shortage for a group of households that use 10 acre-feet per year would not be as severe as a shortage that amounted to 8 acre-feet. In the case of a 2 acre-foot shortage, households would probably have to eliminate some or all outdoor water use, which could have implicit and explicit economic costs including losses to the horticultural and landscaping industry. In the case of an 8 acre-foot shortage, people would have to forgo all outdoor water use and most indoor water consumption. Economic impacts would be much higher in the latter case because people, and would be forced to find emergency alternatives assuming alternatives were available.

To estimate the value of domestic water uses, TWDB staff developed marginal loss functions based on constant elasticity demand curves. This is a standard and well-established method used by economists to value resources such as water that have an explicit monetary cost.

A constant price elasticity of demand is estimated using a standard equation:

$$w = kc^{(-\varepsilon)}$$

where:

- w is equal to average monthly residential water use for a given water user group measured in thousands of gallons;
- k is a constant intercept;
- c is the average cost of water per 1,000 gallons; and
- ε is the price elasticity of demand.

Price elasticities (-0.30 for indoor water use and -0.50 for outdoor use) are based on a study by Bell et al.[9] that surveyed 1,400 water utilities in Texas that serve at least 1,000 people to estimate demand elasticity for several variables including price, income, weather etc. Costs of water and average use per month per household are based on data from the Texas Municipal League's annual water and wastewater rate surveys - specifically average monthly household expenditures on water and wastewater

[9] Bell, D.R. and Griffin, R.C. “*Community Water Demand in Texas as a Century is Turned*.” Research contract report prepared for the Texas Water Development Board. May 2006.

in different communities across the state. After examining variance in costs and usage, three different categories of water user groups based on population (population less than 5,000, cities with populations ranging from 5,000 to 99,999 and cities with populations exceeding 100,000) were selected to serve as proxy values for municipal water groups that meet the criteria (Table 5).[10]

Table 5: Water Use and Costs Parameters Used to Estimated Water Demand Functions
(average monthly costs per acre-foot for delivered water and average monthly use per household)

Community Population	Water	Wastewater	Total monthly cost	Avg. monthly use (gallons)
Less than or equal to 5,000	$1,335	$1,228	$2,563	6,204
5,000 to 100,000	$1,047	$1,162	$2,209	7,950
Great than or equal to 100,000	$718	$457	$1,190	8,409

Source: Based on annual water and wastewater rate surveys published by the Texas Municipal League.

As an example, Table 6 shows the economic impact per acre-foot of domestic water needs for municipal water user groups with population exceeding 100,000 people. There are several important assumptions incorporated in the calculations:

1) Reported values are net of the variable costs of treatment and distribution such as expenses for chemicals and electricity since using less water involves some savings to consumers and utilities alike; and for outdoor uses we do not include any value for wastewater.

2) Outdoor and "non-essential" water uses would be eliminated before indoor water consumption was affected, which is logical because most water utilities in Texas have drought contingency plans that generally specify curtailment or elimination of outdoor water use during droughts.[11] Determining how much water is used for outdoor purposes is based on several secondary sources. The first is a major study sponsored by the American Water Works Association, which surveyed cities in states including Colorado, Oregon, Washington, California, Florida and Arizona. On average across all cities surveyed 58 percent of single family residential water use was for outdoor activities. In cities with climates comparable to large metropolitan areas of Texas, the average was 40 percent.[12] Earlier findings of the U.S. Water Resources Council showed a national

[10] Ideally, one would want to estimate demand functions for each individual utility in the state. However, this would require an enormous amount of time and resources. For planning purposes, we believe the values generated from aggregate data are more than sufficient.

[11] In Texas, state law requires retail and wholesale water providers to prepare and submit plans to the Texas Commission on Environmental Quality (TCEQ). Plans must specify demand management measures for use during drought including curtailment of "non-essential water uses." Non-essential uses include, but are not limited to, landscape irrigation and water for swimming pools or fountains. For further information see the Texas Environmental Quality Code §288.20.

[12] See, Mayer, P.W., DeOreo, W.B., Opitz, E.M., Kiefer, J.C., Davis, W., Dziegielewski, D., Nelson, J.O. "*Residential End Uses of Water*." Research sponsored by the American Water Works Association and completed by Aquacraft, Inc. and Planning and Management Consultants, Ltd. (PMCL@CDM).

average of 33 percent. Similarly, the United States Environmental Protection Agency (USEPA) estimated that landscape watering accounts for 32 percent of total residential and commercial water use on annual basis.[13] A study conducted for the California Urban Water Agencies (CUWA) calculated average annual values ranging from 25 to 35 percent.[14] Unfortunately, there does not appear to be any comprehensive research that has estimated non-agricultural outdoor water use in Texas. As an approximation, an average annual value of 30 percent based on the above references was selected to serve as a rough estimate in this study.

3) As shortages approach 100 percent values become immense and theoretically infinite at 100 percent because at that point death would result, and willingness to pay for water is immeasurable. Thus, as shortages approach 80 percent of monthly consumption, we assume that households and non-water intensive commercial businesses (those that use water only for drinking and sanitation would have water delivered by tanker truck or commercial water delivery companies. Based on reports from water companies throughout the state, we estimate that the cost of trucking in water is around $21,000 to $27,000 per acre-feet assuming a hauling distance of between 20 to 60 miles. This is not an unreasonable assumption. The practice was widespread during the 1950s drought and recently during droughts in this decade. For example, in 2000 at the heels of three consecutive drought years Electra - a small town in North Texas - was down to its last 45 days worth of reservoir water when rain replenished the lake, and the city was able to refurbish old wells to provide supplemental groundwater. At the time, residents were forced to limit water use to 1,000 gallons per person per month - less than half of what most people use - and many were having water delivered to their homes by private contractors.[15] In 2003 citizens of Ballinger, Texas, were also faced with a dwindling water supply due to prolonged drought. After three years of drought, Lake Ballinger, which supplies water to more than 4,300 residents in Ballinger and to 600 residents in nearby Rowena, was almost dry. Each day, people lined up to get water from a well in nearby City Park. Trucks hauling trailers outfitted with large plastic and metal tanks hauled water to and from City Park to Ballinger.[16]

[13] U.S. Environmental Protection Agency. *"Cleaner Water through Conservation*." USEPA Report no. 841-B-95-002. April, 1995.

[14] Planning and Management Consultants, Ltd. "*Evaluating Urban Water Conservation Programs: A Procedures Manual*." Prepared for the California Urban Water Agencies. February 1992.

[15] Zewe, C. "*Tap Threatens to Run Dry in Texas Town*." July 11, 2000. CNN Cable News Network.

[16] Associated Press, "*Ballinger Scrambles to Finish Pipeline before Lake Dries Up*." May 19, 2003.

