TABLE OF CONTENTS – CHAPTER SIX

LIST OF FIGURES

LIST OF TABLES

APPENDICES

CHAPTER 6.0: IMPACTS OF REGIONAL WATER PLAN

6.1 SCOPE OF WORK

A major goal of the regional water planning process is the protection of the State's water, agricultural, and natural resources. This Chapter presents the results of Task 6 of the Project Scope, which addresses:

- Evaluation of the estimated cumulative impacts of the Regional Water Plan (RWP), for example on groundwater levels, spring discharges, bay and estuary inflows, and instream flows.
- Description of the impacts of the RWP regarding:
    - Agricultural Resources;
    - Other Water Resources of the State including other Water Management Strategies and groundwater and surface water interrelationships;
    - Threats to Agricultural and Natural Resources;
    - Third-party social and economic impacts resulting from voluntary redistributions of water including analysis of third-party impacts of moving water from rural and agricultural areas;
    - Major impacts of recommended Water Management Strategies on key parameters of water quality, and;
    - Effects on Navigation.
- Summarization of the identified water needs that remain unmet by the RWP and the socioeconomic impacts of not meeting the identified water needs.

6.2 CUMULATIVE IMPACTS OF THE REGIONAL WATER PLAN

The impacts of individual water management strategies on Colorado River instream flows and bay and estuary freshwater inflows were discussed in Chapter 5. The TWDB also requires an analysis of what the cumulative impacts of the recommended water management strategies would be to the Colorado River and Matagorda Bay.

For the 2016 Region K Plan, many of the recommended water management strategies utilize water under existing water rights, which includes full use of wastewater effluent at 100 percent, consistent with the required surface water availability modeling guidelines. The baseline water availability analyses are conducted using full use of existing water rights; therefore the water for the strategies in the Colorado River basin is generally accounted for in the baseline model simulation.

In general, off-channel reservoirs that utilize existing water rights should not create additional impacts to the system, although variations to instream flows could be expected to occur. Additional groundwater that is used and then discharged to a local stream can create additional flow downstream, but the additional pumping can also potentially lower the water table and reduce spring flows in the area. Reuse of wastewater effluent reduces return flows, but it also reduces the need to divert additional surface water to meet demands. Aquifer Storage and Recovery (ASR) has the potential to reduce higher levels of surface water or groundwater by storing it when it's available, but then also has the potential to keep stream and aquifer levels higher during times of drought by providing an additional source of water.

Conservation and drought management are strategies that encourage efficient and responsible use of the region's water resources.

When return flows are present, they contribute to instream flows and bay and estuary inflows. They provide a consistent source of flow in the river, even when a portion of the return flows are reused. Return flows are a source of flow that is not included in the surface water availability modeling, and show a positive impact to the system as a water management strategy.

Groundwater strategies recommended by the Lower Colorado Regional Water Planning Group (LCRWPG) had yields within the identified Modeled Available Groundwater (MAG) volumes, which are determined based on the Desired Future Condition (DFC) of each aquifer. Groundwater Conservation Districts will continue to monitor aquifer levels to determine if future changes to the DFC and MAG are needed.

The recommendation by the LCRWPG of strategies such as conservation, reuse, and drought management will reduce demands, which will help to maintain the spring discharges in the region, especially during times of drought. In addition, recommended strategies such as off-channel reservoirs and aquifer storage and recovery may aid in balancing peak demands for surface water and groundwater, which could also help maintain spring flows in the region.

6.3 IMPACTS OF WATER MANAGEMENT STRATEGIES ON WATER RESOURCES

A major goal of the regional water planning process is the protection of the State's water, agricultural, and natural resources. This focus has been considered throughout the planning process by the Lower Colorado Regional Water Planning Group (LCRWPG) when selecting water management strategies to meet water needs for the future. Conservation and drought management were considered as initial strategies for meeting water needs. Impacts on the State's resources have been considered before recommending other strategies. The effects of the recommended water management strategies on specific resources are discussed in further detail within this Section.

6.3.1 Agricultural Resources

Rice production in the lower three counties of the Lower Colorado Regional Water Planning Area (LCRWPA) is the agricultural resource most dependent upon a reliable, extensive water supply. LCRA's water rights in these counties used for rice farming are some of the most senior rights within the entire Colorado River Basin. However, the irrigators using these water rights do not have a sufficiently reliable supply of water under drought-of-record (DOR) conditions.

The management strategies introduced in Chapter 5 of this regional water plan were created to meet the needs of all WUGs including agricultural needs. Primarily, the unmet agricultural needs in the LCRWPA are related to rice irrigation in the lower counties of Colorado, Wharton, and Matagorda. These needs have been partially met with recommended water management strategies to help reduce the projected shortages. The use of interruptible water supplies, return flows from the City of Austin, on-farm conservation, conveyance improvements, and conversion to sprinkler irrigation will help to reduce the water needs, but will not eliminate them completely.

6.3.2 Other Water Resources of the State including Groundwater and Surface Water Interrelationships

Water resources available by basin within the LCRWPA are discussed in further detail below.

6.3.2.1 Brazos River Basin

Portions of Bastrop, Burnet, Mills, Travis, and Williamson Counties are within the Brazos River Basin. Local supplies are the only surface water sources originating from the Brazos River Basin in the LCRWPA. The portion of Williamson County within the LCRWPA is within the service area of the City of Austin (COA) and the Lower Colorado River Authority (LCRA) and is served by their respective water supplies from the Colorado River Basin.

Groundwater supplies in the Brazos River Basin are obtained primarily from the Carrizo-Wilcox, Hickory, and Trinity aquifers. Groundwater is also available in lesser quantities from the Edwards-Balcones Fault Zone (BFZ), Ellenburger-San Saba, Gulf Coast, Marble Falls, Queen City, Sparta, Yegua-Jackson, and other unnamed aquifers.

