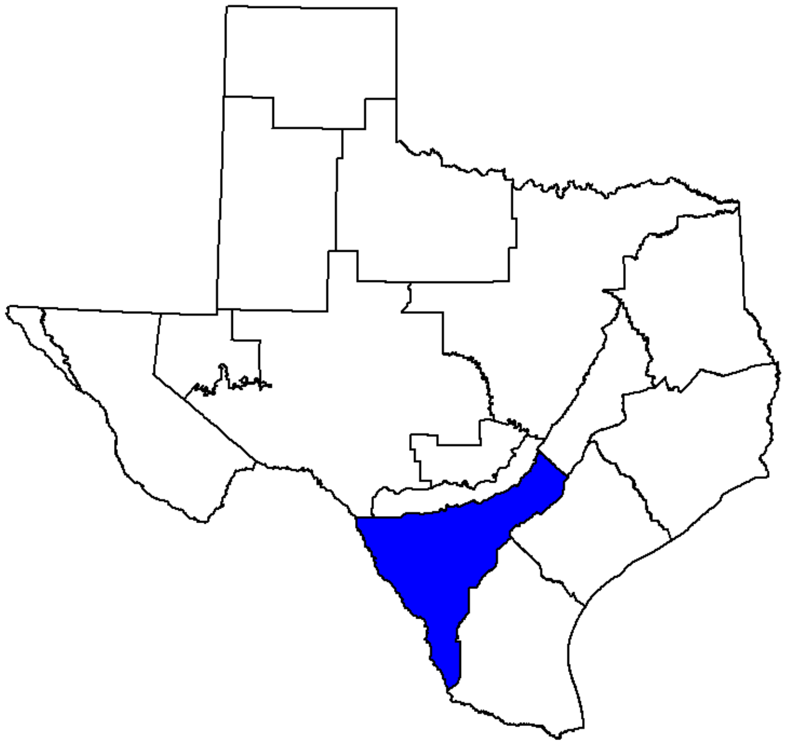
GMA 13 Explanatory Report - Final
Yegua-Jackson Aquifer



Prepared for:
Groundwater Management Area 13

Prepared by:
William R. Hutchison, Ph.D., P.E., P.G.
Independent Groundwater Consultant
9305 Jamaica Beach
Jamaica Beach, TX 77554
512-745-0599
billhutch@texasgw.com

February 22, 2017

GMA 13 Explanatory Report (Final)
Yegua-Jackson Aquifer

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:

William R. Hutchison, Ph.D., P.E. (96287), P.G. (286)

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

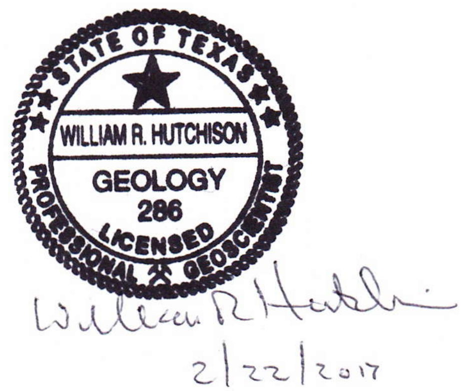


Table of Contents

List of Figures

List of Tables

Appendices

1.0 Groundwater Management Area 13

Groundwater Management Area 13 is one of sixteen groundwater management areas in Texas, and covers a large portion of the southwest part of the state (Figure 1).

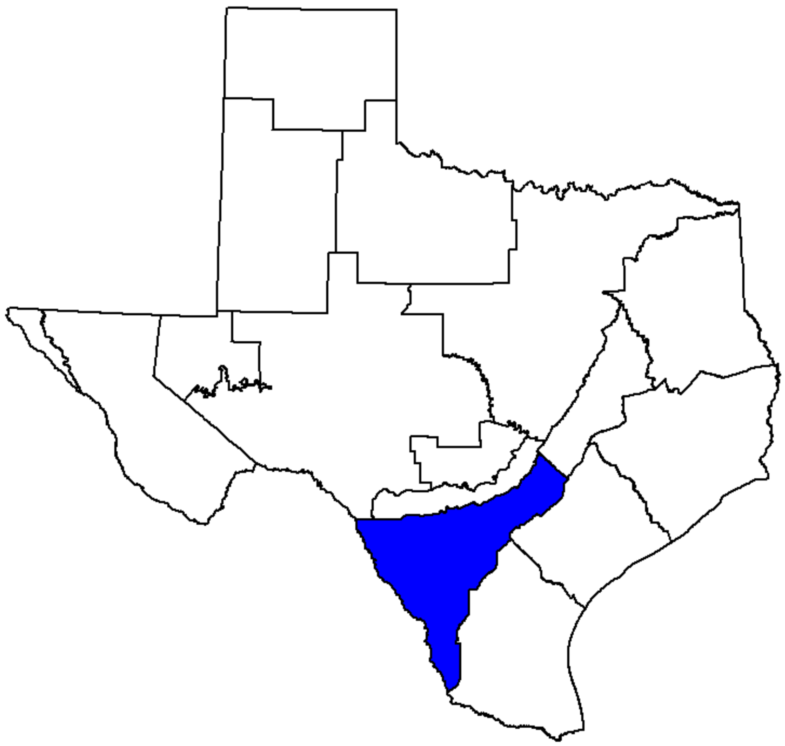


Figure 1. Groundwater Management Area 13

Groundwater Management Area 13 covers all or portions of the following counties: Atascosa, Bexar, Caldwell, Dimmit, Frio, Gonzales, Guadalupe, Karnes, La Salle, Maverick, McMullen, Medina, Uvalde, Webb, Wilson, Zapata, and Zavala (Figure 2).

There are nine groundwater conservation districts in Groundwater Management Area 13: Evergreen Underground Water Conservation District, Gonzales County Underground Water Conservation District, Guadalupe County Groundwater Conservation District, Edwards Aquifer Authority, McMullen Groundwater Conservation District, Medina County Groundwater Conservation District, Plum Creek Conservation District, Uvalde County Underground Water Conservation District, and Wintergarden Groundwater Conservation District (Figure 3). Please note that as shown in Figure 3, the Edwards Aquifer Authority overlaps other groundwater conservation districts in a small portion of Atascosa County, and larger parts of Caldwell, Guadalupe, Medina, and Uvalde counties.

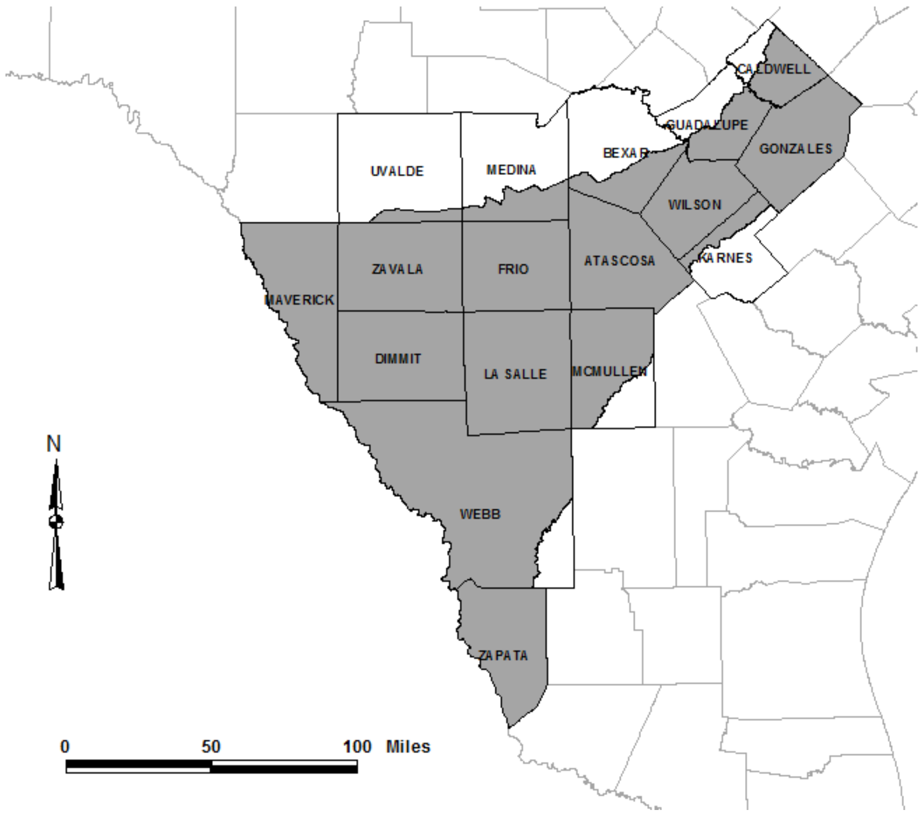


Figure 2. GMA 13 Counties (from TWDB)

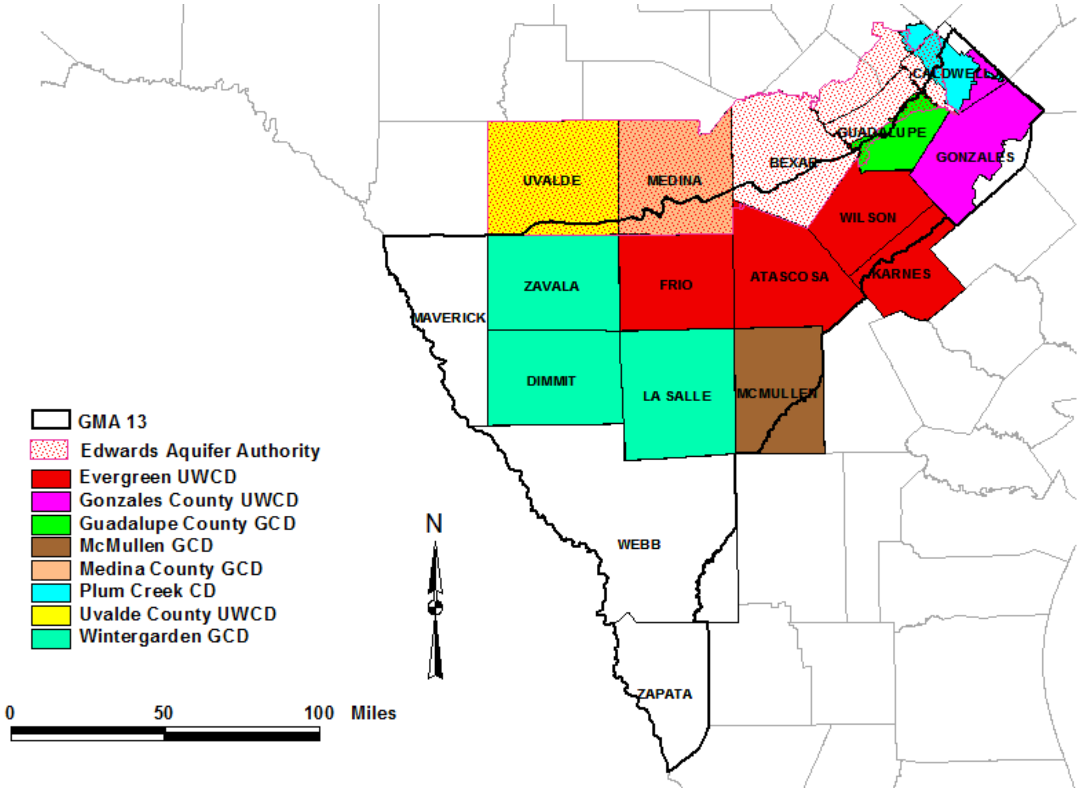


Figure 3. Groundwater Conservation Districts in GMA 13

The explanatory report covers the Yegua-Jackson Aquifer. As described in George and others (2011):

> ***The Yegua-Jackson Aquifer*** *is a minor aquifer stretching across the southeast part of the state. It includes water-bearing parts of the Yegua Formation (part of the upper Claiborne Group) and the Jackson Group (comprising the Whitsett, Manning, Wellborn, and Caddell formations). These geologic units consist of interbedded sand, silt, and clay layers originally deposited as fluvial and deltaic sediments. Freshwater saturated thickness averages about 170 feet. Water quality varies greatly owing to sediment composition in the aquifer formations, and in all areas the aquifer becomes highly mineralized with depth. Most groundwater is produced from the sand units of the aquifer, where the water is fresh and ranges from less than 50 to 1,000 milligrams per liter of total dissolved solids. Some slightly to moderately saline water, with concentrations of total dissolved solids ranging from 1,000 to 10,000 milligrams per liter, also occurs in the aquifer. No significant water level declines have occurred in wells measured by the TWDB. Groundwater for domestic and livestock purposes is available from shallow wells over most of the aquifer's extent. Water is also used for some municipal, industrial, and irrigation purposes. The regional water planning groups, in their 2006 Regional Water Plans, recommended several water management strategies that use the Yegua-Jackson Aquifer, including drilling more wells and desalinating the water.*

2.0 Desired Future Condition

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

The desired future conditions for the Yegua-Jackson Aquifer in Groundwater Management Area 13 are summarized in GMA 13 Technical Memorandum 16-04:

- For Gonzales County, the average drawdown from 2010 to 2070 is 3 feet
- For Karnes County, the average drawdown from 2010 to 2070 is 1 foot
- For all other counties in GMA 13, the Yegua-Jackson is classified 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 13.
- Water supply needs and water management strategies included in the 2012 State Water Plan
- Hydrologic conditions within Groundwater Management Area 13 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 13 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 13.

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 Yegua-Jackson Aquifer, the groundwater conservation districts in Groundwater Management Area 13 relied on the initial ten simulations that were completed in 2010 when the first desired future condition was approved. Based on the analysis of the results in 2010, Groundwater Management Area 13 adopted a desired future condition that was based on Scenario 4.0 (Oliver, 2010).

An additional simulation was completed to account for increased pumping by the oil and gas industry in Gonzales and Karnes County, and extending the simulation to the year 2070. Documentation of this additional scenario is contained in Technical Memorandum 16-04.

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

Table 1 presents the 2012 estimated pumping (from the TWDB pumping data base) organized by county, and the simulated pumping for each county used in Scenario 4.0 of Oliver (2010). The simulated pumping became the basis for the modeled available groundwater (MAG) for the Yegua-Jackson Aquifer in GMA 13. It should be noted that TWDB's estimated pumping in 2012 assumed no pumping in the mining category (i.e. no groundwater pumping associated with oil and gas). Evergreen UWCD and Gonzales UWCD provided updated oil and gas pumping estimates for 2012, 2013 and 2014.

Table 1. Estimates of Historic Pumping and Simulated Pumping from Oliver (2010)

County	2012 Estimated Pumping (TWDB)	Simulated Pumping in 2060 (Oliver, 2010)
Atascosa	396	856
Gonzales	687	975
Karnes	271	776
La Salle	54	92
McMullen	29	180
Webb	4	19,999
Wilson	177	840
Zapata	159	8,000

In Gonzales County, groundwater pumping from the Yegua-Jackson Aquifer for oil and gas activities peaked at 2,500 AF/yr. Oil and gas related groundwater pumping in Karnes County peaked at 1,741 AF/yr based on data provided by the districts.

After reviewing monitoring well data and initial model runs, Gonzales County UWCD requested that pumping be increased to achieve a drawdown of 3 feet. This required adding an additional 1,500 AF/yr of pumping in Gonzales County (above the 2,500 AF/yr historic oil and gas related pumping). These amounts were added to the TWDB estimated historic use pumping estimates to update the simulation in Oliver (2010).

Table 2 summarizes the pumping that was used for the simulation that is the basis for the desired future condition.

Table 2. Assumed Pumping for Updated Simulation

County	Assumed Pumping for Updated Simulation (AF/yr)
Atascosa	856
Gonzales	4,687
Karnes	2,012
La Salle	92
McMullen	180
Webb	19,999
Wilson	840
Zapata	8,000

The model input file from Oliver (2010) for his Scenario 4.0 was used to develop the pumping input file for this simulation by increasing pumping in Gonzales County by a factor of 4.81, and increasing pumping in Karnes County by a factor of 2.59. In addition, an additional 10 years was added to the simulation to extend it to 2070.

5.2 Groundwater Supply Needs and Strategies

The 2016 Region L 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. No strategies are listed for the Yegua-Jackson Aquifer in GMA 13.

5.3 Hydrologic Conditions, including Total Estimated Recoverable Storage

The groundwater budget for the calibration period of the model (1910 to 2009) and for the period of the simulation (2010 to 2070) is presented in Table 2. Please note that the difference between the two periods is also shown. The increase in pumping is primarily derived from decreased storage, with smaller amounts of the pumping coming from decreased evapotranspiration and decreased stream discharge.

**Table 3. Groundwater Budget of Yegua-Jackson Aquifer in GMA 13
All Values in AF/yr**

Inflow	1910-2009	2010-2070	Diffference
Recharge	86,967	86,967	0
Reservoir Leakage	392	324	-69
Boundary Inflow (GHB)	679	661	-18
From GMA 12	6,016	5,994	-22
From GMA 15	1,880	1,816	-63
From GMA 16	1,251	1,329	78
Total Inflow	97,185	97,091	-94
Outflow			
Pumping	845	36,689	35,844
Springs	45	44	-1
Evapotranspiration	8,496	7,366	-1,130
Stream Discharge	85,647	81,552	-4,095
Total Outflow	95,033	125,651	30,618
Inflow-Outflow	2,152	-28,560	-30,712
Model Estimated Storage Change	2,152	-28,562	-30,714
Model Error	0.62	1.91	1.28

Wade and Bradley (2013) documented the total estimated recoverable storage for the GMA 13 portion of the Yegua-Jackson Aquifer. Total storage estimates are presented in Table 3.