Table 6: Economic Losses Associated with Domestic Water Shortages in Communities with Populations Exceeding 100,000 people				
Water shortages as a percentage of total monthly household demands	**No. of gallons remaining per household per day**	**No of gallons remaining per person per day**	**Economic loss (per acre-foot)**	**Economic loss (per gallon)**
1%	278	93	$748	$0.00005
5%	266	89	$812	$0.0002
10%	252	84	$900	$0.0005
15%	238	79	$999	$0.0008
20%	224	75	$1,110	$0.0012
25%	210	70	$1,235	$0.0015
30%[a]	196	65	$1,699	$0.0020
35%	182	61	$3,825	$0.0085
40%	168	56	$4,181	$0.0096
45%	154	51	$4,603	$0.011
50%	140	47	$5,109	$0.012
55%	126	42	$5,727	$0.014
60%	112	37	$6,500	$0.017
65%	98	33	$7,493	$0.02
70%	84	28	$8,818	$0.02
75%	70	23	$10,672	$0.03
80%	56	19	$13,454	$0.04
85%	42	14	$18,091 ($24,000)[b]	$0.05 ($0.07)[b]
90%	28	9	$27,363 ($24,000)	$0.08 ($0.07)
95%	14	5	$55,182 ($24,000)	$0.17 ($0.07)
99%	3	0.9	$277,728 ($24,000)	$0.85 ($0.07)
99.9%	1	0.5	$2,781,377 ($24,000)	$8.53 ($0.07)
100%	0	0	Infinite ($24,000)	Infinite ($0.07)

[a] The first 30 percent of needs are assumed to be restrictions of outdoor water use; when needs reach 30 percent of total demands all outdoor water uses would be restricted. Needs greater than 30 percent include indoor use

[b] As shortages approach 100 percent the value approaches infinity assuming there are not alternatives available; however, we assume that communities would begin to have water delivered by tanker truck at an estimated cost of $24,000 per acre-foot when shortages breached 85 percent.

Commercial Businesses

Effects of water shortages on commercial sectors were estimated in a fashion similar to other business sectors meaning that water shortages would affect the ability of these businesses to operate. This is particularly true for “water intensive” commercial sectors that are need large amounts of water (in addition to potable and sanitary water) to provide their services. These include:

- car-washes,
- laundry and cleaning facilities,
- sports and recreation clubs and facilities including race tracks,
- amusement and recreation services,
- hospitals and medical facilities,
- hotels and lodging places, and
- eating and drinking establishments.

A key assumption is that commercial operations would not be affected until water shortages were at least 50 percent of total municipal demand. In other words, we assume that residential water consumers would reduce water use including all non-essential uses before businesses were affected.

An example will illustrate the breakdown of municipal water needs and the overall approach to estimating impacts of municipal needs. Assume City A experiences an unexpected shortage of 50 acre-feet per year when their demands are 200 acre-feet per year. Thus, shortages are only 25 percent of total municipal use and residents of City A could eliminate needs by restricting landscape irrigation. City B, on the other hand, has a deficit of 150 acre-feet in 2020 and a projected demand of 200 acre-feet. Thus, total shortages are 75 percent of total demand. Emergency outdoor and some indoor conservation measures could eliminate 50 acre-feet of projected needs, yet 50 acre-feet would still remain. To eliminate” the remaining 50 acre-feet water intensive commercial businesses would have to curtail operations or shut down completely.

Three other areas were considered when analyzing municipal water shortages: 1) lost revenues to water utilities, 2) losses to the horticultural and landscaping industries stemming for reduction in water available for landscape irrigation, and 3) lost revenues and related economic impacts associated with reduced water related recreation.

Water Utility Revenues

Estimating lost water utility revenues was straightforward. We relied on annual data from the “*Water and Wastewater Rate Survey*” published annually by the Texas Municipal League to calculate an average value per acre-foot for water and sewer. For water revenues, average retail water and sewer rates multiplied by total water needs served as a proxy. For lost wastewater, total unmet needs were adjusted for return flow factor of 0.60 and multiplied by average sewer rates for the region. Needs reported as “county-other” were excluded under the presumption that these consist primarily of self-supplied water uses. In addition, 15 percent of water demand and needs are considered non-billed or “unaccountable” water that comprises things such as leakages and water for municipal government functions (e.g., fire departments). Lost tax receipts are based on current rates for the “miscellaneous gross receipts tax, “which the state collects from utilities located in most incorporated cities or towns in Texas. We do not include lost water utility revenues when aggregating impacts of municipal water shortages to regional and state levels to prevent double counting.

Horticultural and Landscaping Industry

The horticultural and landscaping industry, also referred to as the "green Industry," consists of businesses that produce, distribute and provide services associated with ornamental plants, landscape and garden supplies and equipment. Horticultural industries often face big losses during drought. For example, the recent drought in the Southeast affecting the Carolinas and Georgia horticultural and landscaping businesses had a harsh year. Plant sales were down, plant mortality increased, and watering costs increased. Many businesses were forced to close locations, lay off employees, and even file for bankruptcy. University of Georgia economists put statewide losses for the industry at around $3.2 billion during the 3-year drought that ended in 2008.[17] Municipal restrictions on outdoor watering play a significant role. During drought, water restrictions coupled with persistent heat has a psychological effect on homeowners that reduces demands for landscaping products and services. Simply put, people were afraid to spend any money on new plants and landscaping.

In Texas, there do not appear to be readily available studies that analyze the economic effects of water shortages on the industry. However, authors of this report believe negative impacts do and would result in restricting landscape irrigation to municipal water consumers. The difficulty in measuring them is two-fold. First, as noted above, data and research for these types of impacts that focus on Texas are limited; and second, economic data provided by IMPLAN do not disaggregate different sectors of the green industry to a level that would allow for meaningful and defensible analysis.[18]

Recreational Impacts

Recreational businesses often suffer when water levels and flows in rivers, springs and reservoirs fall significantly during drought. During droughts, many boat docks and lake beaches are forced to close, leading to big losses for lakeside business owners and local communities. Communities adjacent to popular river and stream destinations such as Comal Springs and the Guadalupe River also see their business plummet when springs and rivers dry up. Although there are many examples of businesses that have suffered due to drought, dollar figures for drought-related losses to the recreation and tourism industry are not readily available, and very difficult to measure without extensive local surveys. Thus, while they are important, economic impacts are not measured in this study.

Table 7 summarizes impacts of municipal water shortages at differing levels of magnitude, and shows the ranges of economic costs or losses per acre-foot of shortage for each level.

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[17] Williams, D. *"Georgia landscapers eye rebound from Southeast drought."* Atlanta Business Chronicle, Friday, June 19, 2009

[18] Economic impact analyses prepared by the TWDB for 2006 regional water plans did include estimates for the horticultural industry. However, year 2000 and prior IMPLAN data were disaggregated to a finer level. In the current dataset (2006), the sector previously listed as "Landscaping and Horticultural Services" (IMPLAN Sector 27) is aggregated into "Services to Buildings and Dwellings" (IMPLAN Sector 458).