Areas that are supplied from groundwater in the Brazos River Basin would be expected to discharge less water from treatment plants after implementing conservation measures. As wastewater effluent is often an important portion of instream flows, especially during dry periods, conservation measures may result in reduced stream flows.

Expanding the use of groundwater will generally increase the amount of return flows to streams, though the possibility of introducing low quality groundwater, particularly from the Hickory aquifer, to surface systems may have an unfavorable effect on surface water quality.

6.3.2.2 Brazos-Colorado Coastal River Basin

The Brazos-Colorado Coastal River Basin includes portions of Colorado, Matagorda, and Wharton Counties. The only surface water source for this basin in the LCRWPA that is not a local supply is a run-of-river (ROR) right from the San Bernard River. However, surface water originating in the Colorado River Basin is transferred to the Brazos-Colorado Coastal River Basin for agricultural use and is subsequently released to streams in the process of rice production. The entirety of the Brazos-Colorado River Basin within the LCRWPA is served by the Gulf Coast aquifer.

As in the other basins of the LCRWPA, increased groundwater usage may have potential impacts on water quantity in stream channels but possible adverse effects on water quality in some cases. Conservation programs implemented through the LCRA or local farmers may decrease return flows within the Brazos-Colorado Coastal Basin during dry periods and introduce less water from the Colorado River Basin for irrigation use, due to reduced demands. While not a recommended strategy, conjunctive use of groundwater and surface water supplies will decrease aquifer levels during dry times when surface water is not available, but could allow the aquifer to recover when surface water is available.

6.3.2.3 Colorado River Basin

Since the LCRWPA is centered on the Colorado River Basin, nearly every recommended management strategy has the potential to impact water quantity and quality in the basin.

The Colorado River Basin constitutes the largest portion of the LCRWPA as well as the single largest source of water for the region. The Highland Lakes System, operated by the Lower Colorado River Authority (LCRA), provides firm surface water supplies throughout the lower part of the basin. A large amount of water is also available from run-of-river (ROR) supplies in the basin. Other reservoirs in the system provide small yields or receive their water from the Highland Lakes System or a ROR right. The largest amounts of groundwater in the Colorado River Basin are available from the Gulf Coast, Carrizo-Wilcox, Hickory, and Ellenburger-San Saba aquifers. These four (4) aquifers represent approximately 60 percent of the available groundwater supply with various other aquifers providing the remaining 40 percent.

Currently, the use of City of Austin (COA) effluent discharges downstream to increase the reliability of existing diversion rights maintains flow rates from Austin to the downstream point of diversion. There are several recommended City of Austin strategies that incorporate a portion of the effluent as the strategy's source of water. It is possible that COA reuse will become comprehensive enough to reduce these total flows considerably in later decades, though that is not currently projected to occur within the planning horizon for this planning cycle. While the amount of reuse is projected to increase, the amount of Austin's municipal return flows above the reuse strategy amounts are also projected to increase over the planning period. These projected amounts of return flows for the planning period are updated as part of the planning process each cycle.

New contracts and contract amendments may also decrease total flow due to decreased availability to agricultural irrigation and may result in higher concentrations of effluent in the river below wastewater discharges in certain areas during low flow periods.

Operation of the Highland Lakes System with one or more new downstream off-channel reservoirs will create additional available firm water and may be beneficial to instream flows during some periods. In addition, it will reduce the amount of water in the Highland Lakes that has to be released to meet downstream demands.

Conservation practices for irrigation will reduce the demand for stored surface water and thereby result in reduced streamflow, although sediment and nutrient loads from irrigation tail water would be reduced, as well.

Portions of Matagorda and Wharton Counties are within the Colorado-Lavaca Coastal River Basin. All surface water sources in these areas are associated with local supplies or stored water from the Highland Lakes. However, as in the Brazos-Colorado Coastal River Basin, water from the Colorado River Basin is discharged into streams following its use in rice production, and all groundwater supplies are obtained from the Gulf Coast aquifer.

As in the other basins of the LCRWPA, increased groundwater usage may have potential positive impacts on water quantity in stream channels but possible adverse effects on water quality in some cases. Again, conservation programs for irrigation may decrease stream flows during dry periods and introduce less water from the Colorado River Basin for irrigation use.

6.3.2.4 Lavaca River Basin

The western portions of Colorado and Fayette Counties are located in the Lavaca River Basin. There are no firm surface water rights available from the Lavaca River Basin within these two (2) counties. Additionally, the only reservoir in this basin, Lake Texana, is not located in the LCRWPA, and no surface water contracts serve water user groups (WUGs) in the region from Lavaca River Basin supplies. All surface water supplies in the basin are obtained from local supplies. The primary source of groundwater for the Lavaca River Basin in the LCRWPA is the Gulf Coast aquifer.

As in the Brazos and Colorado River Basins, municipal conservation could possibly impair water quality. However, areas served by groundwater would experience some benefit from increased stream flows from additional pumpage, although groundwater quality issues may introduce additional problems to stream water quality in certain instances.

As in the other basins, conservation programs for irrigation may decrease stream flows during dry periods and introduce less water from the Colorado River Basin for irrigation use.

6.3.2.5 Guadalupe River Basin

The Guadalupe River Basin includes portions of Bastrop, Blanco, Fayette, Hays, and Travis counties within the LCRWPA. No major reservoirs exist within the LCRWPA section of the Guadalupe River Basin, and the only firm surface water source is provided by two (2) minor reservoirs operated by the City of Blanco. Other surface water sources are obtained from local supplies.

The Carrizo-Wilcox and Ellenburger-San Saba aquifers are the major groundwater sources for the Guadalupe River Basin. Other smaller groundwater sources include the Edwards-BFZ, Edwards-Trinity, Gulf Coast, Queen City, Sparta, Trinity, and Yegua-Jackson aquifers.