Table 4. Total Estimated Recoverable Storage – Yegua Jackson Aquifer

County	Total Storage (acre-feet)	25% of Total Storage (acre-feet)	75% of Total Storage (acre-feet)
Atascosa	40,000,000	10,000,000	30,000,000
Frio	75,000	18,750	56,250
Gonzales	32,000,000	8,000,000	24,000,000
Karnes	19,000,000	4,750,000	14,250,000
La Salle	56,000,000	14,000,000	42,000,000
McMullen	96,000,000	24,000,000	72,000,000
Webb	210,000,000	52,500,000	157,500,000
Wilson	6,800,000	1,700,000	5,100,000
Zapata	83,000,000	20,750,000	62,250,000
Total	542,875,000	135,718,750	407,156,250

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

Table 2 above includes groundwater budget estimates of spring flow and surface water interaction.

5.5 Subsidence

Subsidence is not an issue in the Yegua-Jackson Aquifer in GMA 13.

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 13 is covered by Regional Planning Groups L and M. In addition, there is an important water management strategy that is sourced in Gonzales County to meet demands in Regional Planning Group K. The socioeconomic impact reports for Regions K, L, and M are included in Appendix B.

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 13 in groundwater is recognized under Texas Water Code Section 36.002.

The desired future conditions adopted by GMA 13 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 L plan) were included in the simulation that is the basis for the desired future condition. The increases in pumping associated the new simulation were directly attributable to increases in groundwater use by the oil and gas industry. As required by Chapter 36 of the Water Code, GMA 13 considered impacts of the increased pumping and balanced them with the increasing demand of water in the GMA 13 area, and concluded that, on balance and with appropriate monitoring and project specific review during the permitting process, these pumping increases can be included in the desired future condition.

5.8 Feasibility of Achieving the Desired Future Condition

Groundwater levels are routinely monitored by the districts and by the TWDB in GMA 13. 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 13 did not consider any other information in developing these DFCs.

6.0 Discussion of Other Desired Future Conditions Considered

There were 11 GAM scenarios completed that included a range of future pumping scenarios. The original ten simulations were completed in 2010 (Oliver, 2010). After the initial review, an 11th scenario was developed based on increased uses in the oil and gas industry.

After review and discussion, the groundwater conservation districts found that the declines associated with the 11th scenario (Technical Memorandum 16-04) was reasonable as a basis for the desired future condition.

7.0 Discussion of Other Recommendations

Public comments were invited and the two districts where a desired future condition was proposed for the Yegua-Jackson Aquifer held a public hearing on the proposed desired future condition for aquifers within their boundaries:

Groundwater Conservation District	Date of Public Hearing	Number of Comments Received
Evergreen UWCD	July 28, 2016	None
Gonzales County UWCD	June 14, 2016	None

No comments were received on the desired future conditions for the Yegua-Jackson Aquifer.

8.0 References

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

Oliver, W., 2010, GAM Task 10-012 Model Run Report. Texas Water Development Board, Groundwater Availability Modeling Section, August 9, 2010, 48p.

Wade, S. and Bradley, R., 2013, GAM Task 13-036 (Revised): Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 13. Texas Water Development Board GAM Task Report, 30 p.

Appendix A

Desired Future Conditions Resolution

Groundwater Management Area 13
Resolution 16-02

Desired Future Conditions for the Yegua-Jackson Aquifer in Groundwater Management Area 13

WHEREAS, Groundwater Conservation Districts (GCDs) located within or partially within Groundwater Management Area 13 (GMA 13) are required under Chapter 36.108, Texas Water Code to conduct joint planning and designate the Desired Future Conditions of aquifers within GMA 13 and;

WHEREAS, the Board Presidents or their Designated Representatives of GCDs in GMA 13 have met in various meetings and conducted joint planning in accordance with §36.108, Texas Water Code since September 2010; and

WHEREAS, the GMA 13 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, regional water plan water management strategies, ground and surface water interactions, that affect groundwater conditions through the year 2070; and

WHEREAS, the member GCDs of GMA 13, having given proper and timely notice, held an open meeting on April 27, 2016 at the offices of the Evergreen Underground Water Conservation District located at 110 Wyoming Blvd., Pleasanton, Texas, to vote to adopt proposed Desired Future Conditions for the Yegua-Jackson Aquifer within the boundaries of GMA 13; and

WHEREAS, the member GCDs in which the Yegua-Jackson Aquifer is relevant for joint planning purposes held open meetings within each said district between June 14, 2016 and July 28, 2016 to take public comment on the proposed DFCs for that district; and

WHEREAS on this day of November 21, 2016 at an open meeting duly noticed and held in accordance with law at the offices of the Evergreen Underground Water Conservation District located at 110 Wyoming Blvd., Pleasanton, Texas, the GCDs within GMA 13, having considered at this meeting comments submitted to the individual districts during the comment period and at this meeting, have voted, __ districts in favor, __ districts opposed, to adopt the following DFCs for in the following counties and districts through the year 2070 as follows:

NOW THEREFORE BE IT RESOLVED, that Groundwater Management Area 13 does hereby document, record, and confirm the above-described Desired Future Conditions for the Yegua-Jackson Aquifer which were adopted by vote of the following Designated Representatives of Groundwater Conservation Districts present and voting on November 21, 2016:

The desired future conditions for the Yegua-Jackson Aquifer in Groundwater Management Area 13 are summarized in GMA 13 Technical Memorandum 16-04:

- For Gonzales County, the average drawdown from 2010 to 2070 is 3 feet
- For Karnes County, the average drawdown from 2010 to 2070 is 1 foot
- For all other counties in GMA 13, the Yegua-Jackson is classified as not relevant for purposes of joint planning.

Diane Savage

For Evergreen Underground Water Conservation District

For Guadalupe County Groundwater Conservation District

For Gonzales County Underground Water Conservation District

Lonnie Stewart

For McMullen Groundwater Conservation District

David M. Caldwell

For Medina County Groundwater Conservation District

Daniel Meyer

For Plum Creek Conservation District

For Uvalde County Underground Water Conservation District

For Wintergarden Groundwater Conservation District

Appendix B

Regions K, L, and M Socioeconomic Impact Reports

TEXAS WATER DEVELOPMENT BOARD

May 21, 2010

Mr. John Burke
Chairman, Lower Colorado Regional Water Planning Group
c/o Aqua Water Supply Corporation Manager
P.O. Drawer P
Bastrop, Texas 78602

Re: Socioeconomic Impact Analysis of Not Meeting Water Needs for the 2011 Lower Colorado Regional Water Plan

Dear Chairman Burke:

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, and Section 2 presents results for 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 Norvell
Manager, Water Planning Research and Analysis
Water Resources Planning Division

SN/ao

Enclosure

c: David Meesey, TWDB
S. Doug Shaw, TWDB

Socioeconomic Impacts of Projected Water Shortages for the Lower Colorado Regional Water Planning Area (Region K)

Prepared in Support of the 2011 Lower Colorado Regional Water Plan

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

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

May 2010

Table of Contents

Tables

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 Lower Colorado Regional Water Planning Group (Region K).

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). As shown in Table 2, the overwhelming majority of irrigation in Region K is for rice. Table 3 displays average (2003-2007) gross revenues per acre for rice production applied in the analysis.

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 K Regional 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	6.96	4%	9	2%
Vegetable and melons	<1	<1%	<1	<1%
Tree nuts	5	3%	7	1%
Fruits	<1	<1%	1.24	<1%
Cotton	1	1%	1.11	<1%
Rice	145	91%	541	97%
Total	**160**	**100%**	**559.96**	**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 K Regional Water Planning Area (2003-2007)		
IMPLAN Sector	**Gross revenues per acre**	**Crops included in estimates**
All Other Crops	$460	Based on five-year (2003-2007) average weighted by acreage for "rice."
*Figures are rounded. Source: Based on data from the Texas Agricultural Statistics Service, Texas Water Development Board, and Texas A&M University.		

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.

3. *Reduce sales revenues for forward processers in proportion to lost rice production*. As discussed in Section 1.1, input output models capture indirect losses to suppliers and other businesses that depend upon rice farming, but only those providing inputs to rice production. Multipliers do not capture potential impacts to forward processors, in this case rice mills, which add considerable value to the product and hence income and jobs to the state. For example, Texas rice farming directly generates about $60 to $80 in gross state product. Once the rice harvested it is sold to rice mills that process and resell the crop. This added value generates an additional $60 to $80 million in direct gross state product. Impacts measured in the study capture this additional value added.

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 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.[5] 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.[6]

Table 4: Description of Livestock Sectors

IMPLAN Category	TWDB Category
Cattle ranching	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.[7] For example,

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

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

[7] 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

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 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.

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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.

Price elasticities (-0.30 for indoor water use and -0.50 for outdoor use) are based on a study by Bell et al.[8] 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 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).[9]

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.[10] Determining how much water is used for outdoor purposes is based on several secondary sources. The first is a major study sponsored by the

[8] 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.

[9] 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.

[10] 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.

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.[11] Earlier findings of the U.S. Water Resources Council showed a national 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.[12] A study conducted for the California Urban Water Agencies (CUWA) calculated average annual values ranging from 25 to 35 percent.[13] 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.[14] 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.[15]

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[11] 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).

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

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

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

[15] 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.[16] 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.[17]

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.

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

[17] 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.[18] 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.

[18] 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.[19] 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.[20]

[19] 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.

[20] 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 *Lower Colorado Regional Water Plan*, during severe drought irrigation, 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 K economy generates slightly more than $79 billion in gross state product for Texas ($73 billion in income and $6 billion in state and local business taxes) and supports nearly 1,033,690 jobs (Table 8). Generating nearly $12 billion worth of income per year manufacturing (particularly computer electronics and pharmaceuticals) is the primary base economic sector in the region.[21] Municipal sectors also generate substantial amounts of activity, nearly $61 billion per year in gross state product, and are major employers in the region. While municipal sectors are the largest employer and source of wealth, 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 such as manufacturing. In other words, without base industries many municipal jobs would not exist.

[21] Base industries are those that supply markets outside of a 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 Lower Colorado Regional Economy by Water User Group ($millions)[a]						
Water Use Category	**Total sales**	**Intermediate sales**	**Final sales**	**Jobs**	**Income**	**Business taxes**
Irrigation[b]	$132.09	$67.62	$64.64	1,905	$62.55	$2.41
Livestock	$992.27	$549.93	$442.34	13,264	$99.62	$13.36
Manufacturing	$56,646.30	$14,932.96	$41,713.34	127,416	$12,275.86	$348.07
Mining	$2,578.62	$1,837.98	$740.64	$4,439.00	$1,572.37	$137.52
Steam-electric	$1,342.07	$377.55	$964.52	2,823	$932.02	$158.93
Municipal	$96,908.91	$31,257.19	$65,651.72	883,845	$57,858.80	$5,225.90
Regional total	$158,600.26	$49,023.23	$109,577.20	1,033,692	$72,801.22	$5,886.19

[a] Appendix 1 displays data for individual IMPLAN sectors that make up each water use category.
[b] Irrigation includes activity for both rice farms and rice mills.
Source: 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

Irrigation

According to the 2011 *Lower Colorado Regional Water Plan*, during severe drought the counties of Bastrop, Colorado, Fayette, Matagorda, Mills and Wharton would experiences shortages of irrigation water without new management strategies. Shortages of these magnitudes would reduce gross state product (income plus state and local business taxes) by an estimated $84 million in 2010 and $56 million in 2060 with potential job losses ranging from 994 to 660 (Table 9). Figures include impacts to rice mills.

Table 9: Economic Impacts of Water Shortages for Irrigation Water User Groups ($millions)			
Decade	**Lost income from reduced rice production and milling activity ***	**Lost state and local tax revenues from reduced rice production and milling activity**	**Lost jobs from rice production and milling activity**
2010	$75.35	$8.72	994
2020	$70.93	$8.21	935
2030	$66.12	$7.65	872
2040	$61.50	$7.12	811
2050	$57.05	$6.60	752
2060	$50.09	$5.80	660

*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.

Livestock

Several counties (Colorado, Fayette, Llano, and Matagorda) show water shortages for livestock producers. Given that these shortages are small relative to total livestock demands, we assume producers would haul water by tanker to fill stock pond and cisterns. The cost to producers across all counties would total about $4.5 million per annum in each decade.

2.3 Impacts of Municipal Water Shortages

Water shortages are projected to occur in a significant number of communities in Region K. At the regional level, the estimated economic value of domestic water shortages totals $63 million in 2010 and $1,034 million in 2060 (Table 10). Municipal shortages would also restrict the operation of many commercial businesses reducing gross state product by an estimated $43 million in 2010 and $633 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	$63.32	$38.33	$3.97	733	$13.24
2020	$277.85	$182.18	$18.26	3,528	$37.05
2030	$385.04	$245.98	$24.88	4,861	$55.64
2040	$529.21	$339.71	$35.32	7,042	$83.14
2050	$756.51	$396.14	$41.36	8,282	$153.95
2060	$1,034.28	$573.34	$60.28	12,222	$230.90

*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 Bastrop, Fayette, Hays, Matagorda and Wharton counties. The Region K planning group estimates that these manufacturers would be short nearly 150 acre-feet of water in 2010 and about 935 acre-feet in 2060. Shortages of these magnitudes would reduce gross state product (income plus taxes) by an estimated $5 million in 2010 and $65 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	$4.64	$0.45	97
2020	$13.09	$1.31	285
2030	$22.11	$2.05	431
2040	$28.59	$2.62	549
2050	$34.26	$3.12	651
2060	$59.48	$4.95	987

*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 Burnett, Fayette, and Liberty counties, and would primarily affect aggregates (sand and gravel) operations. In total, shortages would reduce gross state product by an estimated $19 million in 2010 and $12 million in 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	$17.57	$1.19	159
2020	$16.82	$1.14	153
2030	$15.40	$1.04	140
2040	$13.36	$0.90	122
2050	$10.74	$0.71	98
2060	$11.16	$0.74	102

*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 steam-electric water user groups are projected to occur in Bastrop, Fayette, Matagorda, Travis, and Wharton counties, and would reduce gross state product by $2 million dollars in 2010, and $2,559 million 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	$1.90	$0.27	6
2020	$1,043.13	$149.73	3,546
2030	$1,046.13	$150.16	3,556
2040	$1,802.39	$258.71	6,127
2050	$1,909.17	$274.03	6,490
2060	$2,238.54	$321.31	7,605

*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.

2.7 Social Impacts of Water Shortages

As discussed previously, estimated social impacts focus on changes in population and school enrollment. In 2010, estimated population losses total 2,393 with corresponding reductions in school enrollment of 675 students (Table 14). In 2060, population in the region would decline by 25,988 people and school enrollment would fall by 4,807 students.

Table 14: Social Impacts of Water Shortages (2010-2060)

Year	Population Losses	Declines in School Enrollment
2010	2,393	675
2020	10,174	2,886
2030	11,876	3,146
2040	17,647	3,261
2050	19,601	3,620
2060	25,988	4,807

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 15 displays the results.