Table 7: Impacts of Municipal Water Shortages at Different Magnitudes of Shortages		
Water shortages as percent of total municipal demands	Impacts	Economic costs per acre-foot*
0-30%	✓ Lost water utility revenues ✓ Restricted landscape irrigation and non-essential water uses	\$730 - \$2,040
30-50%	✓ Lost water utility revenues ✓ Elimination of landscape irrigation and non-essential water uses ✓ Rationing of indoor use	\$2,040 - \$10,970
>50%	✓ Lost water utility revenues ✓ Elimination of landscape irrigation and non-essential water uses ✓ Rationing of indoor use ✓ Restriction or elimination of commercial water use ✓ Importing water by tanker truck	\$10,970 - varies
*Figures are rounded		

1.1.4 Industrial Water User Groups

Manufacturing

Impacts to manufacturing were estimated by distributing water shortages among industrial sectors at the county level. For example, if a planning group estimates that during a drought of record water supplies in County A would only meet 50 percent of total annual demands for manufactures in the county, we reduced output for each sector by 50 percent. Since projected manufacturing demands are based on TWDB Water Uses Survey data for each county, we only include IMPLAN sectors represented in the TWBD survey database. Some sectors in IMPLAN databases are not part of the TWDB database given that they use relatively small amounts of water - primarily for on-site sanitation and potable purposes. To maintain consistency between IMPLAN and TWDB databases, Standard Industrial Classification (SIC) codes both databases were cross referenced in county with shortages. Non-matches were excluded when calculating direct impacts.

Mining

The process of mining is very similar to that of manufacturing. We assume that within a given county, shortages would apply equally to relevant mining sectors, and IMPLAN sectors are cross referenced with TWDB data to ensure consistency.

In Texas, oil and gas extraction and sand and gravel (aggregates) operations are the primary mining industries that rely on large volumes of water. For sand and gravel, estimated output reductions are straightforward; however, oil and gas is more complicated for a number of reasons. IMPLAN does not necessarily report the physical extraction of minerals by geographic local, but rather the sales revenues reported by a particular corporation.

For example, at the state level revenues for IMPLAN sector 19 (oil and gas extraction) and sector 27 (drilling oil and gas wells) totals $257 billion. Of this, nearly $85 billion is attributed to Harris County. However, only a very small fraction (less than one percent) of actual production takes place in the county. To measure actual potential losses in well head capacity due to water shortages, we relied on county level production data from the Texas Railroad Commission (TRC) and average well-head market prices for crude and gas to estimate lost revenues in a given county. After which, we used to IMPLAN ratios to estimate resultant losses in income and employment.

Other considerations with respect to mining include:

> 1) Petroleum and gas extraction industry only uses water in significant amounts for secondary recovery. Known in the industry as enhanced or water flood extraction, secondary recovery involves pumping water down injection wells to increase underground pressure thereby pushing oil or gas into other wells. IMPLAN output numbers do not distinguish between secondary and non-secondary recovery. To account for the discrepancy, county-level TRC data that show the proportion of barrels produced using secondary methods were used to adjust IMPLAN data to reflect only the portion of sales attributed to secondary recovery.
>
> 2) A substantial portion of output from mining operations goes directly to businesses that are classified as manufacturing in our schema. Thus, multipliers measuring backward linkages for a given manufacturer might include impacts to a supplying mining operation. Care was taken not to double count in such situations if both a mining operation and a manufacturer were reported as having water shortages.

Steam-electric

At minimum without adequate cooling water, power plants cannot safely operate. As water availability falls below projected demands, water levels in lakes and rivers that provide cooling water would also decline. Low water levels could affect raw water intakes and outfalls at electrical generating units in several ways. For one, power plants are regulated by thermal emission guidelines that specify the maximum amount of heat that can go back into a river or lake via discharged cooling water. Low water levels could result in permit compliance issues due to reduced dilution and dispersion of heat and subsequent impacts on aquatic biota near outfalls.[19] However, the primary concern would be a loss of head (i.e., pressure) over intake structures that would decrease flows through intake tunnels. This would affect safety related pumps, increase operating costs and/or result in sustained shut-downs. Assuming plants did shutdown, they would not be able to generate electricity.

[19] Section 316 (b) of the Clean Water Act requires that thermal wastewater discharges do not harm fish and other wildlife.

Among all water use categories steam-electric is unique and cautions are needed when applying methods used in this study. Measured changes to an economy using input-output models stem directly from changes in sales revenues. In the case of water shortages, one assumes that businesses will suffer lost output if process water is in short supply. For power generation facilities this is true as well. However, the electric services sector in IMPLAN represents a corporate entity that may own and operate several electrical generating units in a given region. If one unit became inoperable due to water shortages, plants in other areas or generation facilities that do not rely heavily on water such as gas powered turbines might be able to compensate for lost generating capacity. Utilities could also offset lost production via purchases on the spot market.[20] Thus, depending upon the severity of the shortages and conditions at a given electrical generating unit, energy supplies for local and regional communities could be maintained. But in general, without enough cooling water, utilities would have to throttle back plant operations, forcing them to buy or generate more costly power to meet customer demands.

Measuring impacts end users of electricity is not part of this study as it would require extensive local and regional level analysis of energy production and demand. To maintain consistency with other water user groups, impacts of steam-electric water shortages are measured in terms of lost revenues (and hence income) and jobs associated with shutting down electrical generating units.

1.2 Social Impacts of Water Shortages

As the name implies, the effects of water shortages can be social or economic. Distinctions between the two are both semantic and analytical in nature – more so analytic in the sense that social impacts are harder to quantify. Nevertheless, social effects associated with drought and water shortages are closely tied to economic impacts. For example, they might include:

- demographic effects such as changes in population,
- disruptions in institutional settings including activity in schools and government,
- conflicts between water users such as farmers and urban consumers,
- health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations),
- mental and physical stress (e.g., anxiety, depression, domestic violence),
- public safety issues from forest and range fires and reduced fire fighting capability,
- increased disease caused by wildlife concentrations,
- loss of aesthetic and property values, and
- reduced recreational opportunities.[21]

[20] Today, most utilities participate in large interstate "power pools" and can buy or sell electricity "on the grid" from other utilities or power marketers. Thus, assuming power was available to buy, and assuming that no contractual or physical limitations were in place such as transmission constraints; utilities could offset lost power that resulted from waters shortages with purchases via the power grid.

[21] Based on information from the website of the National Drought Mitigation Center at the University of Nebraska Lincoln. Available online at: http://www.drought.unl.edu/risk/impacts.htm. See also, Vanclay, F. "*Social Impact Assessment*." in Petts, J. (ed) International Handbook of Environmental Impact Assessment. 1999.

Social impacts measured in this study focus strictly on demographic effects including changes in population and school enrollment. Methods are based on demographic projection models developed by the Texas State Data Center and used by the TWDB for state and regional water planning. Basically, the social impact model uses results from the economic component of the study and assesses how changes in labor demand would affect migration patterns in a region. Declines in labor demand as measured using adjusted IMPLAN data are assumed to affect net economic migration in a given regional water planning area. Employment losses are adjusted to reflect the notion that some people would not relocate but would seek employment in the region and/or public assistance and wait for conditions to improve. Changes in school enrollment are simply the proportion of lost population between the ages of 5 and 17.

2. Results

Section 2 presents the results of the analysis at the regional level. Included are baseline economic data for each water use category, and estimated economics impacts of water shortages for water user groups with reported deficits. According to the 2011 *Region F Regional Water Plan*, during severe drought irrigation, livestock municipal, manufacturing, mining and steam-electric water user groups would experience water shortages in the absence of new water management strategies.