As in the other basins, expanded groundwater usage is expected to increase stream flows with a possibility of negatively impacting water quality from additional discharges and groundwater quality issues.

6.3.3 Threats to Agricultural and Natural Resources

The water management strategies recommended for the LCRWPA in this RWP are intended to protect natural resources while still meeting the projected water needs of the region. The impacts of recommended strategies on specific resources are discussed below.

6.3.3.1 Threatened and Endangered Species

The LCRWPA contains an array of habitats for a variety of wildlife species. A number of these species are listed as threatened or endangered by federal or state authorities, proposed as candidates to be listed, or are otherwise rare but unlisted species. A comprehensive list of these species can be found in *Appendix 1A* of Chapter 1 in this RWP.

The potential impacts to threatened and endangered species are expected to be limited. The construction of infrastructure related to these strategies may potentially impact one or more of the species identified in *Appendix 1A*.

6.3.3.2 Parks and Public Lands

As described in Chapter 1, over 28,000 acres of state parks are within the boundaries of the LCRWPA. These 14 state facilities host a variety of outdoor recreational opportunities for visitors from around the state of Texas. None of the recommended water management strategies are expected to have impacts on public lands. In addition, there are no foreseen impacts to stream segments traversing public lands. Additional information concerning impacts from each strategy can be found in Chapter 5.

6.3.3.3 Matagorda Bay System

The Matagorda Bay system represents a significant ecological resource to the LCRWPA and provides habitat for a number of species while supporting recreation and industry. As the second largest estuary system in Texas, it represents a major priority in protecting the state's natural resources.

Matagorda Bay receives inflows from the Colorado and Lavaca Rivers as well as a coastal contributing area. The target and critical freshwater inflow needs were estimated in a study conducted in 1997 by the LCRA, TNRCC, TWDB, and TPWD. The target inflow is described as the necessary long-term inflows that produce 98 percent of the maximum normalized population biomass for nine (9) key estuarine species while maintaining certain criteria for salinity, population density, and nutrient inflow. The minimum inflow for critical needs represents the amount of water required for bay and estuary inflows to keep salinity at the mouth of the Colorado River to a level of 25 parts per thousand or less. This condition is expected to provide for fish habitat during extreme drought conditions without impacting the long-term ecology of Matagorda Bay.

While a revision of the Freshwater Inflow Needs Study (FINS) was completed in 2006, the 1997 FINS critical and target flows were incorporated into the 2010 LCRA Water Management Plan. The 2010 LCRA Water Management Plan was used in this round of planning when determining the quantitative environmental impacts of the water management strategies. *Table 6-1* shows the monthly freshwater inflow criteria from the Colorado River determined in the 1997 Freshwater Inflow Needs Study.

Table 6-1: Target and Critical Freshwater Inflow Needs for the Matagorda Bay System from the Colorado River

Month	**1997 FINS Freshwater Inflows (1,000 ac-ft)[1]**	
	Critical	**Target**
January	14.26	44.1
February	14.26	45.3
March	14.26	129.1
April	14.26	150.7
May	14.26	162.2
June	14.26	159.3
July	14.26	107.0
August	14.26	59.4
September	14.26	38.8
October	14.26	47.4
November	14.26	44.4
December	14.26	45.2
Annual Totals	171	1,033

[1] Schedule of flows is designed to optimize biodiversity/productivity under normal rainfall. Under drought conditions, target flows should be curtailed in accordance to the severity of the drought and flows should be maintained at or above critical levels based on water quality considerations.

The freshwater inflow values presented in *Table 6-1* were developed following the methodology presented in "Characteristics of an Ecologically Sound Environment for the Guadalupe Estuary" by Boyd and Green, presented in *Freshwater Inflows to Texas Bays and Estuaries: Ecological Relationships and Methods for Determination of Needs* by TPWD, dated 1994. The process of determining freshwater inflow needs was carried out in three (3) distinct phases:

Phase 1: Develop statistical relationships between freshwater inflows and key indicators such as salinity species productivity, and nutrient inflows.

Phase 2: Use the developed statistical functions to compute optimal monthly and seasonal freshwater needs using the Texas Estuarine Mathematical Programming (TXEMP) Model developed by TWDB.

Phase 3: Simulate salinity conditions throughout the estuary using the TxBLEND model developed by TWDB and LCRA.

Phases 2 and 3 were carried out in an iterative process that compared simulated and desired salinity levels throughout the estuary. If the modeled salinity levels were outside of the ranges desired, the TXEMP model was adjusted accordingly. Additional information concerning the development of the target and critical freshwater inflows to the Matagorda Bay system can be found in Freshwater Inflow Needs of the Matagorda Bay System (LCRA 1997).

Additional studies were performed as part of the LSWP analysis. The Matagorda Bay Health Evaluation Study was completed in 2008, and recommended inflow criteria from the Colorado River that covered a wide range of inflow conditions to Matagorda Bay. Low-flow (threshold), long-term average, and four (4) additional volumes of flow with associated percentages of time they should be met were part of the recommendations. The criteria from this study were used by the LCRWPG as a benchmark for evaluating the environmental impacts of the new water management strategies in this round of planning. The use of the criteria as a benchmark does not imply that the LCRWPG endorses the results of the study at this time, but rather it is the most up-to-date scientific data available.

The Matagorda Bay Health Evaluation (MBHE) used the latest data and science to assess the relationship between various factors and bay conditions.[1] Several measures of bay health were investigated, including salinity, habitat condition, species abundance, nutrient supply and benthic condition. The computer models and data analysis in the study were used to develop inflow criteria for the Colorado River. Salinity, habitat and benthic modeling were used to develop criteria for most levels, but additional measures of bay health were used wherever possible.