Table 15: Distribution of Impacts by Major River Basin (2010-2060)

Water Use	2010	2020	2030	2040	2050	2060
Irrigation						
Brazos	<1%	<1%	<1%	<1%	<1%	<1%
Brazos-Colorado	51%	52%	52%	52%	53%	51%
Colorado	3%	3%	3%	3%	3%	3%
Colorado-Lavaca	31%	32%	33%	34%	35%	38%
Lavaca	14%	13%	12%	10%	9%	7%
Livestock						
Brazos	24%	24%	24%	24%	24%	24%
Colorado	40%	40%	40%	40%	40%	40%
Colorado-Lavaca	30%	30%	30%	30%	30%	30%
Lavaca	6%	6%	6%	6%	6%	6%
Manufacturing						
Colorado	64%	73%	77%	79%	80%	80%
Colorado-Lavaca	0%	0%	0%	0%	0%	1%
Guadalupe	5%	3%	2%	2%	2%	2%
Lavaca	31%	23%	21%	19%	18%	17%
Mining						
Brazos	<1%	<1%	<1%	<1%	<1%	<1%
Brazos-Colorado	<1%	<1%	<1%	<1%	<1%	<1%
Colorado	99%	98%	97%	97%	95%	95%
Lavaca	1%	1%	2%	2%	3%	3%
Municipal						
Brazos	<1%	<1%	<1%	<1%	<1%	<1%
Colorado	98%	99%	99%	99%	100%	100%
Guadalupe	0%	0%	0%	0%	0%	0%
Lavaca	2%	1%	1%	1%	0%	0%
Steam-electric						
Brazos-Colorado	0%	0%	0%	0%	0%	<1%
Colorado	100%	100%	100%	100%	100%	>99%

Appendix 1: Economic Data for Individual IMPLAN Sectors for Lower Colorado Regional Water Planning Area

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	All other crop farming (rice)	10	$60.66	$54.54	$6.12	774	$29.71	$1.17
Irrigation	Fruit Farming	5	$28.03	$3.74	$24.45	691	$16.06	$0.61
Irrigation	Rice milling	49	$21.75	$0.17	$21.58	36	$2.49	$0.15
Irrigation	Tree Nut Farming	4	$16.71	$8.95	$7.76	295	$11.56	$0.41
Irrigation	Grain Farming	2	$2.32	$0.11	$2.21	67	$1.07	$0.04
Irrigation	Vegetable and Melon Farming	3	$1.83	$0.09	$1.74	34	$1.34	$0.02
Irrigation	Cotton Farming	8	$0.59	$0.01	$0.58	5	$0.22	$0.01
Irrigation	Oilseed Farming	1	$0.20	$0.01	$0.20	3	$0.10	$0.00
	Total irrigation		**$132.09**	**$67.62**	**$64.64**	**1,905**	**$62.55**	**$2.41**
Livestock	Cattle ranching and farming	11	$469.96	$325.87	$144.09	10,040	$37.13	$9.88
Livestock	Cheese manufacturing	64	$178.60	$73.97	$104.63	241	$12.97	$1.09
Livestock	Meat processed from carcasses	68	$110.94	$32.73	$78.21	258	$10.87	$0.56
Livestock	Fluid milk manufacturing	62	$79.43	$19.11	$60.32	133	$9.13	$0.57
Livestock	Rendering and meat byproduct processing	69	$48.31	$26.81	$21.50	91	$11.48	$0.33
Livestock	Animal production- except cattle and poultry	13	$44.98	$38.14	$6.84	2,201	$4.37	$0.69
Livestock	Poultry and egg production	12	$33.41	$26.18	$7.22	230	$11.25	$0.11
Livestock	Animal- except poultry- slaughtering	67	$26.65	$7.13	$19.53	70	$2.43	$0.13
	Total livestock		**$992.27**	**$549.93**	**$442.34**	**13,264**	**$99.62**	**$13.36**
	Total agriculture		**$1,124.36**	**$617.55**	**$506.99**	**15169**	**$162.17**	**$15.77**

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	$1,901.89	$1,766.26	$135.63	1,831	$1,095.27	$114.04
Mining	Support activities for oil and gas operations	28	$368.31	$51.16	$317.15	1,553	$333.91	$15.15
Mining	Drilling oil and gas wells	27	$120.05	$0.60	$119.45	200	$33.21	$4.38
Mining	Sand- gravel- clay- and refractory mining	25	$114.95	$12.13	$102.81	568	$68.27	$3.28
Mining	Stone mining and quarrying	24	$66.46	$6.84	$59.62	249	$39.02	$0.35
Mining	Support activities for other mining	29	$2.74	$0.04	$2.70	20	$0.91	$0.11
Mining	Other nonmetallic mineral mining	26	$2.30	$0.23	$2.07	11	$1.06	$0.06
Mining	Coal mining	20	$1.94	$0.73	$1.21	7	$0.73	$0.16
Mining	Iron ore mining	21	$0.00	$0.00	$0.00	0	$0.00	$0.00
Mining	Copper- nickel- lead- and zinc mining	22	$0.00	$0.00	$0.00	0	$0.00	$0.00
Mining	Gold- silver- and other metal ore mining	23	$0.00	$0.00	$0.00	0	$0.00	$0.00
Total Mining	**NA**		**$2,578.62**	**$1,837.98**	**$740.64**	**$4,439.00**	**$1,572.37**	**$137.52**
Steam-electric	**Power generation and supply**		**$1,342.07**	**$377.55**	**$964.52**	**2,823**	**$932.02**	**$158.93**
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	Electronic computer manufacturing	302	$24,498.91	$5,702.75	$18,796.15	9,746	$1,613.72	$126.44
Manufacturing	Semiconductors and related device manufacturing	311	$11,287.74	$6,007.64	$5,280.10	12,094	$2,696.34	$76.30
Manufacturing	New residential 1-unit structures- all	33	$3,320.82	$0.00	$3,320.81	21,394	$1,175.14	$18.50
Manufacturing	Commercial and institutional buildings	38	$1,917.68	$0.00	$1,917.68	18,651	$1,006.96	$12.41
Manufacturing	Pharmaceutical and medicine manufacturing	160	$1,607.56	$293.78	$1,313.78	1,747	$455.37	$10.51
Manufacturing	All other electronic component manufacturing	312	$867.97	$497.39	$370.58	3,664	$297.15	$5.02
Manufacturing	Other new construction	41	$840.59	$0.00	$840.59	8,559	$467.01	$3.68
Manufacturing	Plastics and rubber industry machinery	263	$598.81	$26.67	$572.13	1,906	$306.80	$4.48
Manufacturing	Telephone apparatus manufacturing	306	$592.57	$14.51	$578.06	657	$106.99	$3.43
Manufacturing	New residential additions and alterations-all	35	$476.81	$0.00	$476.80	2,548	$186.29	$2.63
Manufacturing	Petroleum refineries	142	$419.22	$155.83	$263.40	18	$238.69	$8.68
Manufacturing	Highway- street- bridge- and tunnel construct	39	$412.91	$0.00	$412.91	3,612	$215.66	$2.75
Manufacturing	New multifamily housing structures- all	34	$370.60	$0.00	$370.59	3,110	$181.41	$1.05
Manufacturing	Jewelry and silverware manufacturing	380	$333.02	$6.72	$326.30	1,297	$112.38	$1.80
Manufacturing	Ready-mix concrete manufacturing	192	$312.44	$1.52	$310.92	1,084	$107.69	$2.73
Manufacturing	Surgical appliance and supplies manufacturing	376	$299.56	$74.76	$224.79	675	$166.49	$1.49
Manufacturing	Water- sewer- and pipeline construction	40	$297.69	$0.00	$297.70	2,364	$138.34	$2.00
Manufacturing	Construction machinery manufacturing	259	$279.00	$38.08	$240.93	392	$51.55	$1.55
Manufacturing	Other communications equipment manufacturing	308	$240.22	$137.70	$102.52	693	$67.04	$1.29
Manufacturing	Industrial process variable instruments	316	$230.83	$72.94	$157.89	858	$94.05	$1.27
Manufacturing	Soft drink and ice manufacturing	85	$224.93	$12.56	$212.37	338	$41.55	$1.84
Manufacturing	Petrochemical manufacturing	147	$214.99	$98.50	$116.49	27	$17.12	$0.97
Manufacturing	Lighting fixture manufacturing	326	$212.77	$0.14	$212.63	856	$70.99	$1.75
Manufacturing	Commercial printing	139	$208.45	$103.56	$104.89	2,468	$147.24	$1.82
Manufacturing	Semiconductor machinery manufacturing	268	$193.53	$36.57	$156.96	305	$45.53	$0.96
Manufacturing	Plastics plumbing fixtures and all other plastics	177	$192.98	$139.80	$53.18	959	$74.55	$1.29
Manufacturing	All other manufacturing	Various	$6,193.72	$1,511.54	$4,682.18	27,394	$2,193.82	$51.48
Manufacturing	**Total manufacturing**	**NA**	$56,646.30	$14,932.96	$41,713.34	127,416	$12,275.86	$348.07

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	$10,178.94	$4,873.30	$5,305.64	45,128	$5,361.62	$1,502.90
Municipal	Real estate	431	$6,309.70	$2,497.72	$3,811.98	30,663	$3,651.19	$776.89
Municipal	Owner-occupied dwellings	509	$5,564.52	$0.00	$5,564.52	0	$4,310.65	$657.97
Municipal	State & Local Non-Education	504	$5,125.29	-$0.01	$5,125.29	77,431	$5,125.29	$0.00
Municipal	Food services and drinking places	481	$3,452.49	$440.88	$3,011.61	66,214	$1,511.16	$176.53
Municipal	State & Local Education	503	$3,007.31	$0.00	$3,007.30	68,855	$3,007.30	$0.00
Municipal	Offices of physicians- dentists- and other he	465	$2,950.97	$0.00	$2,950.97	23,663	$2,104.31	$18.48
Municipal	Telecommunications	422	$2,932.63	$1,007.30	$1,925.32	8,188	$1,210.29	$202.61
Municipal	Software publishers	417	$2,728.88	$313.45	$2,415.43	7,518	$1,535.59	$24.39
Municipal	Monetary authorities and depository credit in	430	$2,223.88	$732.44	$1,491.44	8,321	$1,561.65	$28.45
Municipal	Architectural and engineering services	439	$2,207.35	$1,391.44	$815.91	17,617	$1,198.94	$9.90
Municipal	Hospitals	467	$2,112.08	$0.00	$2,112.08	17,768	$1,151.85	$14.70
Municipal	Insurance carriers	427	$2,002.12	$583.81	$1,418.31	7,713	$745.18	$92.77
Municipal	Warehousing and storage	400	$1,852.94	$1,704.24	$148.70	30,873	$1,354.05	$9.63
Municipal	Legal services	437	$1,613.89	$1,024.27	$589.62	10,916	$1,035.79	$32.03
Municipal	Securities- commodity contracts- investments	426	$1,547.14	$1,027.45	$519.70	12,953	$554.51	$16.41
Municipal	Motor vehicle and parts dealers	401	$1,418.75	$154.27	$1,264.47	12,081	$737.12	$208.18
Municipal	Nondepository credit intermediation and rela	425	$1,327.96	$812.96	$514.99	7,539	$793.32	$60.69
Municipal	Management consulting services	444	$1,229.18	$946.19	$282.99	8,545	$657.82	$5.13
Municipal	Custom computer programming services	441	$1,179.82	$98.33	$1,081.49	10,095	$998.26	$6.21
Municipal	Insurance agencies- brokerages- and related	428	$1,078.66	$632.98	$445.67	7,705	$914.89	$5.69
Municipal	Food and beverage stores	405	$1,059.15	$141.60	$917.55	17,064	$549.69	$120.19
Municipal	Federal Non-Military	506	$963.45	$0.00	$963.45	7,791	$963.45	$0.00
Municipal	All other miscellaneous professional and tech	450	$922.27	$823.43	$98.84	1,894	$332.44	$6.66
Municipal	Building material and garden supply stores	404	$903.30	$140.09	$763.21	8,855	$440.94	$134.02
	All other municipal sectors	NA	$6,193.72	$1,511.54	$4,682.18	27,394	$2,193.82	$51.48
	Total municipal	**NA**	**$96,908.91**	**$31,257.19**	**$65,651.72**	**883,845**	**$57,858.80**	**$5,225.90**
Based on year 2006 data from the Minnesota IMPLAN Group, Inc.								

Appendix 2: Impacts by Water User Group

Irrigation ($millions)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Bastrop County						
Reduced income from reduced crop production	$0.0133	$0.0056	$0.0045	$0.0035	$0.0027	$0.0019
Reduced business taxes from reduced crop production	$0.0015	$0.0006	$0.0005	$0.0004	$0.0003	$0.0002
Reduced jobs from reduced crop production	0	0	0	0	0	0
Colorado County						
Reduced income from curtailed rice production and milling activity	$6.90	$5.89	$4.91	$3.96	$3.04	$2.16
Reduced business taxes from curtailed rice production and milling activity	$0.80	$0.68	$0.57	$0.46	$0.35	$0.25
Reduced jobs from curtailed rice production and milling activity	91	78	65	52	40	28
Fayette County						
Reduced income from reduced crop production	$0.00	$0.01	$0.01	$0.01	$0.01	$0.01
Reduced business taxes from reduced crop production	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Reduced jobs from reduced crop production	0	0	0	0	0	0
Matagorda County						
Reduced income from curtailed rice production and milling activity	$70.93	$67.75	$63.99	$60.38	$56.92	$53.58
Reduced business taxes from curtailed rice production and milling activity	$8.21	$7.84	$7.41	$6.99	$6.59	$6.20
Reduced jobs from curtailed rice production and milling activity	935	893	844	796	751	706
Mills County						
Reduced income from reduced crop production	$0.04	$0.03	$0.03	$0.02	$0.02	$0.02
Reduced business taxes from reduced crop production	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Reduced jobs from reduced crop production	0	0	0	0	0	0
Wharton County						
Reduced income from curtailed rice production and milling activity	$13.03	$11.98	$10.97	$9.99	$9.05	$5.48
Reduced business taxes from curtailed rice production and milling activity	$1.51	$1.39	$1.27	$1.16	$1.05	$0.63
Reduced jobs from curtailed rice production and milling activity	172	158	145	132	119	72

Livestock ($millions)						
	2010	2020	2030	2040	2050	2060
Burnet County						
Annual costs of hauling water by tanker	$0.55	$0.55	$0.55	$0.55	$0.55	$0.55
Colorado County						
Annual costs of hauling water by tanker	$0.60	$0.60	$0.60	$0.60	$0.60	$0.60
Fayette County						
Annual costs of hauling water by tanker	$0.53	$0.53	$0.53	$0.53	$0.53	$0.53
Llano County						
Annual costs of hauling water by tanker	$1.49	$1.49	$1.49	$1.49	$1.49	$1.49
Matagorda County						
Annual costs of hauling water by tanker	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34

Manufacturing ($millions)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Bastrop County						
Reduced income from reduced manufacturing activity	$0.47	$0.99	$1.64	$2.22	$2.69	$7.01
Reduced business taxes from reduced manufacturing activity	$0.04	$0.08	$0.13	$0.18	$0.22	$0.58
Reduced jobs from reduced manufacturing activity	8	18	29	39	48	124
Fayette County						
Reduced income from reduced manufacturing activity	$3.13	$9.73	$13.06	$16.26	$19.04	$22.51
Reduced business taxes from reduced manufacturing activity	$0.35	$1.08	$1.45	$1.80	$2.11	$2.49
Reduced jobs from reduced manufacturing activity	78	243	327	407	477	563
Hays County						
Reduced income from reduced manufacturing activity	$1.04	$2.37	$7.42	$10.11	$12.54	$29.53
Reduced business taxes from reduced manufacturing activity	$0.07	$0.15	$0.47	$0.64	$0.79	$1.87
Reduced jobs from reduced manufacturing activity	11	24	75	102	127	299
Matagorda County						
Reduced income from reduced manufacturing activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.41
Reduced business taxes from reduced manufacturing activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01
Reduced jobs from reduced manufacturing activity	0	0	0	0	0	1
Wharton County						
Reduced income from reduced manufacturing activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.0169
Reduced business taxes from reduced manufacturing activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.0018
Reduced jobs from reduced manufacturing activity	0	0	0	0	0	0

Mining ($millions)						
	2010	2020	2030	2040	2050	2060
Burnet County						
Reduced income from reduced mining activity	$1.45	$1.62	$1.69	$1.76	$1.80	$1.89
Reduced business taxes from reduced mining activity	$0.08	$0.09	$0.09	$0.09	$0.10	$0.10
Reduced jobs from reduced mining activity	14	16	17	18	18	19
Colorado County						
Reduced income from reduced mining activity	$16.12	$15.20	$13.63	$11.50	$8.83	$9.16
Reduced business taxes from reduced mining activity	$1.12	$1.05	$0.94	$0.80	$0.61	$0.63
Reduced jobs from reduced mining activity	145	137	123	103	79	82
Fayette County						
Reduced income from reduced mining activity	$0.00	$0.00	$0.08	$0.11	$0.11	$0.11
Reduced business taxes from reduced mining activity	$0.00	$0.00	$0.01	$0.01	$0.01	$0.01
Reduced jobs from reduced mining activity	0	0	1	1	1	1

Steam-electric ($millions)						
	2010	2020	2030	2040	2050	2060
Bastrop County						
Reduced income from reduced electrical generation	$0.00	$0.00	$0.00	$31.03	$67.39	$67.39
Reduced business taxes from reduced electrical generation	$0.00	$0.00	$0.00	$4.45	$9.67	$9.67
Reduced jobs from reduced electrical generation	0	0	0	105	229	229
Fayette County						
Reduced income from reduced electrical generation	$0.00	$0.00	$0.00	$707.63	$707.63	$907.02
Reduced business taxes from reduced electrical generation	$0.00	$0.00	$0.00	$101.57	$101.57	$130.19
Reduced jobs from reduced electrical generation	0	0	0	2406	2406	3083
Matagorda County						
Reduced income from reduced electrical generation	$1.90	$1,043.13	$1,043.13	$1,043.13	$1,043.13	$1,045.49
Reduced business taxes from reduced electrical generation	$0.27	$149.73	$149.73	$149.73	$149.73	$150.06
Reduced jobs from reduced electrical generation	6	3,546	3,546	3,546	3,546	3,554
Travis County						
Reduced income from reduced electrical generation	$0.00	$0.00	$2.99	$20.60	$91.01	$217.24
Reduced business taxes from reduced electrical generation	$0.00	$0.00	$0.43	$2.96	$13.06	$31.18
Reduced jobs from reduced electrical generation	0	0	10	70	309	738
Wharton County						
Reduced income from reduced electrical generation	$0.00	$0.00	$0.00	$0.00	$0.00	$1.41
Reduced business taxes from reduced electrical generation	$0.00	$0.00	$0.00	$0.00	$0.00	$0.20
Reduced jobs from reduced electrical generation	0	0	0	0	0	0