2.1 Overview of Regional Economy

On an annual basis, the Region F economy generates $20.8 billion worth of gross state product for Texas ($19.1 billion in income and $1.7 billion in business taxes) and supports nearly 227,000 jobs (Table 8). Generating about $9.8 billion in gross state product, agriculture, manufacturing, and mining are the region's primary base economic sectors.[22] Municipal sectors also generate substantial amounts of income and are major employers in the region; however, many businesses that make up the municipal category such as restaurants and retail stores are non-basic industries meaning they exist to provide services to people who work would in base industries. In other words, without base industries, many jobs categorized as municipal would not exist.

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[22] Base industries are those that supply markets outside of the region. These industries are crucial to the local economy and are called the economic base of a region. Appendix A shows how IMPLAN's 529 sectors were allocated to water use category, and shows economic data for each sector.

Table 8: The Region F Economy by Water User Group ($millions)*						
Water Use Category	**Total sales**	**Intermediate sales**	**Final sales**	**Jobs**	**Income**	**Business taxes**
Irrigation	$131.11	$21.48	$109.67	2,267	$68.24	$1.79
Livestock	$801.61	$432.80	$368.82	11,083	$78.45	$11.11
Manufacturing	$8,793.15	$1,386.66	$7,406.49	36,089	$2,613.94	$51.57
Mining	$11,507.80	$5,279.12	$6,228.68	27,668	$6,415.53	$563.76
Steam-electric	$376.64	$105.96	$270.68	932	$261.54	$44.63
Municipal	$15,709.07	$3,801.30	$11,907.77	148,786	$9,682.07	$981.89
Regional total	$37,319.38	$11,027.32	$26,292.11	226,825	$19,119.77	$1,654.75

[a] Appendix 1 displays data for individual IMPLAN sectors that make up each water use category. Based on data from the Texas Water Development Board, and year 2006 data from the Minnesota IMPLAN Group, Inc.

2.2 Impacts of Agricultural Water Shortages

According to the 2011 *Region F Regional Water Plan*, during severe drought most counties in the region would experiences shortages of irrigation water ranging anywhere from about 5 to 90 percent of total annual irrigation demands. Shortages of these magnitudes would reduce gross state product (income plus state and local business taxes) by about $30 to 35 million depending upon the decade Table 9).

Table 9: Economic Impacts of Water Shortages for Irrigation Water User Groups ($millions)			
Decade	**Lost income from reduced crop production ***	**Lost state and local tax revenues from reduced crop production**	**Lost jobs from reduced crop production**
2010	$34.97	$1.70	454
2020	$34.45	$1.68	448
2030	$33.89	$1.65	442
2040	$33.02	$1.61	432
2050	$32.48	$1.58	426
2060	$31.97	$1.56	419

*Changes to income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.3 Impacts of Municipal Water Shortages

Water shortages are projected to occur in a significant number of communities throughout the region, and deficits range anywhere from 1 to 100 percent of total annual water demands. At the regional level, the estimated economic value of domestic water shortages totals $164 million in 2010 and $446 million in 2060 (Table 10). Due to curtailment of commercial business activity, municipal shortages would also reduce gross state product (income plus taxes) by $40 million in 2010 and $433 million in 2060.

Table 10: Economic Impacts of Water Shortages for Municipal Water User Groups ($millions)

Decade	Monetary value of domestic water shortages	Lost income from reduced commercial business activity*	Lost state and local taxes from reduced commercial business activity	Lost jobs from reduced commercial business activity	Lost water utility revenues
2010	$164.31	$35.84	1,165	$3.58	$22.60
2020	$244.46	$36.34	1,180	$3.64	$38.89
2030	$275.39	$119.12	3,208	$9.52	$48.62
2040	$363.08	$366.53	9,367	$27.34	$62.99
2050	$432.97	$386.74	9,940	$29.00	$67.58
2060	$446.11	$403.41	10,360	$30.22	$72.94

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.4 Impacts of Manufacturing Water Shortages

Manufacturing water shortages are projected to occur in the counties of Coleman, Ector, Howard, Kimble, Runnels, and Tom Green. Projected shortages would reduce gross state product (income plus taxes) by an estimated $891 million in 2020 and $1,356 million in 2060 (Table 11).

Table 11: Economic Impacts of Water Shortages for Manufacturing Water User Groups ($millions)			
Decade	**Lost income due to reduced manufacturing output***	**Lost state and local business tax revenues due to reduced manufacturing output**	**Lost jobs due to reduced manufacturing output**
2010	$829.61	$62.12	15,723
2020	$936.77	$69.97	17,705
2030	$994.28	$75.07	19,076
2040	$1,092.03	$82.10	20,836
2050	$1,166.59	$87.70	22,261
2060	$1,261.31	$94.74	24,041

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.5 Impacts of Mining Water Shortages

Mining water shortages are projected to occur in Coleman, Coke, and Howard counties, and would primarily affect oil extraction. Combined shortages for each county would result in estimated losses of gross state product totaling $13.5 million dollars in 2010 and $11.0 million 2060 (Table 12).

Table 12: Economic Impacts of Water Shortages for Mining Water User Groups ($millions)			
Decade	**Lost income due to reduced mining output***	**Lost state and local business tax revenues due to reduced mining output**	**Lost jobs due to reduced mining output**
2010	$12.50	$0.94	78
2020	$16.04	$1.21	101
2030	$2.26	$0.14	13
2040	$4.75	$0.33	29
2050	$6.70	$0.49	41
2060	$9.83	$0.73	61

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.6 Impacts of Steam-electric Water Shortages

Water shortages for electrical generating units are projected in Coke, Ector, Mitchell, Tom Green and Ward counties resulting in estimated losses of gross state product totaling $607 million dollars in 2010, and $2,017 billion in 2060 (Table 13).

Table 13: Economic Impacts of Water Shortages for Steam-electric Water User Groups ($millions)			
Decade	**Lost income due to reduced electrical generation***	**Lost state and local business tax revenues due to reduced electrical generation**	**Lost jobs due to reduced electrical generation**
2010	$530.83	$76.19	1,805
2020	$691.34	$99.23	2,350
2030	$1,045.50	$150.07	3,554
2040	$1,232.24	$176.87	4,189
2050	$1,468.65	$210.80	4,993
2060	$1,763.75	$253.16	5,996

*Changes to Income and business taxes are collectively equivalent to a decrease in gross state product, which is analogous to gross domestic product measured at the state rather than national level. Appendix 2 shows results by water user group.

2.7 Social Impacts of Water Shortages

As discussed previously, social impacts focus on changes in population and school enrollment in the region. In 2010, estimated population losses total 25,050 with corresponding reductions in school enrollment of 7,065 students (Table 15). In 2060, population would decline by 49,236 and school enrollment would fall by 9,106.