The recommended Colorado River inflows from the MBHE study were designed to cover the full range of inflow conditions into Matagorda Bay, with a regime that incorporates five levels of inflow, each with an associated desired achievement guideline. The lowest level, “Threshold,” is a fixed monthly value to provide refuge conditions that would ideally be achieved 100% of the time. The remaining levels, MBHE-1 through MBHE-4, represent different inflow targets that were recommended to be achieved with the following frequencies: MBHE-1, 90%; MBHE-2, 75%; MBHE-3, 60%; and MBHE-4, 35%. The levels all include seasonal variability and incorporate influxes of fresh water into the Bay in the spring and fall that reflect the natural pattern of inflows into the bay. The MBHE freshwater inflow categories and descriptions are summarized in *Table 6-2*. The inflow values associated with these inflow levels are presented in *Table 6-3*.

Table 6-2: Summary of Matagorda Bay Health Evaluation Inflow Levels

Inflow Level	Descriptions
Threshold	Refuge conditions for all species and habitat
MBHE-1	Maintain tolerable oyster reef health, benthic character, and habitat conditions
MBHE-2	Provide inflow variability and sustain oyster reef health, benthic condition, low estuarine marsh, and shellfish and forage fish habitat
MBHE-3	Provide inflow variability and support quality oyster reef health, benthic condition, low estuarine marsh, and shellfish and forage fish habitat
MBHE-4	Provide inflow variability and support high levels of primary productivity, and high quality oyster reef health, benthic condition, low estuarine marsh, and shellfish and forage fish habitat

---

[1] FINAL REPORT: MATAGORDA BAY INFLOW CRITERIA (COLORADO RIVER), MATAGORDA BAY HEALTH EVALUATION, Prepared for LCRA and SAWS (Dec. 2008).

Table 6-3: Matagorda Bay Health Inflow Values (acre-feet)

Inflow Category	Spring (3 month total)	Fall (3 month total)	Intervening (6 month total)	Monthly
Threshold	-	-	-	15,000
MBHE-1	114,000	81,000	105,000	-
MBHE-2	168,700	119,900	155,400	-
MBHE-3	246,200	175,000	226,800	-
MBHE-4	433,200	307,800	399,000	-

6.3.4 Third-party Social and Economic Impacts resulting from Voluntary Redistributions of Water

While the LCRWPG has not specifically recommended a “voluntary redistribution of water” strategy, the term essentially means one entity providing surplus water to another entity in need of water. Recommended strategies in the 2016 Region K Plan that would fall under this category include the Water Purchase strategy, as well as the New LCRA Contracts and LCRA Contract Amendment strategies.

Because the redistribution of water is voluntary, it is assumed that the existing water supplies would not be redistributed if doing so caused negative social and economic impacts to the entity selling the water. In most cases, it can be anticipated that there would be a positive economic impact to the entity selling the water, and a positive social impact to the entity purchasing the water.

6.3.5 Moving Water from Rural and Agricultural Areas

It is estimated that in Year 2020, the water used in rural (livestock) and agricultural areas will represent 52 percent of the total water used in Region K. It is estimated that this will be reduced to 37 percent of the Region’s 1,461,800 acre-feet (ac-ft) demand projected in Year 2070 as a result of growth in municipal and industrial demands and a decrease in agricultural production. The projected decrease in irrigation demand is anticipated to be approximately 13 percent between 2020 and 2070. Livestock demand is constant over the planning period.

Water management strategies, along with current sources of water supply, are available to agricultural users throughout the planning period; therefore, the impacts on agricultural users are not directly related to moving water from these areas. The potential impacts of moving water from rural and agricultural areas are mainly associated with socio-economic impacts to third parties. The potential impetus for moving water is expected to occur from two (2) sources: (1) the cost of raw water may become too great for the local irrigator to afford, and they may elect to voluntarily leave the industry for economic reasons; or (2) the value of the water for municipal or industrial purposes may create a market for the wholesale owner to redirect the sale of the water making it unavailable to the irrigator. Several management strategies are outlined in the RWP to provide water to irrigators, especially in the lower basin counties of Colorado, Wharton, and Matagorda, but do not meet all of the projected water needs.

It may be feasible for a third party to pay for conservation measures and then utilize the saved water for their own needs (through re-contracting or other agreements) and allow the irrigator to remain in business; however, there are few contractual and institutional measures in effect to allow this trade-off to occur at this time.

6.4 IMPACTS OF WATER MANAGEMENT STRATEGIES ON KEY PARAMETERS OF WATER QUALITY

The potential impacts that water management strategies (WMS) may have on water quality are discussed in this section, including the identified water quality parameters which are deemed important to the use of the water resources within the Region.

Under the Clean Water Act, the State of Texas must define designated uses for all major water bodies and, consequently, the water quality standards that are appropriate for that designated water use. The water quality parameters which are listed for the Lower Colorado Regional Water Planning Area (LCRWPA) below were selected based on the *Texas Commission on Environmental Quality (TCEQ) Water Quality Inventory for Designated Water Body Uses* as well as the water quality parameters identified in the TCEQ 303d List of Impaired Water Bodies.

6.4.1 Surface Water

Key surface water parameters identified within the LCRWPA fall into two (2) broad categories:

1. **Nutrients and Non-Conservative Substances**

- Bacteria
- pH
- Dissolved Oxygen
- Total Suspended Solids (TSS)
- Temperature
- Nutrients (nitrogen, phosphorus)
- Minerals and Conservative Substances
- Total Dissolved Solids (TDS)
- Chlorides
- Mercury
- Salinity
- Sediment Contaminants

Non-conservative substances are those parameters that undergo rapid degradation or change as the substance flows downstream, such as nutrients which are consumed by plant life. Nutrients and non-conservative loadings to surface water originate from a variety of natural and man-made sources. One (1) significant source of these loads is wastewater treatment facilities. As population increases, the number and size of these wastewater discharges will likely increase. Stormwater runoff from certain land use types constitutes another significant source of nutrient loading to the Region’s watercourses, including such land use types as agricultural areas, golf courses, residential development, or other landscaped areas where fertilizers are applied. Nutrient loads in the LCRWPA are typically within the limits deemed acceptable for conventional water treatment facilities and are, therefore, not considered a major concern as related to source of supply.