Municipal ($millions)	2010	2020	2030	2040	2050	2060
Aqua WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.62	$26.11	$75.35	$142.24
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$52.86
Lost jobs due to reduced commercial business activity	0	0	0	0	0	1,176
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$5.63
Lost utility revenues	$0.00	$0.00	$1.10	$6.79	$11.39	$17.24
Austin						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$27.42	$69.83
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$46.14	$95.28
Barton Creek West						
Monetary value of domestic water shortages	$0.07	$0.07	$0.06	$0.05	$0.05	$0.05
Lost utility revenues	$0.10	$0.10	$0.09	$0.09	$0.09	$0.09
Bastrop						
Monetary value of domestic water shortages	$0.08	$0.50	$3.04	$4.26	$7.73	$13.76
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$16.21	$24.16	$68.28
Lost jobs due to reduced commercial business activity	0	0	0	361	537	1,519
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$1.72	$2.57	$7.27
Lost utility revenues	$0.12	$1.49	$2.81	$4.74	$6.33	$8.32
Bastrop County WCID #2						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.18
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.29
Bee Cave Village						
Monetary value of domestic water shortages	$19.27	$24.02	$28.74	$32.96	$36.04	$39.16
Lost income from reduced commercial business activity	$28.34	$36.37	$44.33	$51.44	$56.65	$61.92
Lost jobs due to reduced commercial business activity	457	586	715	829	913	998
Lost state and local taxes from reduced commercial business activity	$2.55	$3.27	$3.99	$4.63	$5.10	$5.57
Lost utility revenues	$1.85	$2.32	$2.78	$3.20	$3.50	$3.81

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Bertram						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.03	$0.10	$0.21
Lost utility revenues	$0.00	$0.00	$0.00	$0.05	$0.15	$0.26
Briarcliff Village						
Monetary value of domestic water shortages	$0.00	$0.00	$0.06	$0.16	$0.24	$0.30
Lost utility revenues	$0.00	$0.00	$0.09	$0.17	$0.23	$0.30
Buda						
Monetary value of domestic water shortages	$0.00	$0.00	$0.38	$1.18	$8.05	$11.86
Lost utility revenues	$0.00	$0.00	$0.61	$1.50	$2.55	$3.42
Cimarron Park Water Company						
Monetary value of domestic water shortages	$2.82	$5.66	$5.00	$6.41	$10.02	$11.84
Lost income from reduced commercial business activity	$0.00	$0.00	$0.69	$0.98	$1.33	$1.62
Lost jobs due to reduced commercial business activity	0	0	28	39	54	65
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.11	$0.15	$0.21	$0.25
Lost utility revenues	$0.30	$0.47	$0.65	$0.84	$1.06	$1.25
Cottonwood Shores						
Monetary value of domestic water shortages	$0.05	$2.98	$7.22	$11.67	$17.16	$23.01
Lost income from reduced commercial business activity	$0.00	$0.22	$1.02	$1.69	$2.43	$3.34
Lost jobs due to reduced commercial business activity	0	9	41	68	98	134
Lost state and local taxes from reduced commercial business activity	$0.00	$0.03	$0.16	$0.26	$0.38	$0.52
Lost utility revenues	$0.05	$0.39	$0.76	$1.19	$1.66	$2.24
County-other (Bastrop)						
Monetary value of domestic water shortages	$0.00	$1.05	$16.93	$47.78	$72.44	$110.51
County-other (Blanco)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.05	$0.08
County-other (Burnet)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.21	$1.15	$1.73	$2.79

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
County-other (Colorado)						
Monetary value of domestic water shortages	$0.11	$0.11	$0.11	$0.10	$0.10	$0.09
County-other (Fayette)						
Monetary value of domestic water shortages	$0.15	$0.17	$0.01	$0.04	$0.03	$0.02
County-other (Hays)						
Monetary value of domestic water shortages	$0.00	$1.01	$17.11	$34.05	$63.12	$90.11
County-other (Llano)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.04	$0.23	$0.46	$0.75
County-other (Mills)						
Monetary value of domestic water shortages	$0.000	$0.000	$0.000	$0.000	$0.031	$0.055
County-other (Travis)						
Monetary value of domestic water shortages	$0.001	$0.001	$0.001	$0.002	$0.004	$0.004
Creedmoor MAHA WSC						
Monetary value of domestic water shortages	$0.00	$6.49	$10.21	$11.95	$13.38	$15.34
Lost income from reduced commercial business activity	$0.00	$1.22	$3.42	$4.16	$4.88	$5.67
Lost jobs due to reduced commercial business activity	0	38	108	131	154	179
Lost state and local taxes from reduced commercial business activity	$0.00	$0.17	$0.49	$0.59	$0.70	$0.81
Lost utility revenues	$0.00	$0.79	$1.00	$1.16	$1.31	$1.48
Dripping Springs						
Monetary value of domestic water shortages	$5.72	$24.82	$32.45	$41.43	$57.16	$65.95
Lost income from reduced commercial business activity	$3.28	$20.82	$28.93	$37.16	$47.36	$55.37
Lost jobs due to reduced commercial business activity	73	463	644	827	1,054	1,232
Lost state and local taxes from reduced commercial business activity	$0.35	$2.22	$3.08	$3.95	$5.04	$5.89
Lost utility revenues	$1.05	$2.47	$3.28	$4.10	$5.12	$5.92
Dripping Springs WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.01	$0.27	$0.59
Lost utility revenues	$0.00	$0.00	$0.00	$0.03	$0.42	$0.72

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Elgin						
Monetary value of domestic water shortages	$0.00	$4.34	$10.34	$19.91	$31.30	$41.55
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$12.10	$18.54	$53.43
Lost jobs due to reduced commercial business activity	0	0	0	269	413	1,189
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$1.29	$1.97	$5.69
Lost utility revenues	$0.00	$1.11	$2.15	$3.72	$5.01	$6.64
Fayette WSC						
Monetary value of domestic water shortages	$0.00	$0.33	$2.92	$4.96	$7.48	$13.97
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.58
Lost jobs due to reduced commercial business activity	0	0	0	0	0	23
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.09
Lost utility revenues	$0.00	$0.47	$1.01	$1.43	$1.95	$2.62
Goforth WSC						
Monetary value of domestic water shortages	$0.10	$0.26	$0.48	$0.70	$0.98	$1.09
Lost utility revenues	$0.02	$0.04	$0.06	$0.07	$0.09	$0.10
Goldthwaite						
Monetary value of domestic water shortages	$10.21	$11.26	$11.42	$11.30	$11.16	$11.14
Lost income from reduced commercial business activity	$6.71	$7.45	$7.56	$7.48	$7.37	$7.36
Lost jobs due to reduced commercial business activity	203	226	229	226	223	223
Lost state and local taxes from reduced commercial business activity	$1.07	$1.18	$1.20	$1.19	$1.17	$1.17
Lost utility revenues	$0.99	$1.10	$1.11	$1.10	$1.09	$1.08
Granite Shoals						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.02	$0.12
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.03	$0.19
Jonestown						
Monetary value of domestic water shortages	$1.28	$4.38	$4.37	$6.24	$8.57	$10.34
Lost income from reduced commercial business activity	$0.00	$0.00	$1.86	$2.70	$3.36	$8.17
Lost jobs due to reduced commercial business activity	0	0	41	60	75	182
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.20	$0.29	$0.36	$0.87
Lost utility revenues	$0.26	$0.46	$0.65	$0.82	$0.95	$1.10

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Kingsland WSC						
Monetary value of domestic water shortages	$0.31	$0.45	$0.44	$0.44	$0.47	$0.51
Lost utility revenues	$0.35	$0.44	$0.43	$0.43	$0.46	$0.50
Lake LBJ MUD						
Monetary value of domestic water shortages	$0.14	$0.33	$0.43	$0.49	$0.63	$0.83
Lost utility revenues	$0.25	$0.53	$0.62	$0.70	$0.80	$0.93
Lakeway						
Monetary value of domestic water shortages	$15.03	$38.28	$50.54	$37.90	$42.37	$56.68
Lost income from reduced commercial business activity	$0.00	$0.00	$20.19	$27.77	$33.43	$39.11
Lost jobs due to reduced commercial business activity	0	0	449	618	744	870
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$2.15	$2.96	$3.56	$4.16
Lost utility revenues	$3.08	$4.79	$6.43	$7.95	$9.07	$10.21
Llano						
Monetary value of domestic water shortages	$22.12	$23.75	$23.99	$24.17	$24.48	$24.98
Lost income from reduced commercial business activity	$21.04	$22.66	$22.90	$23.08	$23.37	$23.87
Lost jobs due to reduced commercial business activity	$17.35	$18.69	$18.88	$19.03	$19.28	$19.69
Lost state and local taxes from reduced commercial business activity	456	491	496	500	506	517
Lost utility revenues						
Manor						
Monetary value of domestic water shortages	$0.00	$8.20	$11.97	$22.74	$25.07	$27.44
Lost income from reduced commercial business activity	$0.00	$6.03	$8.17	$20.34	$23.31	$26.34
Lost jobs due to reduced commercial business activity	0	134	182	452	519	586
Lost state and local taxes from reduced commercial business activity	$0.00	$0.64	$0.87	$2.16	$2.48	$2.80
Lost utility revenues	$0.00	$1.72	$2.15	$2.55	$2.84	$3.14
Manville WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$6.12	$39.06	$45.99	$52.74
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$14.03	$17.24	$20.55
Lost jobs due to reduced commercial business activity	0	0	0	442	544	648
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$2.00	$2.46	$2.93
Lost utility revenues	$0.00	$0.00	$1.52	$4.00	$4.73	$5.56

Municipal (cont.)	2010	2020	2030	2040	2050	2060
Marble Falls						
Monetary value of domestic water shortages	$0.00	$0.22	$1.41	$9.08	$12.43	$18.68
Lost utility revenues	$0.00	$0.39	$1.79	$3.15	$3.95	$4.86
Meadow Lakes						
Monetary value of domestic water shortages	$2.63	$6.32	$9.82	$20.20	$24.42	$27.58
Lost income from reduced commercial business activity	$0.00	$0.00	$2.50	$7.20	$8.51	$9.96
Lost jobs due to reduced commercial business activity	0	0	79	227	268	314
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.36	$1.03	$1.21	$1.42
Lost utility revenues	$0.63	$1.14	$1.70	$2.24	$2.56	$2.91
Mountain City						
Monetary value of domestic water shortages	$0.04	$0.04	$0.04	$0.03	$0.03	$0.03
Lost utility revenues	$0.05	$0.05	$0.05	$0.04	$0.04	$0.04
Pflugerville						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.94	$2.27
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$1.68	$3.63
Polonia WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.01	$0.14	$0.23	$0.33
Lost utility revenues	$0.00	$0.00	$0.01	$0.03	$0.05	$0.06
Richland SUD						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.003	$0.003	$0.005
Lost utility revenues	$0.00	$0.00	$0.00	$0.01	$0.01	$0.01
River Place on Lake Austin						
Monetary value of domestic water shortages	$5.14	$9.03	$9.03	$8.96	$8.96	$8.96
Lost utility revenues	$1.13	$1.63	$1.63	$1.62	$1.62	$1.62
Rolling Wood						
Monetary value of domestic water shortages	$0.00	$7.58	$7.54	$7.50	$7.48	$7.52
Lost income from reduced commercial business activity	$0.00	$3.04	$3.03	$3.01	$3.00	$3.02
Lost jobs due to reduced commercial business activity	0	96	95	95	95	95
Lost state and local taxes from reduced commercial business activity	$0.00	$0.43	$0.43	$0.43	$0.43	$0.43
Lost utility revenues	$0.00	$0.74	$0.74	$0.74	$0.73	$0.74

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Round Rock						
Monetary value of domestic water shortages	$0.19	$3.02	$5.30	$10.62	$12.62	$14.64
Lost income from reduced commercial business activity	$0.00	$3.83	$14.12	$19.27	$24.41	$29.50
Lost jobs due to reduced commercial business activity	0	62	228	311	393	476
Lost state and local taxes from reduced commercial business activity	$0.00	$0.34	$1.27	$1.73	$2.20	$2.66
Lost utility revenues	$0.31	$0.67	$1.05	$1.32	$1.61	$1.90
Schulenburg						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.04	$0.11	$0.30
Lost utility revenues	$0.00	$0.00	$0.00	$0.07	$0.20	$0.38
Smithville						
Monetary value of domestic water shortages	$0.00	$4.34	$10.34	$19.91	$31.30	$41.55
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$1.14	$2.13
Lost jobs due to reduced commercial business activity	0	0	0	0	36	67
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.16	$0.30
Lost utility revenues	$0.14	$0.57	$0.96	$1.73	$2.04	$2.93
Travis Co. WCID #18						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.16	$0.45
Lost utility revenues	$0.00	$0.00	$0.00	$0.01	$0.25	$0.52
West Lake Hills						
Monetary value of domestic water shortages	$0.00	$36.95	$41.31	$43.91	$46.77	$49.82
Lost income from reduced commercial business activity	$0.00	$62.37	$69.72	$74.11	$78.95	$84.08
Lost jobs due to reduced commercial business activity	0	1,005	1,124	1,195	1,272	1,355
Lost state and local taxes from reduced commercial business activity	$0.00	$5.61	$6.28	$6.67	$7.11	$7.57
Lost utility revenues	$0.00	$3.63	$4.06	$4.31	$4.59	$4.89
Windermere Utility Co.						
Monetary value of domestic water shortages	$0.00	$44.80	$44.37	$43.95	$43.95	$43.95
Lost income from reduced commercial business activity	$0.00	$40.83	$40.44	$40.06	$40.06	$40.06
Lost jobs due to reduced commercial business activity	0	908	900	891	891	891
Lost state and local taxes from reduced commercial business activity	$0.00	$4.35	$4.30	$4.26	$4.26	$4.26
Lost utility revenues	$0.00	$4.07	$4.03	$3.99	$3.99	$3.99

June 15, 2010

Mr. Con Mims
Chairman, South Central Texas
Regional Water Planning Group
c/o Nueces River Authority
P.O. Box 349
Uvalde, Texas 78802-0349

Re: Socioeconomic Impact Analysis of Not Meeting Water Needs for the 2011 South Central Texas Regional Water Plan

Dear Chairman Mims:

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: Sam Vaughn, HDR Inc
Matt Nelson, TWDB

Socioeconomic Impacts of Projected Water Shortages for the South Central Texas Regional Water Planning Area (Region L)

Prepared in Support of the 2011 South Central Texas Regional Water Plan

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

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

June 2010

Table of Contents

Tables

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 South Central Texas Regional Water Planning Group (Region L).

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

[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.

as “output” in an IO model. Thus, total sales double-count or overstate the true economic value of goods 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

[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.

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]

- 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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[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 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 South Central Texas Regional Water Planning Area (average 2003-2007)

Sector	Acres (1000s)	Distribution of acres	Water use (1000s of AF)	Distribution of water use
Oilseeds	2	1%	2	1%
Grains	108	43%	123	38%
Vegetable and melons	34	14%	39	12%
Tree nuts	3	1%	7	2%
Fruits	<1	<1%	<1	<1%
Cotton	32	13%	45	14%
All “other” crops	70	28%	105	33%
Total	251	100%	321	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 South Central Texas Regional Water Planning Area (2003-2007)

IMPLAN Sector	Gross revenues per acre	Crops included in estimates
Oilseeds	$178	Based on five-year (2003-2007) average weighted by acreage for "irrigated soybeans" and "irrigated 'other' oil crops."
Grains	$235	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	$5,725	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	$3,374	Based on five-year (2003-2007) average weighted by acreage for "irrigated pecans."
Fruits	$26,423	Based on five-year (2003-2007) average weighted by acreage for "irrigated citrus", "irrigated vineyards" and "irrigated 'other' orchard."
Cotton	$543	Based on five-year (2003-2007) average weighted by acreage for "irrigated cotton."
All "other" crops	$359	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

[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.

is (30 x 200 = 6,000 gallons) or 6.7 acre-feet per year. Water not attributed to commercial use is considered 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

[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.

wastewater rate surveys - specifically average monthly household expenditures on water and wastewater 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

[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).

national 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]

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[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.

[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 *South Central Texas Regional Water Plan*, during severe drought irrigation, 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 South Central Texas economy generates $82 billion in gross state product for Texas ($76 billion in income and $6 billion worth of business taxes) and supports 1,163,680 jobs (Table 8). Generating about $11 billion worth of income per year manufacturing is the primary base economic sector in the region.[22] Municipal sectors also generate substantial amounts of income and are major employers. However, while municipal sectors are the largest employer and source of wealth, 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 such as manufacturing, agriculture and mining. In other words, without base industries such agriculture, many municipal jobs in the region would not exist.

[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 South Central Texas Regional Economy by Water User Group ($millions)*						
Water Use Category	**Total sales**	**Intermediate sales**	**Final sales**	**Jobs**	**Income**	**Business taxes**
Irrigation	$266.54	$47.35	$219.07	4,110	$174.18	$3.23
Livestock	$889.48	$644.74	$244.74	13,506	$134.69	$14.13
Manufacturing	$35,019.65	$4,677.32	$30,342.33	134,359	$11,132.59	$268.65
Mining	$3,841.83	$2,060.19	$1,781.64	9,733	$2,355.49	$194.87
Steam-electric	$534.13	$150.26	$383.87	1,312	$370.93	$63.26
Municipal	$104,098.04	$30,414.34	$73,683.69	1,000,660	$61,736.55	$5,406.62
Regional total	$144,649.67	$37,994.20	$106,655.34	1,163,680	$75,904.43	$5,950.76

[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 *South Central Texas Regional Water Plan*, during severe drought the counties of Atascosa, Medina and Zavala would experiences shortages of irrigation water. Shortages range from about 1 to 76 percent of annual irrigation demands over the planning horizon, and farmers would be short 68,465 acre-feet in 2010 and 41,782 in 2060. Shortages would reduce gross state product (income plus state and local business taxes) by an estimated $45 million per year in 2010 to $33 million in 2060.