Table 15: Social Impacts of Water Shortages (2010-2060)		
Year	**Population Losses**	**Declines in School Enrollment**
2010	25,050	7,065
2020	26,239	7,444
2030	31,670	8,389
2040	41,980	7,759
2050	45,362	8,378
2060	49,236	9,106

2.8 Distribution of Impacts by Major River Basin

Administrative rules require that impacts are presented by both planning region and major river basin. To meet rule requirements, impacts were allocated among basins based on the distribution of water shortages in relevant basins. For example, if 50 percent of water shortages in River Basin A and 50 percent occur in River Basin B, then impacts were split equally among the two basins. Table 16 displays the results.

Table 16: Distribution of Impacts by Major River Basin (2010-2060)

River Basin	2010	2020	2030	2040	2050	2060
Brazos	1%	1%	1%	1%	1%	1%
Colorado	80%	82%	82%	83%	83%	83%
Rio Grande	19%	17%	17%	16%	16%	16%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Appendix 1: Economic Data for Individual IMPLAN Sectors

Economic Data for Agricultural Water User Groups ($millions)

Water Use Category	IMPLAN Sector	IMPLAN Code	Total Sales	Intermediate Sales	Final Sales	Jobs	Income	Business Taxes
Irrigation	Cotton Farming	8	$53.73	$0.73	$53.04	919	$19.78	$0.48
Irrigation	Vegetable and Melon Farming	3	$27.14	$0.97	$26.17	233	$19.84	$0.24
Irrigation	Tree Nut Farming	4	$19.17	$1.01	$18.16	376	$13.34	$0.46
Irrigation	All "Other" Crop Farming	10	$18.30	$16.92	$1.38	206	$8.98	$0.35
Irrigation	Grain Farming	2	$8.96	$1.29	$7.67	446	$4.14	$0.16
Irrigation	Fruit Farming	5	$3.75	$0.57	$3.18	85	$2.13	$0.08
Irrigation	Oilseed Farming	1	$0.07	$0.00	$0.07	2	$0.03	$0.00
Livestock	Cattle ranching and farming	11	$401.54	$278.43	$123.11	7,838	$31.72	$8.44
Livestock	Animal- except poultry- slaughtering	67	$315.06	$84.24	$230.82	832	$31.15	$1.73
Livestock	Animal production- except cattle and poultry	13	$54.48	$46.20	$8.29	2,237	$5.30	$0.84
Livestock	Poultry and egg production	12	$30.53	$23.93	$6.60	176	$10.28	$0.10
	Total Agriculture		$932.73	$454.27	$478.50	13,350	$146.68	$12.90

Based on year 2006 data from the Minnesota IMPLAN Group, Inc.

Economic Data for Mining and Steam-electric Water User Groups ($millions)

Water Use Category	IMPLAN Sector	IMPLAN Code	Total Sales	Intermediate Sales	Final Sales	Jobs	Income	Business Taxes
Mining	Oil and gas extraction	19	$5,205.54	$4,834.32	$371.22	8,214	$3,001.63	$308.29
Mining	Drilling oil and gas wells	27	$3,371.52	$16.83	$3,354.69	5,299	$997.63	$131.53
Mining	Support activities for oil and gas operations	28	$2,408.86	$334.58	$2,074.28	11,698	$2,184.47	$98.47
Mining	Stone mining and quarrying	24	$348.51	$35.86	$312.65	2,055	$178.44	$13.95
Mining	Natural gas distribution	31	$134.21	$53.79	$80.42	261	$31.27	$10.24
Mining	Sand- gravel- clay- and refractory mining	25	$22.60	$2.39	$20.21	85	$13.55	$0.67
Mining	Other nonmetallic mineral mining	26	$13.05	$1.30	$11.74	30	$7.39	$0.49
Mining	Support activities for other mining	29	$3.52	$0.05	$3.47	26	$1.16	$0.14
Total Mining	NA		$11,507.80	$5,279.12	$6,228.68	27,668	$6,415.53	$563.76
Steam-electric	Power generation and supply		$376.64	$105.96	$270.68	932	$261.54	$44.63

Based on year 2006 data from the Minnesota IMPLAN Group, Inc.

Economic Data for Manufacturing Water User Groups ($millions)

Water Use Category	IMPLAN Sector	IMPLAN Code	Total Sales	Intermediate Sales	Final Sales	Jobs	Income	Business Taxes
Manufacturing	Petroleum refineries	142	$1,416.82	$526.63	$890.19	156	$154.70	$5.98
Manufacturing	New residential one-unit structures- all	33	$851.38	$0.00	$851.38	5,727	$282.36	$4.44
Manufacturing	Oil and gas field machinery and equipment	261	$523.73	$19.50	$504.22	1,465	$124.96	$2.54
Manufacturing	Other aluminum rolling and drawing	213	$482.71	$13.42	$469.30	642	$68.79	$2.74
Manufacturing	Commercial and institutional buildings	38	$479.41	$0.00	$479.41	4,993	$242.23	$2.98
Manufacturing	Air and gas compressor manufacturing	289	$392.54	$4.04	$388.51	911	$128.34	$2.41
Manufacturing	Vitreous china plumbing fixture manufacturing	182	$370.11	$19.16	$350.94	1,581	$194.11	$3.58
Manufacturing	Prefabricated metal buildings and components	232	$244.97	$12.30	$232.68	1,032	$50.43	$1.18
Manufacturing	Other new construction	41	$209.12	$0.00	$209.12	2,290	$112.29	$0.88
Manufacturing	Other miscellaneous chemical products	171	$149.55	$78.24	$71.31	333	$26.61	$0.65
Manufacturing	Synthetic rubber manufacturing	153	$148.58	$3.64	$144.94	199	$34.04	$0.82
Manufacturing	Asphalt paving mixture and blocks	143	$140.29	$125.83	$14.46	211	$27.81	$0.15
Manufacturing	Machine shops	243	$134.79	$32.53	$102.26	860	$70.03	$1.12
Manufacturing	Fabricated structural metal manufacturing	233	$121.00	$6.27	$114.74	482	$41.45	$0.67
Manufacturing	New residential additions and alterations-all	35	$120.95	$0.00	$120.95	682	$44.73	$0.63
Manufacturing	Cement manufacturing	191	$120.37	$0.32	$120.05	202	$53.57	$1.09
Manufacturing	Plastics pipe- fittings- and profile shapes	173	$116.14	$71.44	$44.70	310	$35.38	$0.80
Manufacturing	Plate work manufacturing	234	$110.15	$6.93	$103.21	446	$43.92	$0.57
Manufacturing	Iron- steel pipe and tubes	205	$107.02	$7.47	$99.55	209	$37.69	$0.96
Manufacturing	Motor vehicle parts manufacturing	350	$104.97	$8.44	$96.53	279	$26.82	$0.49
Manufacturing	Highway- street- bridge- and tunnel construct	39	$103.00	$0.00	$103.00	967	$51.86	$0.66
Manufacturing	Soft drink and ice manufacturing	85	$93.76	$5.24	$88.52	161	$7.92	$0.35
Manufacturing	New multifamily housing structures	34	$92.77	$0.00	$92.77	832	$43.47	$0.25
Manufacturing	Cut and sew apparel manufacturing	107	$76.34	$2.07	$74.27	541	$26.77	$0.43
Manufacturing	Water- sewer- and pipeline construction	40	$74.90	$0.00	$74.90	630	$33.22	$0.48
Manufacturing	Paperboard container manufacturing	126	$74.18	$0.79	$73.39	241	$18.19	$0.71
Manufacturing	Household vacuum cleaner manufacturing	328	$73.63	$2.78	$70.84	263	$24.46	$0.55
Manufacturing	All other manufacturing	various	$1,859.96	$439.61	$1,420.35	9,444	$607.80	$13.47
	Total manufacturing		**$8,793.15**	**$1,386.66**	**$7,406.49**	**36,089**	**$2,613.94**	**$51.57**

Based on year 2006 data from the Minnesota IMPLAN Group, Inc.