2. Conservative Substances

Conservative substances are those that do not undergo rapid degradation or do not significantly change in the water as the substance flows downstream, such as metals. Minerals and other conservative substances contributing to surface water generally originate from three (3) sources: (1) non-point source runoff or groundwater seepage from mineralized areas, either natural or man-made, (2) wastewater discharges, and (3) sea water migration above estuaries. Wastewater discharges and industrial discharges have improved over the past 30 years due to the requirements of the Clean Water Act. If local concentrations of conservative contaminants are identified, they are remediated by the appropriate agency. Natural features such as elevation tend to limit salinity migration above estuaries.

6.4.2 Groundwater

Groundwater in the LCRWPA is generally of good quality with no usage limitations. Water quality parameters of interest include TDS, metals, and hardness.

Groundwater in the Gulf Coast aquifer containing less than 500 mg/L dissolved solids is located at various depths throughout the lower three (3) Counties, but at no depths greater than 3,200 feet. The Carrizo-Wilcox aquifer has localized areas of water quality problems which include hydrogen sulfide, methane, increased salinity levels, and dissolved solids. The Edwards aquifer is typically fresh, although hard, with dissolved solids concentrations typically less than 500 mg/L.

Water quality from the Trinity aquifer is acceptable for most municipal and industrial purposes; however, excess concentrations of certain constituents in many places exceed drinking water standards. Heavy pumpage and water level declines in this Region have contributed to deteriorating water quality in the aquifer.

Wells completed in the Middle Trinity aquifer (especially the Hensell Sand) may exhibit levels of sodium, sulfate, and chloride, which are believed to be the result of leakage from the overlying Glen Rose Formation. This is less likely to be true for wells completed in the Lower Trinity aquifer. The Hammett Shale acts as an aquitard and effectively prevents leakage from the overlying formations. In some areas, poor quality water occurs in and near wells that have not been properly cased. These wells may have deteriorated casings, insufficient casing or cement, or the casing may have been perforated at multiple depths in an effort to maximize the well yield. These wells serve as a conduit for poor quality water originating in the evaporite beds near the contact of the Upper and Lower Glen Rose Formations. Water quality declines in the down-dip direction of all of the Trinity aquifer water-bearing units.

Natural chemical quality of Edwards-Trinity (Plateau) water ranges from fresh to slightly saline. The water is typically hard and may vary widely in concentrations of dissolved solids, composed mostly of calcium and bicarbonate. The salinity of the groundwater tends to increase toward the west. Water quality of springs issuing from the aquifer in the southern and eastern border areas is typically excellent.

In general, the quality of water from the Hickory aquifer could be described as moderate to low quality. The TDS concentrations vary from 300 to 500 mg/L. In some areas the groundwater may have dissolved solids concentrations as high as 3,000 mg/L. The water may contain alpha particle and total radium concentrations that may exceed the safe drinking water levels of the U.S. Environmental Protection Agency (EPA) and TCEQ. Radon gas may also be entrained, although no limits have been established for radon. Most of the radioactive groundwater is thought to be produced from the middle Hickory unit, while the upper Hickory unit produces water that exceeds secondary limits for concentration of iron. High nitrate levels may be found in the shallower portions of the aquifer where there may be interaction with surface activities such as fertilizer applications and septic systems.

Throughout most of the LCRWPA, the chemical quality of the Queen City aquifer water is excellent, but water quality may deteriorate fairly rapidly down-dip. The water may be fairly acidic (low pH), have high iron concentrations, or contain hydrogen sulfide gas. All of these conditions are relatively easy to remedy with standard water treatment methods.

Usable quality water is commonly found within the Sparta aquifer outcrop and for a few miles down-dip. The water quality in most of this aquifer is excellent, but the quality does decrease in the down-dip direction. In some areas, the water can contain iron concentrations exceeding the secondary drinking water standards.

Water produced from the Ellenburger-San Saba aquifer may have dissolved concentrations that range from 200 mg/L to as high as 3,000 mg/L, but in most cases is usually less than 1,000 mg/L. The quality of water declines rapidly in the down-dip direction.

The water produced from the Marble Falls aquifer is suitable for most purposes, but some wells in Blanco County have produced water with high nitrate concentrations. The down-dip portion of the aquifer is not extensive, but in these areas, the water becomes highly mineralized. Since the limestone formation comprising this aquifer is relatively shallow, it is susceptible to pollution by surface uses and activities.

Water quality in the Yegua-Jackson aquifer varies greatly. Water produced from the Yegua-Jackson aquifer may have dissolved concentrations as high as 3,000 mg/L. Chlorides and sulfates are also a concern for this aquifer, as well as some areas of high concentrations of dissolved manganese. In general, small amounts of usable water can be found at less than 300 feet deep throughout most of the aquifer.

6.4.3 Brackish Groundwater

Total dissolved solids (TDS) is the most commonly used parameter to describe overall groundwater quality because it is a measure of all of the dissolved constituents in water. In this section of the RWP, TDS will be used as the general description of groundwater quality. The term “brackish”, as used in this section of the RWP, describes slightly-saline or moderately-saline groundwater and thus includes water between 1,000 and 10,000 mg/L TDS.

Many water-bearing formations in Texas contain a large volume of brackish groundwater. Discussions on brackish groundwater in Region K are based on information found in “*Brackish Groundwater Manual for Texas Regional Planning Groups*”, prepared for the Texas Water Development Board (TWDB) in February 2003.