Table 9: Economic Impacts of Water Shortages for Irrigation Water User Groups ($millions)			
Decade	**Lost income from reduced crop production [a]**	**Lost state and local tax revenues from reduced crop production**	**Lost jobs from reduced crop production**
2010	$43.32	$2.16	545
2020	$40.63	$2.03	511
2030	$38.04	$1.90	478
2040	$35.55	$1.77	447
2050	$33.17	$1.66	416
2060	$31.13	$1.55	391

*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 in the region. At the regional level, the estimated economic value of domestic water shortages totals $715 million in 2010 and $2,823 million in 2060 (Table 100). Due to curtailment of commercial business activity operation, municipal shortages would reduce gross state product (income plus taxes) by an estimated $53 million in 2020 and $3,780 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	$715.54	$42.91	$5.67	1,067	$149.36
2020	$1,479.80	$1,417.03	$7.66	1,512	$212.55
2030	$1,331.33	$1,909.07	$82.41	17,808	$276.64
2040	$1,805.79	$2,547.77	$111.92	24,229	$340.64
2050	$2,426.71	$3,197.28	$134.26	29,081	$402.51
2060	$2,823.29	$3,621.31	$157.25	34,108	$468.01

*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 in the region are projected to occur in Bexar, Calhoun, Comal and Victoria counties. In 2010, the planning group estimates that these manufacturers would be short about 6,539 acre-feet; and by 2060, this figure increases to nearly 43,072 acre-feet. Shortages of these magnitudes would reduce gross state product (income plus taxes) by an estimated $179 million in 2010 and $2,080 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	$146.77	$22.22	8,274
2020	$324.94	$52.44	11,956
2030	$496.18	$81.52	15,436
2040	$948.36	$159.05	23,170
2050	$1,451.00	$245.34	31,553
2060	$1,777.09	$301.91	38,187

*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 in Region L are projected to occur in Bexar, Comal and Hays counties and would primarily affect aggregates operations (e.g., sand and gravel producers). Combined shortages for each county would result in estimated losses in gross state product totaling $3 million dollars in 2010, and about $7 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	$2.67	$0.14	27
2020	$3.12	$0.17	31
2030	$4.64	$0.34	53
2040	$5.01	$0.37	57
2050	$6.44	$0.48	72
2060	$6.81	$0.51	77

*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 to occur in Atascosa and Victoria counties, and would result in estimated losses of gross state product totaling $72 million in 2020, and $4,011 million 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	$63.17	$9.07	215
2020	$3,493.56	$501.45	5,938
2030	$3,495.55	$501.73	5,941
2040	$3,497.61	$502.03	5,945
2050	$3,503.90	$502.93	5,963
2060	$3,507.77	$503.49	5,973

*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, estimated social impacts focus on changes in population and school enrollment in the region. In 2010, estimated population losses total 12,886 with corresponding reductions in school enrollment of 3,635 students (Table 14). In 2060, population in the region would decline by 54,411 and school enrollment would fall by 10,064.

Table 14: Social Impacts of Water Shortages (2010-2060)

Year	Population Losses	Declines in School Enrollment
2010	12,886	3,635
2020	43,823	12,433
2030	58,402	15,470
2040	74,857	13,835
2050	86,896	16,049
2060	54,411	10,064

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 15 displays the results.

Table 15: Distribution of Impacts by Major River Basin (2010-2060)

River Basin	2010	2020	2030	2040	2050	2060
Colorado	<1%	<1%	<1%	<1%	<1%	<1%
Colorado-Lavaca	<1%	<1%	<1%	<1%	<1%	<1%
Guadalupe	7%	27%	27%	29%	30%	32%
Nueces	37%	22%	19%	16%	14%	12%
San Antonio	57%	51%	55%	57%	57%	58%

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	Oilseeds	1	$0.36	$0.01	$0.34	10	$0.19	$0.01
Irrigation	Grains	2	$25.64	$4.34	$21.30	1,145	$11.80	$0.46
Irrigation	Vegetable and melons	3	$178.72	$11.67	$167.05	2,122	$131.27	$1.68
Irrigation	Tree nuts	4	$10.65	$6.75	$3.82	154	$7.37	$0.26
Irrigation	Fruits	5	$8.48	$1.24	$7.18	172	$4.82	$0.18
Irrigation	Cotton	8	$17.60	$0.29	$17.34	212	$6.48	$0.16
	All other crops	10	$25.09	$23.05	$2.04	295	$12.25	$0.48
	Total irrigation		$266.54	$47.35	$219.07	4,110	$174.18	$3.23
Livestock	Cattle ranching and farming	11	$605.58	$419.90	$185.67	10,638	$47.84	$12.73
Livestock	Poultry and egg production	12	$247.53	$194.00	$53.53	834	$83.31	$0.84
Livestock	Animal production- except cattle and poultry	13	$36.37	$30.84	$5.53	2,034	$3.54	$0.56
	Total livestock	-	$889.48	$644.74	$244.74	13,506	$134.69	$14.13
	Total agriculture	-	$1,156.02	$692.09	$463.81	17,616	$308.87	$17.36
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	$1,996.63	$1,854.24	$142.38	3,290	$1,148.96	$120.59
Mining	Support activities for oil and gas operations	28	$1,026.56	$142.59	$883.98	4,522	$930.58	$42.34
Mining	Drilling oil and gas wells	27	$577.01	$2.88	$574.13	997	$150.15	$19.80
Mining	Sand- gravel- clay- and refractory mining	25	$92.43	$9.76	$82.67	537	$54.54	$2.53
Mining	Coal mining	20	$64.63	$24.22	$40.41	207	$23.55	$7.12
Mining	Stone mining and quarrying	24	$44.53	$4.58	$39.95	149	$26.40	$0.27
Mining	Gold- silver- and other metal ore mining	23	$39.13	$21.85	$17.27	27	$20.87	$2.20
Mining	Other nonmetallic mineral mining	26	$0.58	$0.06	$0.52	3	$0.26	$0.02
Mining	Support activities for other mining	29	$0.33	$0.00	$0.33	1	$0.19	$0.00
	Total mining		$534.13	$150.26	$383.87	1,312	$370.93	$63.26
Steam-electric	**Power generation and supply**	**30**	$3,841.83	$2,060.19	$1,781.64	9,733	$2,355.49	$194.87
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	New residential 1-unit structures- all	33	$3,607.93	$0.00	$3,607.92	23,970	$1,220.47	$19.21
Manufacturing	Plastics material and resin manufacturing	152	$2,571.32	$101.83	$2,469.49	1,813	$469.87	$15.37
Manufacturing	Petroleum refineries	142	$2,362.74	$878.23	$1,484.51	141	$1,068.08	$39.12
Manufacturing	Commercial and institutional buildings	38	$2,045.58	$0.00	$2,045.58	20,895	$1,045.42	$12.89
Manufacturing	Automobile and light truck manufacturing	344	$1,659.11	$1.77	$1,657.33	1,127	$209.81	$5.74
Manufacturing	Pharmaceutical and medicine manufacturing	160	$1,302.79	$238.08	$1,064.71	1,218	$457.37	$10.82
Manufacturing	Aircraft manufacturing	351	$1,231.30	$62.64	$1,168.65	2,422	$220.90	$3.78
Manufacturing	Alumina refining	208	$1,119.35	$50.99	$1,068.35	1,268	$238.82	$20.42
Manufacturing	Soft drink and ice manufacturing	85	$1,048.19	$58.55	$989.64	1,643	$163.97	$7.26
Manufacturing	Other new construction	41	$893.86	$0.00	$893.86	9,585	$484.91	$3.82
Manufacturing	Iron and steel mills	203	$811.22	$58.43	$752.78	873	$210.18	$7.81
Manufacturing	Motor vehicle parts manufacturing	350	$759.01	$61.03	$697.98	2,009	$196.86	$3.17
Manufacturing	Meat processed from carcasses	68	$596.94	$176.11	$420.83	1,360	$66.29	$3.43
Manufacturing	New residential additions and alterations-all	35	$514.58	$0.00	$514.58	2,855	$193.43	$2.73
Manufacturing	Wood kitchen cabinet and countertop manufacturing	362	$480.41	$374.24	$106.18	3,866	$209.65	$3.47
Manufacturing	AC- refrigeration- and forced air heating	278	$459.38	$0.00	$459.38	1,443	$100.71	$2.64
Manufacturing	Highway- street- bridge- and tunnel construct	39	$439.94	$0.00	$439.94	4,046	$223.89	$2.85
Manufacturing	Pesticide and other agricultural chemical man	159	$415.02	$69.54	$345.48	200	$162.38	$2.85
Manufacturing	Bread and bakery product- except frozen- manufacturing	73	$411.42	$91.87	$319.55	2,551	$182.21	$2.93
Manufacturing	New multifamily housing structures- all	34	$396.64	$0.00	$396.64	3,482	$188.50	$1.09
Manufacturing	Cement manufacturing	191	$394.93	$1.06	$393.87	407	$201.94	$4.12
Manufacturing	Other basic organic chemical manufacturing	151	$348.82	$65.03	$283.78	302	$54.93	$2.20
Manufacturing	Aircraft engine and engine parts manufacturing	352	$344.04	$94.27	$249.77	910	$71.12	$1.01
Manufacturing	Other animal food manufacturing	47	$331.48	$39.98	$291.50	465	$29.31	$2.24
Manufacturing	Water- sewer- and pipeline construction	40	$319.41	$0.00	$319.41	2,649	$143.64	$2.08
Manufacturing	Ready-mix concrete manufacturing	192	$316.77	$1.54	$315.23	1,003	$121.49	$3.30
Manufacturing	All other manufacturing	-	$9,837.48	$2,252.12	$7,585.36	41,856	$3,196.44	$82.30
Manufacturing	**Total manufacturing**	-	**$35,019.65**	**$4,677.32**	**$30,342.33**	**134,359**	**$11,132.59**	**$268.65**
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	Owner-occupied dwellings	509	$6,426.35	$0.00	$6,426.35	0	$4,978.29	$759.88
Municipal	Wholesale trade	390	$6,141.21	$2,940.19	$3,201.02	36,563	$3,233.08	$908.45
Municipal	Real estate	431	$5,071.02	$2,007.38	$3,063.64	27,385	$2,934.53	$624.25
Municipal	Insurance carriers	427	$4,588.64	$1,338.03	$3,250.60	16,586	$1,813.63	$225.94
Municipal	Monetary authorities and depository credit in	430	$4,297.56	$1,415.42	$2,882.14	17,925	$3,017.82	$54.97
Municipal	Food services and drinking places	481	$4,044.01	$516.41	$3,527.59	80,052	$1,729.17	$202.02
Municipal	State & Local Education	503	$3,973.22	$0.00	$3,973.22	92,541	$3,973.22	$0.00
Municipal	Federal Military	505	$3,676.66	$0.01	$3,676.66	34,658	$3,676.66	$0.00
Municipal	Offices of physicians- dentists- and other he	465	$3,582.61	$0.00	$3,582.61	29,480	$2,549.08	$22.39
Municipal	Telecommunications	422	$3,560.49	$1,222.96	$2,337.52	7,129	$1,623.90	$270.70
Municipal	Hospitals	467	$2,687.75	$0.00	$2,687.74	22,732	$1,461.31	$18.67
Municipal	Motor vehicle and parts dealers	401	$2,090.72	$227.34	$1,863.37	18,289	$1,083.57	$306.77
Municipal	State & Local Non-Education	504	$1,971.28	$0.00	$1,971.28	34,133	$1,971.28	$0.00
Municipal	Pipeline transportation	396	$1,964.70	$859.23	$1,105.47	1,251	$835.12	$178.13
Municipal	Truck transportation	394	$1,909.79	$1,034.09	$875.69	17,671	$734.47	$16.89
Municipal	Federal Non-Military	506	$1,666.73	$0.01	$1,666.72	9,364	$1,666.72	$0.00
Municipal	Management of companies and enterprises	451	$1,665.00	$1,565.78	$99.22	7,815	$1,007.27	$16.08
Municipal	Architectural and engineering services	439	$1,580.82	$996.49	$584.33	12,844	$849.85	$7.03
Municipal	Hotels and motels- including casino hotels	479	$1,427.17	$735.24	$691.93	14,042	$790.79	$135.39
Municipal	General merchandise stores	410	$1,257.83	$132.57	$1,125.26	21,584	$579.77	$184.49
Municipal	Other State and local government enterprises	499	$1,216.82	$396.23	$820.59	5,493	$477.38	$0.16
Municipal	Legal services	437	$1,201.39	$762.47	$438.92	9,070	$760.65	$23.62
Municipal	Other ambulatory health care services	466	$1,165.44	$75.80	$1,089.64	8,243	$566.52	$8.44
Municipal	Food and beverage stores	405	$1,124.71	$150.37	$974.34	18,856	$578.36	$126.75
Municipal	Funds- trusts- and other financial vehicles	429	$1,119.37	$21.23	$1,098.14	3,732	$246.75	$9.89
Municipal	Securities- commodity contracts- investments	426	$1,110.71	$737.61	$373.10	9,095	$411.31	$12.11
Municipal	**All other municipal**		$29,595.50	$11,187.27	$18,408.23	409,988	$15,779.81	$1,260.49
Manufacturing	**Total**		**$100,117.50**	**$28,322.13**	**$71,795.32**	**966,521**	**$59,330.31**	**$5,373.51**
Based on year 2006 data from the Minnesota IMPLAN Group, Inc.								

Appendix 2: Impacts by Water User Group

Irrigation ($millions)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Atascosa County						
Reduced income from lost crop production	$1.13	$0.88	$0.63	$0.40	$0.17	$0.05
Reduced business taxes from lost crop production	$0.05	$0.04	$0.03	$0.02	$0.01	$0.00
Reduced jobs from lost crop production	13	10	7	5	2	1
Medina County						
Reduced income from lost crop production	$1.29	$0.98	$0.68	$0.39	$0.11	$0.00
Reduced business taxes from lost crop production	$0.07	$0.05	$0.03	$0.02	$0.01	$0.00
Reduced jobs from lost crop production	19	14	10	6	2	0
Zavala County						
Reduced income from lost crop production	$40.90	$38.77	$36.73	$34.77	$32.89	$31.08
Reduced business taxes from lost crop production	$2.04	$1.94	$1.83	$1.74	$1.64	$1.55
Reduced jobs from lost crop production	513	487	461	436	413	390

Manufacturing ($millions)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Bexar County						
Reduced income from lost manufacturing	$32.89	$119.92	$202.26	$566.31	$708.72	$863.34
Reduced business taxes from lost manufacturing	$5.67	$20.68	$34.87	$97.64	$122.19	$148.85
Reduced jobs from lost crop livestock manufacturing	501	1,826	3,080	8,624	10,793	13,148
Calhoun County						
Reduced income from lost manufacturing	$0.00	$0.00	$0.00	$0.00	$0.00	$7.27
Reduced business taxes from lost manufacturing	$0.00	$0.00	$0.00	$0.00	$0.00	$2.12
Reduced jobs from lost crop livestock manufacturing	0	0	0	0	0	755
Comal County						
Reduced income from lost manufacturing	$113.88	$132.15	$148.60	$164.59	$178.32	$197.62
Reduced business taxes from lost manufacturing	$16.55	$19.21	$21.60	$23.92	$25.92	$28.72
Reduced jobs from lost crop livestock manufacturing	7,773	9,020	10,143	11,234	12,171	13,488
Victoria County						
Reduced income from lost manufacturing	$0.00	$72.87	$145.32	$217.45	$563.96	$708.86
Reduced business taxes from lost manufacturing	$0.00	$12.56	$25.06	$37.49	$97.23	$122.22
Reduced jobs from lost crop livestock manufacturing	0	1,110	2,213	3,312	8,588	10,795

Mining ($millions)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Bexar County						
Reduced income from lost mining output	$0.00	$0.00	$1.25	$1.38	$1.52	$1.65
Reduced business taxes from lost mining output	$0.00	$0.00	$0.15	$0.17	$0.19	$0.20
Reduced jobs from lost mining output	0	0	18	20	22	24
Comal County						
Reduced income from lost mining output	$0.44	$0.64	$0.76	$0.87	$2.15	$2.36
Reduced business taxes from lost mining output	$0.03	$0.05	$0.05	$0.06	$0.15	$0.17
Reduced jobs from lost mining output	5	7	8	9	22	24
Hays County						
Reduced income from lost mining output	$2.23	$2.48	$2.64	$2.75	$2.78	$2.80
Reduced business taxes from lost mining output	$0.11	$0.12	$0.13	$0.14	$0.14	$0.14
Reduced jobs from lost mining output	22	25	26	27	28	28

Steam-electric ($millions)						
	2010	2020	2030	2040	2050	2060
Atascosa County						
Reduced income from lost electrical generation	$1.78	$0.00	$0.00	$0.00	$4.10	$6.39
Reduced business taxes from lost electrical generation	$0.26	$0.00	$0.00	$0.00	$0.59	$0.92
Reduced jobs from lost electrical generation	6	0	0	0	14	22
Victoria County						
Reduced income from lost electrical generation	$61.39	$3,493.56	$3,495.55	$3,497.61	$3,499.80	$3,501.38
Reduced business taxes from lost electrical generation	$8.81	$501.45	$501.73	$502.03	$502.34	$502.57
Reduced jobs from lost electrical generation	209	5938	5941	5945	5949	5951