Economic Data for Municipal Water User Groups ($millions)								
Water Use Category	**IMPLAN Sector**	**IMPLAN Code**	**Total Sales**	**Intermediate Sales**	**Final Sales**	**Jobs**	**Income**	**Business Taxes**
Municipal	Wholesale trade	390	$2,098.95	$1,004.90	$1,094.05	12,934	$1,105.37	$310.12
Municipal	Owner-occupied dwellings	509	$1,892.34	$0.00	$1,892.34	0	$1,465.93	$223.76
Municipal	State & Local Education	503	$1,254.80	$0.00	$1,254.79	31,837	$1,254.80	$0.00
Municipal	Telecommunications	422	$965.38	$331.59	$633.79	3,360	$362.46	$60.38
Municipal	Food services and drinking places	481	$928.45	$118.56	$809.89	19,811	$373.53	$43.64
Municipal	Monetary authorities and depository credit in	430	$736.91	$242.70	$494.21	4,003	$517.47	$9.43
Municipal	State & Local Non-Education	504	$729.16	$0.00	$729.16	13,857	$729.16	$0.00
Municipal	Offices of physicians- dentists- and other he	465	$692.35	$0.00	$692.35	6,505	$486.53	$4.26
Municipal	Pipeline transportation	396	$617.24	$269.94	$347.30	801	$204.11	$43.20
Municipal	Truck transportation	394	$524.82	$284.17	$240.64	4,007	$240.77	$5.45
Municipal	Hospitals	467	$508.85	$0.00	$508.85	4,933	$252.98	$3.23
Municipal	Motor vehicle and parts dealers	401	$498.77	$54.24	$444.54	4,626	$257.34	$72.89
Municipal	Machinery and equipment rental and leasing	434	$433.59	$235.80	$197.78	1,401	$175.66	$6.14
Municipal	Real estate	431	$414.65	$164.14	$250.51	2,447	$240.10	$50.89
Municipal	Commercial machinery repair and maintenance	485	$413.71	$217.81	$195.90	2,466	$216.38	$15.81
Municipal	Architectural and engineering services	439	$402.20	$253.54	$148.67	3,640	$201.97	$1.68
Municipal	General merchandise stores	410	$375.62	$39.59	$336.03	7,016	$167.88	$53.50
Municipal	Other State and local government enterprises	499	$356.82	$116.19	$240.62	1,797	$121.61	$0.04
Municipal	Federal Military	505	$312.73	$0.00	$312.73	4,027	$312.73	$0.00
Municipal	Food and beverage stores	405	$283.68	$37.93	$245.75	5,296	$142.16	$31.15
Municipal	Federal Non-Military	506	$261.85	$0.00	$261.84	1,655	$261.84	$0.00
Municipal	Nursing and residential care facilities	468	$260.81	$0.00	$260.81	5,608	$161.88	$3.82
Municipal	Legal services	437	$258.66	$164.16	$94.50	2,162	$161.43	$5.06
Municipal	Management of companies and enterprises	451	$243.64	$229.12	$14.52	1,331	$136.89	$2.19
Municipal	Gasoline stations	407	$243.12	$36.92	$206.19	3,266	$131.09	$35.27
Municipal	All other municipal	various	$5,964.80	$2,337.40	$3,627.40	95,011	$2,952.30	$228.33
Municipal	Total municipal		$15,709.07	$3,801.30	$11,907.77	148,786	$9,682.07	$981.89
Based on year 2006 data from the Minnesota IMPLAN Group, Inc.								

Appendix 2: Impacts by Water User Group

Irrigation cont. ($millions)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Andrews County						
Reduced income from curtailed crop production	$2.6873	$2.6810	$2.6522	$2.3621	$2.3197	$2.2847
Reduced business taxes from curtailed crop production	$0.1093	$0.1090	$0.1079	$0.0961	$0.0943	$0.0929
Reduced jobs from curtailed crop production	33	33	33	29	29	28
Borden County						
Reduced income from curtailed crop production	$0.49	$0.49	$0.49	$0.49	$0.49	$0.49
Reduced business taxes from curtailed crop production	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
Reduced jobs from curtailed crop production	6	6	6	6	6	6
Brown County						
Reduced income from curtailed crop production	$1.31	$1.31	$1.31	$1.30	$1.30	$1.30
Reduced business taxes from curtailed crop production	$0.06	$0.06	$0.06	$0.06	$0.06	$0.06
Reduced jobs from curtailed crop production	31	31	31	31	31	31
Coke County						
Reduced income from curtailed crop production	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03
Reduced business taxes from curtailed crop production	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Reduced jobs from curtailed crop production	1	1	1	1	1	1
Coleman County						
Reduced income from curtailed crop production	$0.23	$0.23	$0.23	$0.23	$0.23	$0.23
Reduced business taxes from curtailed crop production	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01
Reduced jobs from curtailed crop production	6	6	6	6	6	6
Glasscock County						
Reduced income from curtailed crop production	$12.24	$12.06	$11.88	$11.69	$11.51	$11.33
Reduced business taxes from curtailed crop production	$0.60	$0.59	$0.58	$0.57	$0.56	$0.55
Reduced jobs from curtailed crop production	142	140	138	136	134	132