Historically, the TWDB has defined aquifer water quality in terms of TDS concentrations expressed in milligrams per liter (mg/L) and has classified water into four (4) broad categories; fresh (less than 1,000 mg/L), slightly-saline (1,000 - 3,000 mg/L), moderately-saline (3,000 - 10,000 mg/L), and very-saline (10,000 - 35,000 mg/L).

Official TWDB delineations of the down-dip boundaries of aquifers such as the Edwards (BFZ), Trinity, Queen City, Sparta, and Carrizo-Wilcox have historically been based on water quality, specifically the

TDS concentrations that meet the needs of the aquifers' primary uses. The down-dip extent of most aquifers in the state is defined by the 3,000 mg/L dissolved solids level, as groundwater with less than 3,000 mg/L TDS meets most agricultural and industrial needs. However, a few aquifers have different TDS criteria defining the aquifer extent, including: Edwards (BFZ) (1,000 mg/L TDS).

The availability of brackish groundwater is a general measure of the amount of brackish groundwater in a water-bearing unit. All of the major and minor aquifers in the Region K water planning area contain brackish groundwater, which are listed below:

Major Aquifers

- Carrizo-Wilcox
- Edwards (BFZ)
- Edwards-Trinity (Plateau)
- Trinity
- Gulf Coast

Minor Aquifers

- Ellenburger-San Saba
- Hickory
- Marble Falls
- Queen City
- Sparta
- Yegua-Jackson

6.4.3.1 Carrizo-Wilcox Aquifer

The Carrizo-Wilcox aquifer is one of the most continuous and permeable water-bearing formations in Texas. In the LCRWPA, it extends into Bastrop and Fayette Counties. Throughout the extent of the aquifer, it provides groundwater acceptable for most irrigation, public supply and industrial purposes. It also has significant brackish water resources in down-dip portions of the aquifer that may be used as additional water supplies.

In Central Texas groundwater from the Carrizo is principally sodium chloride and sodium sulfate types. The availability of brackish groundwater from the Carrizo-Wilcox aquifer in Region K is considered high.[2]

6.4.3.2 Edwards (BFZ) Aquifer

The Edwards (Balcones Fault Zone-BFZ) aquifer extends in Travis and Hays Counties in Region K. The boundary between the fresh-water and brackish sections of the Edwards aquifer is commonly referred to as the "Bad Water Line", which is the 1,000 mg/L TDS line.

---

[2] "*Brackish Groundwater Manual for Texas Regional Planning Groups*", prepared for TWDB by LBG-Guyton Associates in association with NRS Consulting Engineers, February, 2003.

Groundwater in the fresh portion of the Edwards is a hard, calcium-bicarbonate water. As the salinity of the water increases in the saline portion of the aquifer, the concentrations of sulfate and chloride increase, as does the concentration of sodium, and the water becomes a sodium-mixed anion type water. The quality of the saline water in the Edwards aquifer does not appear to vary significantly areally. In general, poorer quality water in the aquifer is found in the down-dip portions of the aquifer, and may also correlate with low permeability sections of the formations. Similarly, there are no consistent vertical trends in water quality. In places, wells produce fresh water at shallow depths, brackish to saline water at greater depths, and fresh water again at even greater depths. Hydrogen sulfide is often found in the Saline Zone.

Availability of brackish groundwater from Edwards (BFZ) aquifer in Region K is low to moderate.[2]

6.4.3.3 Edwards-Trinity (Plateau) Aquifer

Much of the groundwater found in the Edwards-Trinity (Plateau) aquifer is fresh to slightly-saline. The chemical quality of the Edwards and associated limestones is generally better than that in the underlying Trinity aquifer in the Plateau region. Groundwater is fairly uniform in quality, with water from the Edwards and associated limestones being a very hard, calcium bicarbonate type, usually containing less than 500 mg/L TDS, although in some areas the TDS can exceed 1,000 mg/L. The water quality in the Trinity tends to be poorer than in the Edwards.

There is no availability of brackish groundwater from Edwards Trinity (Plateau) aquifer in Region K.[2]

6.4.3.4 Trinity Aquifer

Trinity Group deposits include sands, limestones, shales and clays. The stratigraphy of the Trinity Group is complicated, in part because of the large area that it covers.

In Central Texas, the Hensell and Hosston Sands are the most productive units in the Trinity aquifer. The Hensell is fairly prolific in many areas, and is known to yield small to large amounts of water to wells. It is also referred to as the “First” or “Upper” Trinity Sand by drillers and locals in Central Texas.

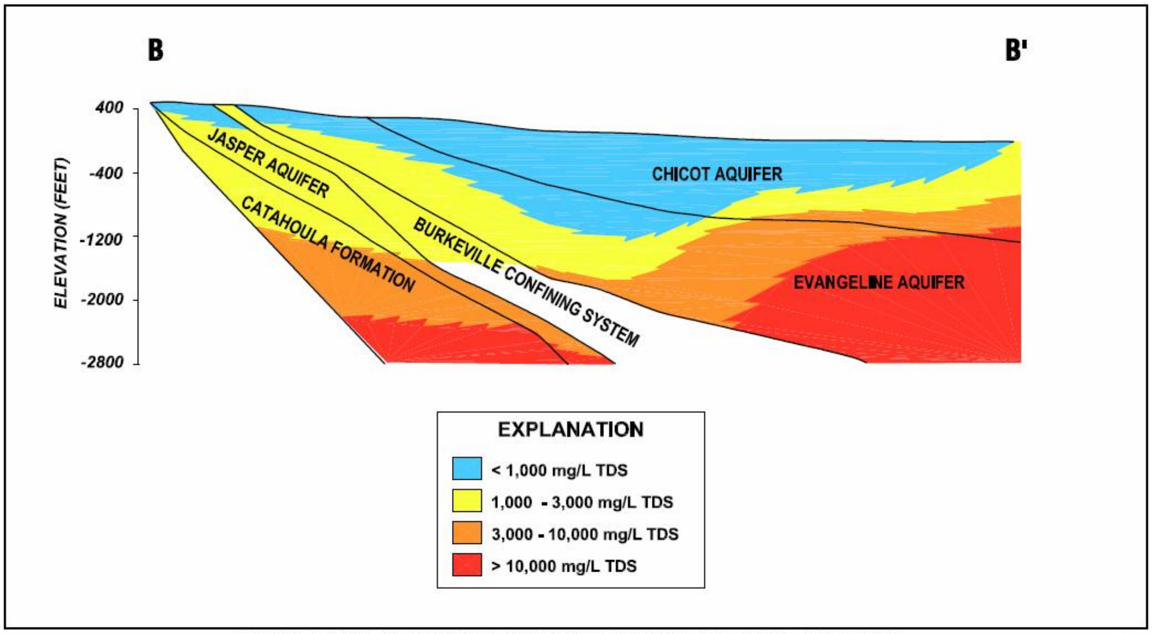
A significant source of brackish water may be found in the down-dip areas of the Trinity aquifer. The availability of brackish groundwater from the Trinity aquifer in most of Region K is considered moderate.[2]