Municipal ($millions)	2010	2020	2030	2040	2050	2060
Alamo Heights						
Monetary value of domestic water shortages	$0.96	$1.06	$1.07	$1.06	$1.08	$1.12
Lost utility revenues	$1.06	$1.18	$1.18	$1.17	$1.20	$1.24
Aqua WSC						
Monetary value of domestic water shortages	$0.10	$1.68	$4.04	$3.70	$4.53	$5.42
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.17	$0.23	$0.30
Lost jobs due to reduced commercial business activity	0	0	0	7	9	12
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.03	$0.04	$0.05
Lost utility revenues	$0.10	$0.24	$0.35	$0.48	$0.59	$0.72
Atascosa Rural WSC						
Monetary value of domestic water shortages	$9.49	$11.95	$15.32	$17.74	$19.56	$21.76
Lost income from reduced commercial business activity	$2.11	$3.07	$3.92	$4.63	$5.24	$5.87
Lost jobs due to reduced commercial business activity	47	68	87	103	117	131
Lost state and local taxes from reduced commercial business activity	$0.22	$0.33	$0.42	$0.49	$0.56	$0.62
Lost utility revenues	$0.98	$1.29	$1.56	$1.79	$1.99	$2.19
Benton City WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.23	$0.64	$3.12	$3.92
Lost utility revenues	$0.00	$0.00	$0.36	$0.83	$1.28	$1.63
Bexar Met Water District						
Monetary value of domestic water shortages	$29.85	$43.51	$52.16	$59.71	$68.58	$82.71
Lost income from reduced commercial business activity	$8.43	$13.75	$19.10	$23.71	$28.77	$34.02
Lost jobs due to reduced commercial business activity	136	222	308	382	464	548
Lost state and local taxes from reduced commercial business activity	$0.76	$1.24	$1.72	$2.13	$2.59	$3.06
Lost utility revenues	$7.23	$8.43	$9.92	$10.75	$11.88	$13.15

Municipal (cont.)	2010	2020	2030	2040	2050	2060
Boerne						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.25
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.50
Bulverde City						
Monetary value of domestic water shortages	$6.31	$24.37	$39.17	$59.32	$75.71	$93.29
Lost income from reduced commercial business activity	$2.26	$5.50	$9.19	$12.86	$16.68	$20.77
Lost jobs due to reduced commercial business activity	91	221	369	517	671	835
Lost state and local taxes from reduced commercial business activity	$0.32	$0.78	$1.31	$1.83	$2.38	$2.96
Lost utility revenues	$1.17	$2.41	$3.83	$5.23	$6.69	$8.26
Canyon Lake WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.11	$3.17	$25.78	$47.65
Lost utility revenues	$0.00	$0.00	$0.23	$3.95	$8.03	$12.17
Castle Hills						
Monetary value of domestic water shortages	$0.12	$0.10	$0.08	$0.07	$0.05	$0.05
Lost utility revenues	$0.19	$0.16	$0.14	$0.11	$0.09	$0.09
Castroville						
Monetary value of domestic water shortages	$3.63	$4.28	$5.55	$8.93	$9.88	$10.75
Lost income from reduced commercial business activity	$0.94	$1.41	$1.84	$2.22	$2.68	$3.08
Lost jobs due to reduced commercial business activity	22	33	43	51	61	70
Lost state and local taxes from reduced commercial business activity	$0.79	$1.17	$1.54	$1.86	$2.19	$2.51
Lost utility revenues	$0.58	$0.71	$0.82	$0.93	$1.03	$1.14
Converse						
Monetary value of domestic water shortages	$0.00	$0.00	$0.12	$0.51	$0.92	$1.57
Lost utility revenues	$0.00	$0.00	$0.24	$0.81	$1.29	$1.74
County Line WSC						
Monetary value of domestic water shortages	$0.00	$13.95	$20.67	$22.12	$32.21	$41.84
Lost income from reduced commercial business activity	$0.00	$1.99	$2.98	$3.21	$3.89	$5.04
Lost jobs due to reduced commercial business activity	0	80	120	129	156	203
Lost state and local taxes from reduced commercial business activity	$0.00	$0.31	$0.46	$0.50	$0.60	$0.78
Lost utility revenues	$0.00	$1.89	$2.59	$2.91	$3.50	$4.35

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
County-other (Bexar)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.11	$0.37	$0.67
County-other (Comal)						
Monetary value of domestic water shortages	$18.36	$23.89	$26.38	$34.60	$39.04	$43.36
County-other (Kendall)						
Monetary value of domestic water shortages	$0.23	$1.11	$2.47	$10.95	$15.73	$24.74
County-other (Medina)						
Monetary value of domestic water shortages	$0.00	$0.27	$0.76	$1.28	$6.09	$8.23
County-other (Victoria)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.07	$0.18	$0.32
County-other (Wilson)						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.03
Creedmore –Maha WSC						
Monetary value of domestic water shortages	$1.07	$2.73	$4.75	$5.90	$7.07	$8.75
Lost income from reduced commercial business activity	$0.00	$0.38	$0.58	$0.79	$0.99	$1.21
Lost jobs due to reduced commercial business activity	0	15	23	32	40	48
Lost state and local taxes from reduced commercial business activity	$0.00	$0.06	$0.09	$0.12	$0.15	$0.19
Lost utility revenues	$0.21	$0.36	$0.49	$0.62	$0.75	$0.89
Crystal Clear WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.67	$3.07	$14.98	$23.52
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.63
Lost jobs due to reduced commercial business activity	0	0	0	0	0	25
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.10
Lost utility revenues	$0.00	$0.00	$0.79	$1.78	$3.05	$4.30

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
East Central WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.28	$0.69	$1.87	$3.45
Lost utility revenues	$0.00	$0.00	$0.46	$0.91	$1.32	$1.74
East Medina SUD						
Monetary value of domestic water shortages	$0.00	$0.11	$0.27	$0.44	$0.64	$2.59
Lost utility revenues	$0.00	$0.19	$0.38	$0.54	$0.71	$0.88
Floresville						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.15	$0.50
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.29	$0.78
Garden Ridge						
Monetary value of domestic water shortages	$2.54	$5.97	$9.83	$13.42	$16.68	$20.57
Lost income from reduced commercial business activity	$0.00	$0.58	$0.92	$1.27	$1.62	$2.01
Lost jobs due to reduced commercial business activity	0	23	37	51	65	81
Lost state and local taxes from reduced commercial business activity	$0.00	$0.09	$0.14	$0.20	$0.25	$0.31
Lost utility revenues	$0.51	$0.78	$1.09	$1.41	$1.73	$2.08
Goforth WSC						
Monetary value of domestic water shortages	$0.00	$0.02	$0.56	$4.64	$10.05	$12.53
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$2.58
Lost jobs due to reduced commercial business activity	0	0	0	0	0	104
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.40
Lost utility revenues	$0.00	$0.05	$0.80	$1.61	$2.61	$3.43

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Green Valley WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.68
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$1.17
Hill Country Village						
Monetary value of domestic water shortages	$26.38	$26.27	$26.12	$26.01	$25.94	$25.94
Lost income from reduced commercial business activity	$4.30	$4.28	$4.25	$4.23	$4.22	$4.22
Lost jobs due to reduced commercial business activity	136	135	134	134	133	133
Lost state and local taxes from reduced commercial business activity	$0.61	$0.61	$0.61	$0.60	$0.60	$0.60
Lost utility revenues	$1.45	$1.44	$1.43	$1.43	$1.42	$1.42
Hollywood Park						
Monetary value of domestic water shortages	$40.26	$41.77	$43.17	$44.23	$45.32	$46.35
Lost income from reduced commercial business activity	$8.29	$8.63	$8.95	$9.19	$9.43	$9.66
Lost jobs due to reduced commercial business activity	261	272	282	290	297	305
Lost state and local taxes from reduced commercial business activity	$1.18	$1.23	$1.27	$1.31	$1.34	$1.38
Lost utility revenues	$3.90	$4.05	$4.18	$4.29	$4.40	$4.50
Hondo						
Monetary value of domestic water shortages	$0.41	$0.87	$3.91	$5.25	$6.88	$7.95
Lost utility revenues	$0.57	$0.96	$1.33	$1.63	$1.95	$2.25
Jourdanton						
Monetary value of domestic water shortages	$0.16	$0.27	$0.35	$0.54	$0.62	$0.69
Lost utility revenues	$0.22	$0.34	$0.45	$0.53	$0.61	$0.67
Karnes City						
Monetary value of domestic water shortages	$1.64	$1.83	$2.46	$2.65	$2.77	$2.87
Lost utility revenues	$0.36	$0.40	$0.44	$0.48	$0.50	$0.52

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Kenedy						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.04	$0.10	$0.16
Lost utility revenues	$0.00	$0.00	$0.00	$0.07	$0.17	$0.23
Kirby						
Monetary value of domestic water shortages	$1.77	$1.76	$1.78	$1.75	$1.81	$1.92
Lost utility revenues	$0.60	$0.60	$0.61	$0.60	$0.62	$0.65
Kyle						
Monetary value of domestic water shortages	$0.00	$0.45	$0.92	$1.12	$2.22	$2.76
Lost utility revenues	$0.00	$0.78	$1.28	$1.57	$2.46	$3.05
Lacoste						
Monetary value of domestic water shortages	$0.91	$1.20	$1.20	$1.43	$1.76	$1.95
Lost income from reduced commercial business activity	$0.00	$0.00	$0.17	$0.19	$0.22	$0.26
Lost jobs due to reduced commercial business activity	0	0	7	8	9	10
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.03	$0.03	$0.03	$0.04
Lost utility revenues	$0.18	$0.22	$0.25	$0.27	$0.30	$0.33
Lockhart						
Monetary value of domestic water shortages	$0.00	$0.33	$1.23	$7.43	$11.27	$17.68
Lost utility revenues	$0.00	$0.58	$1.54	$2.53	$3.51	$4.52
Luling						
Monetary value of domestic water shortages	$0.00	$0.12	$0.24	$0.38	$0.65	$0.82
Lost utility revenues	$0.00	$0.22	$0.38	$0.53	$0.72	$0.91
Lytle						
Monetary value of domestic water shortages	$0.32	$0.39	$0.45	$1.44	$1.54	$1.63
Lost utility revenues	$0.28	$0.30	$0.32	$0.33	$0.35	$0.37
Marion						
Monetary value of domestic water shortages	$0.00	$0.00	$0.02	$0.05	$0.09	$0.15
Lost utility revenues	$0.00	$0.01	$0.04	$0.07	$0.10	$0.15

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Martindale WSC						
Monetary value of domestic water shortages	$0.06	$0.38	$0.76	$1.52	$2.21	$2.88
Lost utility revenues	$0.08	$0.14	$0.19	$0.25	$0.30	$0.36
Maxwell WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.09	$0.43	$0.74	$5.25
Lost utility revenues	$0.00	$0.00	$0.15	$0.49	$0.94	$1.36
McCoy WSC						
Monetary value of domestic water shortages	$0.00	$0.02	$0.48	$1.07	$1.99	$5.63
Lost utility revenues	$0.00	$0.02	$0.38	$0.79	$1.18	$1.48
Mountain City						
Monetary value of domestic water shortages	$0.00	$0.04	$0.54	$1.04	$2.45	$3.04
Lost utility revenues	$0.00	$0.04	$0.10	$0.15	$0.21	$0.27
Mustang Ridge						
Monetary value of domestic water shortages	$0.03	$0.51	$0.98	$1.68	$2.43	$3.41
Lost utility revenues	$0.04	$0.12	$0.20	$0.27	$0.35	$0.42
Natalia						
Monetary value of domestic water shortages	$2.92	$4.25	$5.23	$5.93	$6.56	$7.16
Lost income from reduced commercial business activity	$0.55	$0.73	$0.89	$1.04	$1.18	$1.31
Lost jobs due to reduced commercial business activity	17	23	28	33	37	41
Lost state and local taxes from reduced commercial business activity	$0.08	$0.10	$0.13	$0.15	$0.17	$0.19
Lost utility revenues	$0.38	$0.47	$0.55	$0.62	$0.69	$0.76
New Braunfels						
Monetary value of domestic water shortages	$0.00	$0.91	$8.24	$40.33	$63.55	$105.08
Lost income from reduced commercial business activity	$0.00	$0.00	$1.79	$5.14	$8.84	$12.91
Lost jobs due to reduced commercial business activity	0	0	40	114	197	287
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.19	$0.55	$0.94	$1.37
Lost utility revenues	$0.00	$1.65	$7.34	$12.97	$18.80	$25.25

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Niederwald						
Monetary value of domestic water shortages	$0.56	$1.84	$3.44	$5.86	$7.61	$9.05
Lost utility revenues	$0.11	$0.23	$0.36	$0.48	$0.63	$0.75
Oak Hills WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.41
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.59
Plum Creek Water Co.						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.25	$2.40	$3.79
Lost utility revenues	$0.00	$0.00	$0.00	$0.35	$0.82	$1.18
Point Comfort						
Monetary value of domestic water shortages	$0.07	$1.44	$5.15	$9.38	$9.19	$9.19
Lost utility revenues	$0.09	$0.29	$0.64	$0.99	$0.97	$0.97
Polonia WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.06	$0.30
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.12	$0.48
Sabinal						
Monetary value of domestic water shortages	$0.18	$0.17	$0.16	$0.16	$0.15	$0.15
Lost utility revenues	$0.25	$0.24	$0.23	$0.22	$0.22	$0.22
San Antonio						
Monetary value of domestic water shortages	$505.60	$1,169.02	$914.55	$1,223.47	$1,613.29	$1,769.69
Lost income from reduced commercial business activity	$0.00	$0.00	$683.59	$942.18	$1,132.44	$1,322.45
Lost jobs due to reduced commercial business activity	0	0	15,208	20,961	25,194	29,421
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$72.75	$100.27	$120.51	$140.73
Lost utility revenues	$117.71	$165.77	$205.50	$239.53	$266.76	$293.93
San Marcos						
Monetary value of domestic water shortages	$0.00	$0.00	$1.35	$7.74	$49.10	$80.16
Lost utility revenues	$0.00	$0.00	$2.37	$8.58	$15.30	$20.47

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Santa Clara						
Monetary value of domestic water shortages	$0.63	$2.85	$6.54	$11.64	$15.41	$19.44
Lost utility revenues	$0.15	$0.41	$0.69	$0.96	$1.27	$1.60
Schertz						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.67	$3.15
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$1.17	$4.40
Selma						
Monetary value of domestic water shortages	$0.00	$0.56	$1.54	$1.52	$2.01	$2.63
Lost utility revenues	$0.00	$0.71	$1.51	$1.50	$1.48	$1.49
Shavano Park						
Monetary value of domestic water shortages	$2.88	$3.03	$3.14	$3.22	$3.32	$3.43
Lost utility revenues	$0.63	$0.67	$0.69	$0.71	$0.73	$0.75
SS WSC						
Monetary value of domestic water shortages	$0.26	$4.99	$12.19	$19.80	$35.60	$44.69
Lost utility revenues	$0.40	$1.55	$2.78	$3.98	$5.28	$6.63
Sunko WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.07
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.14
Universal City						
Monetary value of domestic water shortages	$0.10	$0.48	$0.87	$0.81	$0.78	$0.78
Lost utility revenues	$0.20	$0.76	$1.22	$1.13	$1.09	$1.09
Uvalde						
Monetary value of domestic water shortages	$28.56	$28.86	$29.03	$29.06	$29.08	$29.31
Lost income from reduced commercial business activity	$16.03	$16.34	$16.51	$16.54	$16.56	$16.79
Lost jobs due to reduced commercial business activity	357	364	367	368	368	374
Lost state and local taxes from reduced commercial business activity	$1.71	$1.74	$1.76	$1.76	$1.76	$1.79
Lost utility revenues	$5.70	$5.77	$5.81	$5.81	$5.82	$5.87

Municipal (cont.)	2010	2020	2030	2040	2050	2060
Water Services Inc.						
Monetary value of domestic water shortages	$21.86	$27.55	$33.22	$38.38	$43.22	$48.43
Lost utility revenues	$1.80	$2.27	$2.74	$3.17	$3.57	$4.00
Wimberly						
Monetary value of domestic water shortages	$0.36	$2.79	$5.26	$7.91	$14.28	$17.07
Lost utility revenues	$0.39	$0.79	$1.20	$1.59	$2.12	$2.53
Windcrest						
Monetary value of domestic water shortages	$0.30	$0.29	$0.28	$0.27	$0.26	$0.27
Lost utility revenues	$0.42	$0.41	$0.39	$0.38	$0.37	$0.38
Woodcreek						
Monetary value of domestic water shortages	$0.03	$0.19	$1.46	$2.51	$4.41	$6.19
Lost utility revenues	$0.05	$0.18	$0.32	$0.45	$0.63	$0.77
Woodcreek Utilities Inc.						
Monetary value of domestic water shortages	$6.33	$19.35	$30.50	$40.34	$52.42	$61.92
Lost utility revenues	$0.90	$1.69	$2.52	$3.33	$4.32	$5.11
Yancey WSC						
Monetary value of domestic water shortages	$0.31	$0.00	$0.00	$7.01	$8.28	$9.54
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.96	$1.26	$1.55
Lost jobs due to reduced commercial business activity	0	0	0	21	28	34
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.10	$0.13	$0.16
Lost utility revenues	$0.42	$0.78	$1.11	$1.41	$1.69	$1.95

TEXAS WATER DEVELOPMENT BOARD

June 15, 2010

Mr. Glenn Jarvis
Chairman, Rio Grande Regional Water Planning Group
c/o Law Offices of Glenn Jarvis
InterNational Bank
1801 South Second Street, Suite 550
McAllen, Texas 78503

Re: Socioeconomic Impact Analysis of Not Meeting Water Needs for the 2011 Rio Grande Regional Water Plan

Dear Chairman Jarvis:

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. Connie Townsend, TWDB
S. Doug Shaw, TWDB

Socioeconomic Impacts of Projected Water Shortages for the Rio Grande Regional Water Planning Area (Region M)

Prepared in Support of the 2011 Rio Grande Regional Water Plan

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

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

June 2010

Table of Contents

Tables

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 Rio Grande Regional Water Planning Group (Region M).