Irrigation cont. ($millions)						
	2010	2020	2030	2040	2050	2060
Irion County						
Reduced income from curtailed crop production	$0.13	$0.12	$0.12	$0.11	$0.11	$0.10
Reduced business taxes from curtailed crop production	$0.003	$0.003	$0.003	$0.003	$0.003	$0.003
Reduced jobs from curtailed crop production	2	2	2	1	1	1
Martin County						
Reduced income from curtailed crop production	$0.26	$0.19	$0.11	$0.00	$0.00	$0.00
Reduced business taxes from curtailed crop production	$0.01	$0.01	$0.00	$0.00	$0.00	$0.00
Reduced jobs from curtailed crop production	5	5	5	5	4	4
Menard County						
Reduced income from curtailed crop production	$0.46	$0.46	$0.45	$0.45	$0.44	$0.44
Reduced business taxes from curtailed crop production	$0.03	$0.03	$0.03	$0.02	$0.02	$0.02
Reduced jobs from curtailed crop production	10	10	10	10	10	10
Midland County						
Reduced income from curtailed crop production	$1.72	$1.73	$1.73	$1.72	$1.71	$1.69
Reduced business taxes from curtailed crop production	$0.09	$0.09	$0.09	$0.09	$0.08	$0.08
Reduced jobs from curtailed crop production	22	22	22	22	22	22
Reagan County						
Reduced income from curtailed crop production	$1.36	$1.31	$1.25	$1.18	$1.11	$1.04
Reduced business taxes from curtailed crop production	$0.07	$0.07	$0.06	$0.06	$0.06	$0.05
Reduced jobs from curtailed crop production	15	14	14	13	12	11
Runnels County						
Reduced income from curtailed crop production	$3.17	$3.09	$3.02	$2.94	$2.87	$2.79
Reduced business taxes from curtailed crop production	$0.16	$0.15	$0.15	$0.15	$0.14	$0.14
Reduced jobs from curtailed crop production	45	44	43	42	41	40
Tom Green County						
Reduced income from curtailed crop production	$0.20	$0.20	$0.20	$0.20	$0.19	$0.19
Reduced business taxes from curtailed crop production	$0.01	$0.01	$0.01	$0.01	$0.01	$0.01
Reduced jobs from curtailed crop production	3	3	3	3	3	3
Upton County						
Reduced income from curtailed crop production	$5.99	$5.96	$5.93	$5.90	$5.86	$5.83
Reduced business taxes from curtailed crop production	$0.30	$0.30	$0.30	$0.29	$0.29	$0.29
Reduced jobs from curtailed crop production	79	78	78	77	77	77

Irrigation cont. ($millions)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Ward County						
Reduced income from curtailed crop production	$0.09	$0.08	$0.10	$0.11	$0.11	$0.11
Reduced business taxes from curtailed crop production	$0.004	$0.004	$0.005	$0.01	$0.01	$0.01
Reduced jobs from curtailed crop production	2	1	2	2	2	2

Manufacturing ($millions)						
	2010	2020	2030	2040	2050	2060
Coleman County						
Reduced income from reduced manufacturing output	$0.78	$0.78	$0.78	$0.78	$0.78	$0.78
Reduced business taxes from reduced manufacturing output	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11
Reduced jobs from reduced manufacturing output	55	55	55	55	55	55
Ector County						
Reduced income from reduced manufacturing output	$14.56	$19.85	$4.30	$15.75	$15.36	$16.23
Reduced business taxes from reduced manufacturing output	$0.71	$0.97	$0.21	$0.77	$0.75	$0.80
Reduced jobs from reduced manufacturing output	147	201	43	159	155	164
Howard County						
Reduced income from reduced manufacturing output	$7.04	$11.97	$0.00	$2.82	$4.93	$8.75
Reduced business taxes from reduced manufacturing output	$0.35	$0.59	$0.00	$0.14	$0.24	$0.43
Reduced jobs from reduced manufacturing output	71	121	0	29	50	89
Kimble County						
Reduced income from reduced manufacturing output	$50.42	$55.11	$59.15	$63.27	$67.02	$72.07
Reduced business taxes from reduced manufacturing output	$2.69	$2.94	$3.16	$3.38	$3.58	$3.84
Reduced jobs from reduced manufacturing output	163	179	192	205	217	234
Runnels County						
Reduced income from reduced manufacturing output	$20.83	$23.14	$25.13	$27.11	$28.76	$31.08
Reduced business taxes from reduced manufacturing output	$1.60	$1.78	$1.93	$2.09	$2.21	$2.39
Reduced jobs from reduced manufacturing output	421	467	508	548	581	628
Tom Green County						
Reduced income from reduced manufacturing output	$735.98	$825.91	$904.93	$982.30	$1,049.74	$1,132.40
Reduced business taxes from reduced manufacturing output	$56.65	$63.58	$69.66	$75.61	$80.81	$87.17
Reduced jobs from reduced manufacturing output	14,865	16,682	18,278	19,840	21,203	22,872

Mining ($millions)						
	2010	2020	2030	2040	2050	2060
Coke County						
Reduced income from reduced mining activity	$2.12	$2.93	$0.05	$0.59	$1.06	$1.77
Reduced business taxes from reduced mining activity	$0.15	$0.20	$0.00	$0.04	$0.07	$0.12
Reduced jobs from reduced mining activity	13	18	0	4	6	11
Coleman County						
Reduced income from reduced mining activity	$1.91	$2.02	$2.02	$2.02	$2.02	$2.02
Reduced business taxes from reduced mining activity	$0.11	$0.12	$0.12	$0.12	$0.12	$0.12
Reduced jobs from reduced mining activity	11	12	12	12	12	12
Howard County						
Reduced income from reduced mining activity	$8.48	$11.09	$0.19	$2.14	$3.63	$6.04
Reduced business taxes from reduced mining activity	$0.68	$0.89	$0.02	$0.17	$0.29	$0.49
Reduced jobs from reduced mining activity	54	71	1	14	23	39

Steam-electric ($millions)						
	2010	2020	2030	2040	2050	2060
Coke County						
Reduced income from reduced electrical generation	$23.08	$18.39	$21.52	$25.24	$29.86	$35.52
Reduced business taxes from reduced electrical generation	$3.31	$2.64	$3.09	$3.62	$4.29	$5.10
Reduced jobs from reduced electrical generation	78	63	73	86	102	121
Ector County						
Reduced income from reduced electrical generation	$31.29	$203.76	$565.96	$759.10	$994.54	$1,281.52
Reduced business taxes from reduced electrical generation	$4.49	$29.25	$81.23	$108.96	$142.75	$183.94
Reduced jobs from reduced electrical generation	106	693	1,924	2,580	3,381	4,356
Mitchell County						
Reduced income from reduced electrical generation	$456.24	$440.25	$424.18	$408.10	$392.11	$376.04
Reduced business taxes from reduced electrical generation	$65.49	$63.19	$60.88	$58.58	$56.28	$53.97
Reduced jobs from reduced electrical generation	1,551	1,497	1,442	1,387	1,333	1,278
Tom Green County						
Reduced income from reduced electrical generation	$20.22	$28.93	$33.85	$39.80	$47.06	$55.92
Reduced business taxes from reduced electrical generation	$2.90	$4.15	$4.86	$5.71	$6.76	$8.03
Reduced jobs from reduced electrical generation	69	98	115	135	160	190
Ward County						
Reduced income from reduced electrical generation	$0.00	$0.00	$0.00	$0.00	$5.07	$14.74
Reduced business taxes from reduced electrical generation	$0.00	$0.00	$0.00	$0.00	$0.73	$2.12
Reduced jobs from reduced electrical generation	0	0	0	0	17	50