6.4.3.5 Gulf Coast Aquifer

The Gulf Coast aquifer extends through a large area of Region K in Fayette, Colorado, Wharton and Matagorda counties.

Water quality varies with depth and locality in the Gulf Coast aquifer. The water quality is generally fresh in the northeastern half of the aquifer, from the Coastal Bend region to Louisiana. Some areas in this half do produce slightly-saline water, in particular near the coast between the City of Houston and Louisiana. The groundwater quality in the southwestern half of the aquifer (generally south of the San Antonio River) is generally more brackish than in the northern section, with most areas containing slightly- to moderately-saline groundwater, and very few areas containing fresh water. The depths that fresh, slightly-saline, moderately-saline, and saline groundwater is found varies from individual aquifer to aquifer throughout the extent of the aquifer system. *Figure 6-1* shows concentrations of total dissolved solids in the Gulf Coast aquifer in a cross-section running through Lavaca, Wharton, and Matagorda Counties.[2]

Figure 6-1: Simplified Cross-Section of the Gulf Coast Aquifer System running through Lavaca, Wharton, and Matagorda Counties



SIMPLIFIED CROSS SECTION B-B' OF THE GULF COAST AQUIFER SYSTEM WITH GENERALIZED WATER QUALITY RANGES

(Modified from Baker, 1979)

The availability of brackish groundwater from the Gulf Coast aquifer in most of Region K is considered moderate to high.[2]

6.4.4 Other Aquifer Water Quality Information

While the Groundwater Availability Model (GAM) reports may contain information pertaining to water quality of aquifer formations, the models do not provide any outcomes concerning water quality issues.

TWDB's water well database tracks concentration of several water quality constituents including Sodium, Potassium, Strontium, Bicarbonates, Sulfate, Chloride, Fluorides, Nitrates, Alkalinity, and Hardness.

6.4.5 Potential Water Quality Impacts Resulting from Increased Drawdown of Aquifers

The potential water quality impacts resulting from increased drawdown in the LCRWPA are currently not well understood. The following is a discussion of potential water quality issues:

The wells close to the coast have greater risk to be impacted. As they are drawn down, there is a greater potential for salt water intrusion which begins to increase the total dissolved solids in the water. Overall, water quality has been good throughout the lower counties, and they have experienced higher demands and lower water tables in the past than what is currently projected under this RWP.

Concerns for most of the Central Texas aquifers are largely based on limiting or ceasing spring flows rather than quality reasons. With the lack of current knowledge on the locations of the potential salt deposits, it can be stated that increased drawdown could, in some cases, result in deteriorated water quality associated with total dissolved solids and radiation in some areas.

6.4.6 Management Strategies

The Lower Colorado River Authority (LCRA) has implemented regulatory programs within their jurisdiction to aid in pollution prevention. LCRA regulations include both land-based activities and surface water usage. Land-based activities include on-site sewage facilities, septic systems, construction, and nonpoint source pollution. In addition, LCRA has supported the “no discharge” designation by TCEQ for the Highland Lakes. The water quality parameters and water management strategies selected by the LCRWPG were evaluated to determine the impacts on water quality as a result of these recommended strategies. The recommended management strategies, as described in Chapter 5 of this RWP and used in this evaluation, are:

- Water Conservation (Municipal, Industrial, and Agricultural)
- Expansion of Current Groundwater Supplies
- Development of New Groundwater Supplies
- Groundwater Importation
- Aquifer Storage and Recovery (ASR)
- Return Flows / Reuse and Reuse-sourced Projects
- Water Purchase/New or Amended Water Contracts
- Desalination of Brackish Groundwater
- LCRA Water Management Plan for Interruptible Supplies
- LCRA Off-Channel Reservoirs
- Blending tidally-influenced water in the STPNOC reservoir
- Alternate Canal Delivery

The following paragraphs discuss the impacts of each management strategy on the chosen water quality parameters.

<u>Water Conservation</u>, including municipal and industrial, can have both positive and negative impacts on water quality. Water that is being processed through a wastewater treatment plant typically has acquired additional dissolved solids prior to discharge to the waters of the state. Conventional wastewater treatment reduces suspended solids, but does not reduce dissolved solids in the effluent. Water conservation measures will reduce the volume of water passing through the wastewater plants without reducing the mass loading rates (a 1.6-gallon flush carries the same waste mass to the wastewater plant that a 6-gallon flush once carried). This may result in increased constituent loads to the wastewater treatment plants. In the event that, over time, water conservation causes changes to wastewater concentrations, treatment processes may need to be adjusted to maintain permitted discharge parameters. It should be noted that during low flow conditions, the wastewater effluent in a stream may represent water that helps to augment and maintain the minimum stream flows.