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 Rio Grande Regional Water Planning Area (average 2003-2007)

Sector	Acres (1000s)	Distribution of acres	Water use (1000s of AF)	Distribution of water use
Oilseeds	4	1%	5	1%
Grains	143	31%	253	27%
Vegetable and melons	73	16%	120	13%
Tree nuts	7	1%	18	2%
Fruits	13	3%	34	4%
Cotton	59	13%	111	12%
Sugarcane	42	9%	142	15%
All other crops	120	26%	252	27%
Total	459	100%	937	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 Rio Grande Regional Water Planning Area (2003-2007)		
IMPLAN Sector	**Gross revenues per acre**	**Crops included in estimates**
Grains	$267	Based on five-year (2003-2007) average weighted by acreage for "irrigated grain sorghum," "irrigated corn", "irrigated wheat" and "irrigated 'other' grain crops."
Oilseed Farming	$214	Irrigated figure is based on five-year (2003-2007) average weighted by acreage for "irrigated soybeans" and "irrigated 'other' oil crops."
Vegetable and melons	$6,246	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	$3,304	Based on five-year (2003-2007) average weighted by acreage for "irrigated pecans."
Fruits	6,305	Based on five-year (2003-2007) average weighted by acreage for "irrigated citrus", "irrigated vineyards" and "irrigated 'other' orchard."
Cotton	$389	Based on five-year (2003-2007) average weighted by acreage for "irrigated cotton."
Sugarcane	$1,051	Based on five-year (2003-2007) average weighted by acreage for irrigated sugarcane.
All other crops	$254	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

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[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.

200 = 6,000 gallons) or 6.7 acre-feet per year. Water not attributed to commercial use is considered 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

[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.

wastewater rate surveys - specifically average monthly household expenditures on water and wastewater 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

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[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]

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[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.

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[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 *Rio Grande Regional Water Plan*, during severe drought irrigation- 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 Rio Grande regional economy generates roughly $29 billion in gross state product for Texas ($26 billion in income and $2 billion worth of business taxes) and supports an estimated 567,277 jobs (Table 8). Generating about $3.6 billion worth of income per year, agriculture, manufacturing, and mining are the primary base economic sectors in the region.[22] Municipal sectors also generate substantial amounts of income and are major employers. However, while municipal sectors are the largest employer and source of wealth, 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 such as manufacturing, agriculture and mining. In other words, without base industries such agriculture, many municipal jobs in the region would not exist.

[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.

Water Use Category	Total sales	Intermediate sales	Final sales	Jobs	Income	Business taxes
Irrigation	$587.19	$66.29	$472.13	9,576	$368.38	$8.80
Livestock	$337.00	$162.43	$174.57	3,253	$28.32	$4.20
Manufacturing	$7,516.54	$804.21	$6,712.33	51,443	$2,051.56	$43.87
Mining	$1,489.38	$641.26	$848.12	4,822	$1,034.67	$71.02
Steam-electric	$295.72	$83.19	$212.53	790	$205.34	$35.05
Municipal	$36,755.66	$8,169.71	$28,585.95	497,393	$22,215.26	$1,788.13
Regional total	**$46,981.49**	**$9,927.09**	**$37,005.63**	**567,277**	**$25,903.53**	**$1,951.07**

Table 8: The Rio Grande Regional Economy by Water User Group ($millions)*

[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 *Rio Grande Regional Water Plan*, during severe drought the counties of Cameron, Hidalgo, Maverick, Starr, Webb, Willacy, and Zapata would experiences shortages of irrigation water. Shortages range from 28 to 45 percent of annual irrigation demands, and farmers would be short nearly 407,500 acre-feet in 2010 and 258,375 acre-feet in 2060. Shortages of these magnitudes would reduce gross state product (income plus state and local business taxes) by an estimated $126 million per year in 2010 and $50 million in 2060.

Table 9: Economic Impacts of Water Shortages for Irrigation Water User Groups ($millions)

Decade	Lost income from reduced crop production [a]	Lost state and local tax revenues from reduced crop production	Lost jobs from reduced crop production
2010	$123.82	$2.91	1,235
2020	$62.69	$1.59	785
2030	$44.56	$1.16	613
2040	$45.79	$1.19	627
2050	$47.02	$1.22	641
2060	$48.16	$1.25	655

*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 in the region. Deficits range anywhere from 5 to 10 percent of total annual water demands. At the regional level, the estimated economic value of domestic water shortages totals $176 million in 2010 and $3,108 million in 2060 (Table 10). Due to curtailment of commercial business activity operation, municipal shortages would reduce gross state product (income plus taxes) by an estimated $18 million in 2020 and $2,460 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	$176.41	$15.43	$2.23	510	$38.93
2020	$360.33	$19.19	$2.80	667	$103.99
2030	$848.77	$36.04	$4.82	1,135	$188.77
2040	$1,452.62	$437.72	$49.32	11,137	$289.15
2050	$2,277.47	$988.84	$109.90	24,585	$412.11
2060	$3,195.41	$2,213.85	$248.58	53,679	$543.69

*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 in the region are projected to occur in Cameron and Hidalgo counties. In 2010, the Rio Grande planning group estimates that these manufacturers would be short about 1,900 acre-feet; and by 2060, this figure increases to nearly 4,450 acre-feet. Shortages of these magnitudes would reduce gross state product (income plus taxes) by an estimated $206 million in 2010 and $453 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	$184.26	$22.14	3,336
2020	$226.44	$27.20	4,100
2030	$264.64	$31.79	4,791
2040	$302.44	$36.33	5,476
2050	$346.05	$41.46	6,265
2060	$404.80	$48.37	7,329

*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 Steam-electric Water Shortages

Water shortages for electrical generating units are projected to occur in Cameron, Hidalgo and Webb counties, and would result in estimated losses of gross state product totaling $19 million dollars in 2020, and $306 million 2060 (Table 12).

Table 12: 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	$0.00	$0.00	0
2020	$16.70	$2.40	57
2030	$36.89	$5.30	125
2040	$122.99	$17.65	418
2050	$186.31	$26.74	633
2060	$267.93	$38.46	911

*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 Social Impacts of Water Shortages

As discussed previously, estimated social impacts focus on changes in population and school enrollment in the region. In 2010, estimated population losses total 6,112 with corresponding reductions in school enrollment of 1,724 students (Table 13). In 2060, population in the region would decline by 75,252 and school enrollment would fall by 21,349.

Table 13: Social Impacts of Water Shortages (2010-2060)

Year	Population Losses	Declines in School Enrollment
2010	6,112	1,724
2020	6,756	1,917
2030	8,027	2,277
2040	21,269	6,034
2050	38,597	10,950
2060	75,252	21,349

2.7 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 14 displays the results.

Table 14: Distribution of Impacts by Major River Basin (2010-2060)

River Basin	2010	2020	2030	2040	2050	2060
Nueces	1%	1%	1%	1%	1%	1%
Nueces-Rio Grande	80%	76%	71%	70%	70%	70%
Rio Grande	19%	23%	28%	29%	29%	29%

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	Oilseed Farming	1	$0.79	$0.20	$0.59	17	$0.38	$0.02
Irrigation	Grain Farming	2	$42.70	$11.19	$31.33	1,265	$19.56	$0.77
Irrigation	Vegetable and Melon Farming	3	$328.47	$9.66	$318.81	3,755	$241.23	$3.09
Irrigation	Tree Nut Farming	4	$22.56	$0.00	$22.56	295	$15.24	$0.55
Irrigation	Fruit Farming	6	$85.84	$12.52	$73.32	1,346	$49.11	$1.86
Irrigation	Cotton Farming	8	$23.86	$1.53	$22.33	283	$8.79	$0.22
Irrigation	Sugarcane and Sugar Beet Farming	9	$48.83	$0.98	$47.85	2,339	$17.29	$1.63
Irrigation	All “Other” Crop Farming	10	$34.14	$31.19	$3.19	276	$16.78	$0.66
	Total irrigation	**NA**	**$587.19**	**$66.29**	**$472.13**	**9,576**	**$368.38**	**$8.80**
Livestock	Animal- except poultry- slaughtering	67	$153.41	$41.02	$112.39	412	$13.09	$0.73
Livestock	Cattle ranching and farming	11	$153.34	$106.32	$47.01	2,472	$12.11	$3.22
Livestock	Meat processed from carcasses	68	$18.98	$5.60	$13.38	44	$1.76	$0.09
Livestock	Animal production- except cattle and poultry	13	$10.18	$8.63	$1.55	320	$0.99	$0.16
Livestock	Poultry and egg production	12	$1.09	$0.85	$0.24	5	$0.37	$0.00
Livestock	Animal- except poultry- slaughtering	67	$153.41	$41.02	$112.39	412	$13.09	$0.73
	Total livestock	**NA**	**$337.00**	**$162.43**	**$174.57**	**3,253**	**$28.32**	**$4.20**
	Total agriculture		**$924.19**	**$229.69**	**$694.55**	**12,829**	**$396.70**	**$13.00**

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	Support activities for oil and gas operations	28	$701.94	$97.50	$604.44	3,431	$636.63	$28.62
Mining	Oil and gas extraction	19	$580.52	$539.12	$41.40	907	$333.91	$35.21
Mining	Drilling oil and gas wells	27	$175.11	$0.87	$174.23	295	$47.62	$6.28
Mining	Other nonmetallic mineral mining	26	$15.37	$1.54	$13.83	60	$7.62	$0.47
Mining	Sand- gravel- clay- and refractory mining	25	$14.65	$1.55	$13.10	115	$8.44	$0.43
Mining	Gold- silver- and other metal ore mining	23	$1.13	$0.63	$0.50	10	$0.10	$0.01
Mining	Stone mining and quarrying	24	$0.56	$0.06	$0.50	3	$0.31	$0.00
Mining	Support activities for other mining	29	$0.12	$0.00	$0.11	1	$0.04	$0.01
	Total mining	**NA**	**$1,489.38**	**$641.26**	**$848.12**	**4,822**	**$1,034.67**	**$71.02**
Steam-electric	**Power generation and supply**	**30**	**$295.72**	**$83.19**	**$212.53**	**790**	**$205.34**	**$35.05**
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	New residential 1-unit structures- all	33	$1,041.91	$0.00	$1,041.91	7,615	$298.50	$4.70
Manufacturing	Commercial and institutional buildings	38	$554.41	$0.00	$554.41	6,638	$255.32	$3.16
Manufacturing	Flour milling	48	$373.27	$23.80	$349.47	489	$40.43	$2.27
Manufacturing	Motor vehicle parts manufacturing	350	$368.28	$29.61	$338.67	1,061	$73.64	$1.13
Manufacturing	Other oilseed processing	53	$345.06	$11.24	$333.82	165	$13.88	$1.86
Manufacturing	Construction machinery manufacturing	259	$281.29	$38.39	$242.90	452	$23.42	$0.71
Manufacturing	Ship building and repairing	357	$272.69	$1.58	$271.11	1,691	$82.69	$0.93
Manufacturing	Other new construction	41	$239.53	$0.00	$239.53	3,045	$118.49	$0.93
Manufacturing	Agriculture and forestry support activities	18	$235.57	$133.91	$101.66	9,428	$156.33	$1.76
Manufacturing	Ready-mix concrete manufacturing	192	$176.82	$0.86	$175.96	748	$43.38	$1.08
Manufacturing	Paperboard container manufacturing	126	$165.55	$1.75	$163.80	561	$35.93	$1.39
Manufacturing	Fruit and vegetable canning and drying	61	$164.09	$6.08	$158.01	408	$22.71	$0.70
Manufacturing	Soft drink and ice manufacturing	85	$157.13	$8.78	$148.36	254	$20.85	$0.92
Manufacturing	New residential additions and alterations-all	35	$145.30	$0.00	$145.30	907	$47.26	$0.67
Manufacturing	Seafood product preparation and packaging	71	$142.04	$70.24	$71.80	546	$10.63	$0.28
Manufacturing	Coated and uncoated paper bag manufacturing	130	$124.31	$3.51	$120.80	473	$22.71	$0.79
Manufacturing	Highway- street- bridge- and tunnel construct	39	$118.74	$0.00	$118.74	1,286	$54.68	$0.70
Manufacturing	New multifamily housing structures- all	34	$108.80	$0.00	$108.80	1,106	$46.20	$0.27
Manufacturing	Frozen food manufacturing	60	$102.23	$3.21	$99.03	419	$11.90	$0.32
Manufacturing	Aircraft manufacturing	351	$98.51	$5.01	$93.50	202	$14.50	$0.30
Manufacturing	Motor vehicle body manufacturing	346	$98.19	$5.70	$92.49	357	$15.34	$0.34
Manufacturing	Motor and generator manufacturing	334	$89.93	$8.54	$81.38	362	$25.26	$0.55
Manufacturing	Water- sewer- and pipeline construction	40	$88.39	$0.00	$88.39	841	$35.09	$0.51
Manufacturing	Hunting and trapping	17	$77.24	$6.32	$70.92	439	$23.72	$4.44
Manufacturing	Forest nurseries- forest products- and timber	15	$76.26	$1.18	$75.09	132	$10.95	$1.75
Manufacturing	Metal valve manufacturing	248	$70.57	$7.64	$62.92	275	$29.89	$0.39
Manufacturing	**All other manufacturing**		$1,729.89	$434.61	$1,295.28	10,863	$502.82	$10.82
Manufacturing	**Total manufacturing**		$7,516.54	$804.21	$6,712.33	51,443	$2,051.56	$43.87

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	State & Local Education	503	$2,872.91	$0.00	$2,872.90	74,700	$2,872.90	$0.00
Municipal	Owner-occupied dwellings	509	$2,647.04	$0.00	$2,647.04	0	$2,050.58	$313.00
Municipal	Wholesale trade	390	$1,921.04	$919.72	$1,001.32	16,298	$1,010.52	$285.00
Municipal	Hospitals	467	$1,740.08	$0.00	$1,740.08	13,940	$975.26	$12.46
Municipal	Monetary authorities and depository credit in	430	$1,733.72	$571.01	$1,162.71	8,871	$1,217.44	$22.18
Municipal	Food services and drinking places	481	$1,558.30	$198.99	$1,359.30	34,123	$612.65	$71.61
Municipal	Truck transportation	394	$1,520.81	$823.48	$697.34	13,157	$626.91	$14.24
Municipal	Offices of physicians- dentists- and other he	465	$1,376.77	$0.00	$1,376.77	13,818	$960.83	$8.40
Municipal	State & Local Non-Education	504	$1,272.59	$0.00	$1,272.59	23,176	$1,272.59	$0.00
Municipal	Federal Non-Military	506	$1,254.27	$0.00	$1,254.26	7,677	$1,254.27	$0.00
Municipal	Home health care services	464	$1,240.24	$0.01	$1,240.24	41,747	$701.40	$4.12
Municipal	Real estate	431	$1,070.39	$423.72	$646.67	7,015	$619.45	$131.74
Municipal	Motor vehicle and parts dealers	401	$929.81	$101.11	$828.70	9,435	$476.11	$135.01
Municipal	Telecommunications	422	$875.21	$300.62	$574.59	2,632	$350.89	$58.66
Municipal	General merchandise stores	410	$803.47	$84.68	$718.79	15,679	$353.06	$112.32
Municipal	Other State and local government enterprises	499	$759.62	$247.35	$512.26	3,759	$265.66	$0.09
Municipal	Scenic and sightseeing transportation and sup	397	$657.16	$246.54	$410.62	9,272	$446.86	$75.11
Municipal	Food and beverage stores	405	$653.61	$87.39	$566.22	12,000	$328.89	$72.05
Municipal	Legal services	437	$516.88	$328.04	$188.84	5,486	$309.72	$9.81
Municipal	Other ambulatory health care services	466	$479.93	$31.21	$448.71	3,976	$208.81	$3.09
Municipal	Clothing and clothing accessories stores	408	$450.59	$56.41	$394.17	8,756	$230.89	$65.51
Municipal	Social assistance- except child day care services	470	$424.55	$0.08	$424.47	16,832	$179.71	$1.24
Municipal	Building material and garden supply stores	404	$375.36	$58.21	$317.14	4,864	$172.99	$52.61
Municipal	Business support services	455	$312.99	$146.48	$166.51	6,877	$151.73	$5.73
Municipal	Architectural and engineering services	439	$305.74	$192.73	$113.01	2,975	$145.46	$1.22
Municipal	Civic- social- professional and similar organ	493	$305.42	$107.31	$198.11	8,549	$157.56	$0.99
Municipal	All other municipal	NA	$8,697.19	$3,244.61	$5,452.57	131,779	$4,262.14	$331.94
Municipal	**Total**		$36,755.66	$8,169.71	$28,585.95	497,393	$22,215.26	$1,788.13