Municipal ($millions)	2010	2020	2030	2040	2050	2060
Andrews						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.96	$0.98	$0.99
Lost utility revenues	$0.00	$0.00	$0.00	$1.49	$1.51	$1.53
Ballinger						
Monetary value of domestic water shortages	$7.38	$10.75	$7.67	$8.54	$23.75	$24.94
Lost income from reduced commercial business activity	$3.51	$4.15	$1.67	$1.95	$7.52	$7.90
Lost jobs due to reduced commercial business activity	132	156	63	74	284	298
Lost state and local taxes from reduced commercial business activity	$0.38	$0.45	$0.18	$0.21	$0.82	$0.86
Lost utility revenues	$1.31	$1.49	$1.35	$1.51	$2.33	$2.45
Brady						
Monetary value of domestic water shortages	$8.03	$8.13	$7.99	$7.84	$7.75	$7.75
Lost income from reduced commercial business activity	$1.06	$1.09	$1.05	$1.02	$1.00	$1.00
Lost jobs due to reduced commercial business activity	41	42	40	39	38	38
Lost state and local taxes from reduced commercial business activity	$0.12	$0.13	$0.12	$0.12	$0.12	$0.12
Lost utility revenues	$1.97	$2.00	$1.96	$1.92	$1.90	$1.90
Bronte Village						
Monetary value of domestic water shortages	$0.00	$0.02	$0.03	$0.05	$0.07	$0.09
Lost utility revenues	$0.00	$0.04	$0.06	$0.07	$0.09	$0.11
Coahoma						
Monetary value of domestic water shortages	$0.10	$0.12	$0.001	$0.01	$0.02	$0.04
Lost utility revenues	$0.10	$0.12	$0.002	$0.02	$0.04	$0.06
Coleman						
Monetary value of domestic water shortages	$25.91	$25.58	$25.24	$24.90	$24.66	$24.66
Lost income from reduced commercial business activity	$12.43	$12.28	$12.11	$11.95	$11.83	$11.83
Lost jobs due to reduced commercial business activity	348	344	339	335	332	332
Lost state and local taxes from reduced commercial business activity	$0.96	$0.95	$0.94	$0.92	$0.91	$0.91
Lost utility revenues	$2.54	$2.51	$2.48	$2.45	$2.42	$2.42

Municipal ($millions)						
	2010	2020	2030	2040	2050	2060
County-other (Coke)						
Monetary value of domestic water shortages	$0.04	$0.05	$0.00	$0.01	$0.01	$0.02
County-other (Coleman)						
Monetary value of domestic water shortages	$0.46	$0.43	$0.43	$0.43	$0.43	$0.46
County-other (Kimble)						
Monetary value of domestic water shortages	$0.01	$0.01	$0.003	$0.00	$0.00	$0.00
County-other (Menard)						
Monetary value of domestic water shortages	$0.03	$0.03	$0.03	$0.02	$0.02	$0.03
County-other (Runnels)						
Monetary value of domestic water shortages	$7.92	$6.38	$5.21	$3.96	$3.00	$1.85
County-other (Scurry)						
Monetary value of domestic water shortages	$0.07	$0.08	$0.00	$0.01	$0.03	$0.04
County-other (Tom Green)						
Monetary value of domestic water shortages	$0.04	$0.00	$0.00	$0.00	$0.00	$0.00
County-other (Ward)						
Monetary value of domestic water shortages	$0.00	$3.60	$3.60	$3.60	$3.60	$3.60
Junction						
Monetary value of domestic water shortages	$18.87	$18.85	$18.67	$18.49	$18.35	$18.35
Lost income from reduced commercial business activity	$9.58	$9.57	$9.48	$9.38	$9.31	$9.31
Lost jobs due to reduced commercial business activity	373	373	369	365	363	363
Lost state and local taxes from reduced commercial business activity	$1.22	$1.22	$1.21	$1.19	$1.19	$1.19
Lost utility revenues	$1.85	$1.85	$1.83	$1.82	$1.80	$1.80
Menard						
Monetary value of domestic water shortages	$0.07	$0.07	$0.05	$0.05	$0.04	$0.04
Lost utility revenues	$0.10	$0.10	$0.09	$0.07	$0.07	$0.07

Municipal ($millions)	2010	2020	2030	2040	2050	2060
Midland						
Monetary value of domestic water shortages	$1.06	$3.01	$95.81	$201.95	$244.36	$251.36
Lost income from reduced commercial business activity	$0.00	$0.00	$85.32	$311.55	$324.80	$339.87
Lost jobs due to reduced commercial business activity	0	0	2,125	7,760	8,090	8,466
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$6.16	$22.49	$23.45	$24.54
Lost utility revenues	$2.29	$4.88	$30.91	$41.59	$42.80	$44.20
Miles						
Monetary value of domestic water shortages	$5.12	$5.60	$5.97	$3.50	$3.71	$3.91
Lost income from reduced commercial business activity	$1.54	$1.69	$1.80	$1.91	$2.03	$2.14
Lost jobs due to reduced commercial business activity	41	45	48	51	54	57
Lost state and local taxes from reduced commercial business activity	$0.19	$0.21	$0.23	$0.24	$0.26	$0.27
Lost utility revenues	$0.28	$0.30	$0.32	$0.34	$0.36	$0.38
Millersview-Doole WSC						
Monetary value of domestic water shortages	$0.02	$0.03	$0.00	$0.00	$1.66	$2.91
Lost utility revenues	$0.03	$0.05	$0.00	$0.00	$0.47	$0.57
Odessa						
Monetary value of domestic water shortages	$4.36	$61.75	$5.35	$6.24	$7.22	$10.05
Lost utility revenues	$7.35	$18.65	$7.94	$9.18	$10.61	$13.16
Robert Lee						
Monetary value of domestic water shortages	$0.16	$0.22	$0.00	$0.01	$0.03	$0.07
Lost utility revenues	$0.17	$0.21	$0.00	$0.03	$0.05	$0.10
San Angelo						
Monetary value of domestic water shortages	$64.65	$79.05	$83.30	$65.88	$76.44	$77.63
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$21.05	$22.71	$24.02
Lost jobs due to reduced commercial business activity	0	0	0	519	559	592
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$1.46	$1.58	$1.67
Lost utility revenues	$0.17	$0.56	$0.30	$0.39	$0.46	$0.57

Municipal ($millions)						
	2010	2020	2030	2040	2050	2060
Snyder						
Monetary value of domestic water shortages	$0.66	$0.92	$0.01	$0.11	$0.20	$0.32
Lost utility revenues	$0.31	$0.39	$0.01	$0.07	$0.12	$0.19
Stanton						
Monetary value of domestic water shortages	$7.93	$8.54	$8.68	$8.70	$8.40	$7.95
Lost income from reduced commercial business activity	$4.90	$5.29	$5.38	$5.39	$5.20	$4.92
Lost jobs due to reduced commercial business activity	127	137	139	140	135	127
Lost state and local taxes from reduced commercial business activity	$0.40	$0.43	$0.44	$0.44	$0.42	$0.40
Lost utility revenues	$0.78	$0.84	$0.85	$0.85	$0.82	$0.78
Winters						
Monetary value of domestic water shortages	$8.90	$7.24	$7.30	$7.37	$7.42	$7.63
Lost income from reduced commercial business activity	$2.82	$2.29	$2.31	$2.33	$2.35	$2.41
Lost jobs due to reduced commercial business activity	102	83	84	85	85	88
Lost state and local taxes from reduced commercial business activity	$0.30	$0.24	$0.25	$0.25	$0.25	$0.26
Lost utility revenues	$1.09	$1.11	$1.12	$1.13	$1.14	$1.17