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

Appendix 2: Impacts by Water User Group

Irrigation ($millions)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Cameron						
Reduced income from lost crop production	$19.10	$16.64	$13.74	$14.03	$14.32	$14.58
Reduced business taxes from lost crop production	$0.59	$0.51	$0.42	$0.43	$0.44	$0.45
Reduced jobs from lost crop production	363	317	261	267	273	278
Hidalgo						
Reduced income from lost crop production	$79.47	$28.76	$14.62	$15.30	$15.99	$16.62
Reduced business taxes from lost crop production	$1.75	$0.63	$0.32	$0.34	$0.35	$0.37
Reduced jobs from lost crop production	607	220	112	117	122	127
Maverick						
Reduced income from lost crop production	$14.17	$6.57	$5.95	$6.05	$6.14	$6.23
Reduced business taxes from lost crop production	$0.32	$0.19	$0.17	$0.18	$0.18	$0.18
Reduced jobs from lost crop production	104	85	77	79	80	81
Starr						
Reduced income from lost crop production	$1.78	$1.59	$1.41	$1.44	$1.47	$1.50
Reduced business taxes from lost crop production	$0.03	$0.02	$0.02	$0.02	$0.02	$0.02
Reduced jobs from lost crop production	12	11	10	10	10	10
Webb						
Reduced income from lost crop production	$1.97	$1.72	$1.49	$1.52	$1.55	$1.57
Reduced business taxes from lost crop production	$0.03	$0.03	$0.02	$0.03	$0.03	$0.03
Reduced jobs from lost crop production	13	11	10	10	10	10
Willacy						
Reduced income from lost crop production	$5.37	$5.67	$5.84	$5.91	$5.98	$6.05
Reduced business taxes from lost crop production	$0.16	$0.17	$0.17	$0.18	$0.18	$0.18
Reduced jobs from lost crop production	123	130	134	135	137	138
Zapata						
Reduced income from lost crop production	$1.97	$1.74	$1.52	$1.55	$1.58	$1.60
Reduced business taxes from lost crop production	$0.03	$0.03	$0.02	$0.02	$0.02	$0.02
Reduced jobs from lost crop production	13	11	10	10	10	10

Manufacturing ($millions)						
	2010	2020	2030	2040	2050	2060
Cameron County						
Reduced income from lost manufacturing	$184.26	$226.44	$264.64	$302.44	$335.19	$379.51
Reduced business taxes from lost manufacturing	$22.14	$27.20	$31.79	$36.33	$40.27	$45.59
Reduced jobs from lost crop livestock manufacturing	3,336	4,100	4,791	5,476	6,069	6,871
Hidalgo County						
Reduced income from lost manufacturing	$0.00	$0.00	$0.00	$0.00	$10.85	$25.28
Reduced business taxes from lost manufacturing	$0.00	$0.00	$0.00	$0.00	$1.19	$2.78
Reduced jobs from lost crop livestock manufacturing	0	0	0	0	196	458

Steam-electric ($millions)						
	2010	2020	2030	2040	2050	2060
Cameron County						
Reduced income from lost electrical generation	$0.00	$0.00	$0.00	$0.00	$0.89	$6.29
Reduced business taxes from lost electrical generation	$0.00	$0.00	$0.00	$0.00	$0.13	$0.90
Reduced jobs from lost electrical generation	0	0	0	0	3	21
Hidalgo County						
Reduced income from lost electrical generation	$0.00	$16.70	$36.89	$122.99	$182.97	$256.11
Reduced business taxes from lost electrical generation	$0.00	$2.40	$5.30	$17.65	$26.26	$36.76
Reduced jobs from lost electrical generation	0	57	125	418	622	871
Webb County						
Reduced income from lost electrical generation	0	0	0	0	$2.45	$5.52
Reduced business taxes from lost electrical generation	0	0	0	0	$0.35	$0.79
Reduced jobs from lost electrical generation	0	0	0	0	8	19

Municipal ($millions)						
	2010	2020	2030	2040	2050	2060
Alamo						
Monetary value of domestic water shortages	$0.05	$4.40	$18.75	$24.08	$33.17	$50.40
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$5.86	$9.87	$27.98
Lost jobs due to reduced commercial business activity	0	0	0	185	311	882
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.83	$1.41	$3.99
Lost utility revenues	$0.11	$1.37	$2.78	$4.34	$6.13	$7.95
Alton						
Monetary value of domestic water shortages	$0.00	$0.00	$17.22	$33.49	$51.71	$64.37
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$9.27	$13.54	$36.11
Lost jobs due to reduced commercial business activity	0	0	0	584	854	1,139
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$1.32	$1.93	$5.15
Lost utility revenues	$0.00	$0.00	$4.84	$6.77	$8.88	$11.09
Brownsville						
Monetary value of domestic water shortages	$9.13	$23.47	$149.52	$247.63	$399.63	$465.79
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$261.86	$345.50
Lost jobs due to reduced commercial business activity	0	0	0	0	5,826	7,687
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$27.87	$36.77
Lost utility revenues	$14.79	$30.60	$46.58	$63.25	$79.82	$96.19
County-other (Hidalgo)						
Monetary value of domestic water shortages	$0.00	$3.04	$32.68	$73.03	$135.24	$242.12
County-other (Jim Hogg)						
Monetary value of domestic water shortages	$0.66	$0.72	$0.86	$0.89	$0.87	$0.79
County-other (Maverick)						
Monetary value of domestic water shortages	$0.06	$0.81	$1.89	$9.47	$13.10	$17.19
County-other (Starr)						
Monetary value of domestic water shortages	$68.67	$148.68	$185.90	$223.97	$260.26	$294.62
County-other (Webb)						
Monetary value of domestic water shortages	$0.16	$0.55	$0.96	$4.80	$7.76	$11.06

Municipal (cont.)	2010	2020	2030	2040	2050	2060
County-other (Webb)						
Monetary value of domestic water shortages	$0.27	$0.68	$5.21	$3.93	$4.73	$5.83
Donna						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.00	$0.09
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.00	$0.20
East Honda WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.25	$1.29
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.55	$1.99
Edcouch						
Monetary value of domestic water shortages	$0.19	$1.09	$1.80	$4.02	$5.09	$5.28
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.53
Lost jobs due to reduced commercial business activity	0	0	0	0	0	21
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.08
Lost utility revenues	$0.23	$0.34	$0.46	$0.60	$0.76	$0.93
Edinburgh						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$1.85	$7.43	$45.34
Lost utility revenues	$0.00	$0.00	$0.00	$3.25	$9.26	$15.43
El Cenizo						
Monetary value of domestic water shortages	$0.00	$0.05	$0.61	$4.61	$11.08	$15.02
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$2.93	$4.64
Lost jobs due to reduced commercial business activity	0	0	0	0	92	146
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.42	$0.66
Lost utility revenues	$0.00	$0.11	$0.74	$1.44	$2.23	$3.08
El Jardin						
Monetary value of domestic water shortages	$0.36	$1.19	$6.76	$11.38	$20.00	$24.21
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$5.55	$7.32
Lost jobs due to reduced commercial business activity	0	0	0	0	175	231
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.79	$1.04
Lost utility revenues	$0.61	$1.45	$2.32	$3.20	$4.07	$4.94

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Harlingen						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$1.41	$3.49
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$2.48	$5.47
Hidalgo						
Monetary value of domestic water shortages	$0.00	$0.01	$0.24	$1.15	$7.24	$15.58
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$5.74
Lost jobs due to reduced commercial business activity	0	0	0	0	0	138
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$4.99
Lost utility revenues	$0.00	$0.03	$0.43	$1.28	$2.26	$3.26
Hidalgo County MUD#1						
Monetary value of domestic water shortages	$34.98	$58.71	$87.21	$123.26	$157.30	$107.53
Lost income from reduced commercial business activity	$2.24	$3.59	$5.12	$6.77	$8.60	$10.47
Lost jobs due to reduced commercial business activity	$2.76	$4.89	$7.30	$9.89	$12.76	$15.71
Lost state and local taxes from reduced commercial business activity	$0.43	$0.76	$1.13	$1.53	$1.98	$2.44
Lost utility revenues	111	196	293	398	513	632
Indian Lake						
Monetary value of domestic water shortages	$0.25	$0.38	$0.28	$0.46	$0.66	$1.18
Lost income from reduced commercial business activity	$0.00	$0.00	$0.03	$0.05	$0.06	$0.08
Lost jobs due to reduced commercial business activity	0	0	1	2	3	3
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.01	$0.01	$0.01	$0.01
Lost utility revenues	$0.04	$0.05	$0.07	$0.09	$0.11	$0.13
La Grulla						
Monetary value of domestic water shortages	$5.52	$7.46	$8.53	$6.96	$7.73	$8.63
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$1.03	$1.27	$1.60
Lost jobs due to reduced commercial business activity	0	0	0	18	23	27
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.53	$0.64	$0.77
Lost utility revenues	$0.68	$0.79	$0.90	$1.02	$1.15	$1.29

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
La Joya						
Monetary value of domestic water shortages	$0.00	$0.01	$0.12	$0.31	$2.22	$3.41
Lost utility revenues	$0.00	$0.01	$0.17	$0.34	$0.53	$0.75
Laguna Madre WD						
Monetary value of domestic water shortages	$0.00	$0.00	$0.65	$2.71	$16.14	$27.20
Lost utility revenues	$0.00	$0.00	$1.02	$3.01	$5.03	$6.95
Laredo						
Monetary value of domestic water shortages	$4.76	$26.01	$198.41	$320.89	$498.32	$752.76
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$292.93	$465.20	$1,304.36
Lost jobs due to reduced commercial business activity	0	0	0	6,517	10,349	29,019
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$31.17	$49.51	$138.81
Lost utility revenues	$9.52	$33.91	$61.81	$92.91	$126.62	$163.22
Los Fresnos						
Monetary value of domestic water shortages	$0.00	$0.00	$0.18	$0.70	$5.31	$8.77
Lost utility revenues	$0.00	$0.00	$0.29	$0.77	$1.27	$1.75
McAllen						
Monetary value of domestic water shortages	$0.00	$2.56	$10.89	$24.05	$126.60	$207.37
Lost utility revenues	$0.00	$4.50	$15.24	$26.67	$39.44	$52.97
Military Highway WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.07	$1.16	$2.84
Lost utility revenues	$0.00	$0.00	$0.00	$0.16	$1.71	$3.32
Mission						
Monetary value of domestic water shortages	$1.68	$7.25	$49.95	$111.71	$149.64	$223.31
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$66.64	$104.34	$285.95
Lost jobs due to reduced commercial business activity	0	0	0	1,482	2,321	6,362
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$7.09	$11.10	$30.43
Lost utility revenues	$2.64	$8.03	$14.07	$20.43	$27.81	$35.38

Municipal (cont.)	2010	2020	2030	2040	2050	2060
North Alamo WSC						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$2.51	$10.77	$48.66
Lost utility revenues	$0.00	$0.00	$0.00	$4.85	$14.78	$24.88
Olmito WSC						
Monetary value of domestic water shortages	$0.00	$0.46	$4.01	$9.14	$14.01	$20.78
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.99	$1.59	$2.16
Lost jobs due to reduced commercial business activity	0	0	0	40	64	87
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.15	$0.25	$0.33
Lost utility revenues	$0.00	$0.57	$1.25	$1.91	$2.60	$3.26
Palm Valley						
Monetary value of domestic water shortages	$0.13	$0.12	$0.11	$0.09	$0.08	$0.08
Lost utility revenues	$0.15	$0.14	$0.12	$0.11	$0.10	$0.10
Palm Valley Estates UD						
Monetary value of domestic water shortages	$0.01	$0.02	$0.04	$0.09	$0.50	$0.70
Lost utility revenues	$0.01	$0.03	$0.06	$0.09	$0.12	$0.15
Palmhurst						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.30	$1.19	$2.65
Lost utility revenues	$0.00	$0.00	$0.00	$0.59	$1.84	$3.23
Palmview						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.71	$1.84
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.89	$1.79
Penitas						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.01	$0.03

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Pharr						
Monetary value of domestic water shortages	$0.00	$2.01	$6.73	$39.24	$67.93	$124.37
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$34.40
Lost jobs due to reduced commercial business activity	0	0	0	0	0	1,085
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$4.90
Lost utility revenues	$0.00	$3.47	$8.22	$13.46	$19.11	$25.14
Port Isabella						
Monetary value of domestic water shortages	$33.67	$37.00	$41.05	$45.40	$49.14	$52.79
Lost income from reduced commercial business activity	$12.67	$14.30	$15.97	$17.60	$19.35	$21.06
Lost jobs due to reduced commercial business activity	400	451	503	555	610	664
Lost state and local taxes from reduced commercial business activity	$1.81	$2.04	$2.28	$2.51	$2.76	$3.00
Lost utility revenues	$3.74	$4.14	$4.55	$4.95	$5.37	$5.79
Primera						
Monetary value of domestic water shortages	$1.10	$2.12	$4.71	$6.01	$12.83	$15.97
Lost income from reduced commercial business activity	$0.00	$0.00	$0.44	$0.65	$0.86	$1.06
Lost jobs due to reduced commercial business activity	0	0	18	26	34	43
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.07	$0.10	$0.13	$0.17
Lost utility revenues	$0.38	$0.60	$0.82	$1.06	$1.30	$1.54
Rio Bravo						
Monetary value of domestic water shortages	$0.00	$0.58	$11.78	$16.50	$27.00	$44.50
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$1.13	$2.01	$5.84
Lost jobs due to reduced commercial business activity	0	0	0	46	81	235
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.18	$0.31	$0.91
Lost utility revenues	$0.00	$0.51	$1.32	$2.22	$3.22	$4.27
Rio Grande City						
Monetary value of domestic water shortages	$0.55	$1.09	$1.73	$2.21	$9.77	$12.91
Lost utility revenues	$0.87	$1.36	$1.92	$2.45	$3.04	$3.66

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
Rio WSC						
Monetary value of domestic water shortages	$1.91	$3.44	$6.92	$10.66	$13.94	$17.11
Lost income from reduced commercial business activity	$0.00	$0.00	$0.51	$1.46	$1.93	$2.38
Lost jobs due to reduced commercial business activity	0	0	21	59	78	96
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.08	$0.23	$0.30	$0.37
Lost utility revenues	$0.34	$0.62	$0.91	$1.19	$1.49	$1.77
Roma City						
Monetary value of domestic water shortages	$0.09	$0.56	$1.29	$2.13	$10.06	$13.81
Lost utility revenues	$0.21	$0.97	$1.77	$2.60	$3.45	$4.31
San Benito						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.19	$0.85
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.38	$1.49
San Juan						
Monetary value of domestic water shortages	$0.55	$8.68	$20.65	$42.22	$69.32	$137.01
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$12.41	$38.15	$51.83
Lost jobs due to reduced commercial business activity	0	0	0	391	1,203	1,634
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$1.77	$5.44	$7.39
Lost utility revenues	$0.95	$3.25	$5.81	$8.64	$11.90	$15.24
San Perlita						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01
Sebastian						
Monetary value of domestic water shortages	$0.00	$0.00	$0.04	$0.10	$0.13	$0.17
Lost utility revenues	$0.00	$0.00	$0.07	$0.12	$0.16	$0.18
Sharyland WSC						
Monetary value of domestic water shortages	$0.00	$0.40	$0.41	$1.71	$3.72	$19.25
Lost utility revenues	$0.00	$0.77	$0.79	$2.64	$4.55	$6.60

Municipal (cont.)						
	2010	2020	2030	2040	2050	2060
South Padre Island						
Monetary value of domestic water shortages	$8.23	$16.74	$12.58	$18.82	$30.52	$36.03
Lost income from reduced commercial business activity	$0.00	$0.00	$11.79	$17.80	$47.58	$59.10
Lost jobs due to reduced commercial business activity	0	0	262	396	1,059	1,315
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$1.25	$1.89	$5.06	$6.29
Lost utility revenues	$1.35	$2.48	$3.66	$4.83	$6.01	$7.13
Sullivan City						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.27	$0.84
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$0.39	$0.81
Valley MUD #2						
Monetary value of domestic water shortages	$0.00	$0.00	$0.15	$2.16	$6.56	$7.18
Lost income from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.50
Lost jobs due to reduced commercial business activity	0	0	0	0	0	20
Lost state and local taxes from reduced commercial business activity	$0.00	$0.00	$0.00	$0.00	$0.00	$0.08
Lost utility revenues	$0.00	$0.00	$0.19	$0.43	$0.69	$0.94
Webb County Water Utility						
Monetary value of domestic water shortages	$0.07	$1.26	$3.01	$5.05	$9.28	$14.37
Lost utility revenues	$0.08	$0.28	$0.49	$0.72	$0.98	$1.25
Weslaco						
Monetary value of domestic water shortages	$0.00	$0.00	$0.00	$0.00	$0.47	$1.93
Lost utility revenues	$0.00	$0.00	$0.00	$0.00	$1.02	$3.33