Conservation of irrigation water (through on-farm water conservation measures, irrigation district conveyance improvements, and conversion to sprinkler irrigation), pump limited amounts of groundwater during drought conditions, and primarily capture the remaining permitted portion of Colorado River flows. Return flows generated by runoff from rice irrigation are returned via tail water runoff in the Colorado River Basin or the coastal basin. Tail water is the term used to describe that water returned to the stream after application to irrigated cropland. Tail water may carry nutrients, sediments, salts, and other pollutants from the farmland. This return flow can have a negative impact on water quality, and by implementing conservation measures which reduce tail water losses, the nutrient and sediment loading can be reduced. However, this return flow tends to be introduced into the receiving stream during normally dry periods so it may have a net beneficial effect in terms of maintaining minimum streamflow conditions.

The impacts on water quality of the Expansion of Current Groundwater Supplies, Development of New Groundwater Supplies, and Groundwater Importation strategies are uncertain. However, they are not expected to have adverse impacts to the water quality in the aquifer. In some particular situations, these strategies may negatively influence water quality. As previously stated, water quality in the Hickory aquifer could be described as moderate to low quality. The use of this aquifer by municipal users may require additional treatment compared to a standard groundwater treatment plant, especially in areas of high concentrations of TDS, areas that may contain alpha particle and total radium concentrations that may exceed the safe drinking water levels of the EPA and TCEQ, and areas with high nutrient levels. The use of this aquifer by irrigators could potentially release the above constituents into surface water sources, thus causing increased levels of the above described water quality parameters.

The recommended Aquifer Storage and Recovery (ASR) projects in this plan utilize a variety of water sources for storage. Fresh groundwater, brackish or saline groundwater, wastewater effluent, and surface water are all sources that are identified for the various recommended strategies. The groundwater sources should have limited impacts on water quality, although storing fresh water in the Saline Zone for a long period of time can increase the TDS and decrease the quality of the stored water. Utilizing wastewater effluent and surface water that is diverted from the Colorado River could reduce instream flows downstream, which in turn, could negatively impact water quality during certain months of the year when instream flows are already lower.

Reuse and Reuse-sourced Projects are part of the City of Austin's (COA) management strategy to respond to droughts and meet future growth and subsequent water supply shortages. The COA plans to use a portion of their wastewater effluent as a source for a number of recommended strategies to extend current supplies and help alleviate future shortages. The COA plans to use indirect reuse, if authorized by TCEQ, or direct reuse with infrastructure for a variety of projects. While the amount of reuse is projected to increase, municipal return flows are also projected to increase over the planning period. When available on an interruptible basis, downstream water rights can continue to divert, in seniority order, these return flows. In any event, the quality of water produced by City of Austin wastewater facilities is such that no adverse impacts on water quality are anticipated. In other parts of the region, reuse provides a purposeful use for treated wastewater effluent that cannot otherwise be discharged to the Highland Lakes, due to TCEQ restrictions. This effluent is currently being used to irrigate areas that do not normally require irrigation. In a sense, this strategy would simply relocate the treated effluent to more useful locations that are currently irrigated with potable water. Due to the treatment standards of the effluent, there should be no water quality issues from this strategy. Since the effluent is currently not allowed to be discharged to the Highland Lakes, there is also no issue of reduced return flows downstream.

Water Purchase and Additional Contracts as management strategies can decrease instream and bay and estuary freshwater inflows as a result of the full utilization of water supplies, although the Water Management Plan provides for environmental flows in the river below Austin and Matagorda Bay. Fully utilizing existing water supply projects may amplify some existing concerns, particularly contaminant concentrations due to reduced opportunities for instream dilution. The continued return of flows via wastewater treatment facility discharges will provide some mitigation of that effect. Typical municipal return flows are approximately 60 percent of the total quantity diverted for use, although that percentage may be expected to decrease as reuse and reuse-sourced projects develop.

<u>LCRA Off-Channel Reservoirs</u> potentially will have a positive impact on water quality since one or more will operate partially or wholly as a “scalping reservoir” such that diversions are made to the reservoir only when flows in the river are sufficient to meet higher priority need. The water that is diverted and stored in reservoirs would allow some sediments to settle out, so that water released from the reservoir would be of higher quality. However, the water would be stored for consumptive use, and instream flows along with bay and estuary freshwater inflows would slightly decrease. In general, increased return flows are expected to occur in this region as demand increases, and this increase in return flows will continue to occur during low flow events, thus, potentially increasing instream flows during DOR conditions.

<u>LCRA Water Management Plan</u> allows LCRA to supply rice irrigators in the Lower Colorado River Basin with interruptible supplies of water from the Highland Lakes, when available. Releases from storage provide streamflow in the river on the way to the diversion point, with impacts to water quality that are similar to return flows.

<u>Desalination of Brackish Groundwater</u>, such as the Edwards-BFZ Saline Zone, will provide a usable water supply with a level of dissolved solids low enough to be used for municipal purposes. A significant side effect of this strategy is the disposal of wastes generated from the desalination process. If deep well injection is used for brine disposal, minimal impacts to water quality should occur.

<u>Blending tidally-influenced water in the STPNOC reservoir</u> will increase the TDS levels in the reservoir. As long as there is sufficient freshwater in the reservoir, the TDS levels should remain low enough to be used for steam-electric power generation. No desalination process should be necessary.

<u>Alternate Canal Delivery</u> by STPNOC will decrease the TDS levels in the STPNOC reservoir by allowing for water diversions with lower TDS to dilute the TDS of the water in the STPNOC cooling pond

6.5 IMPACTS OF WATER MANAGEMENT STRATEGIES ON NAVIGATION

Due to the nature of the strategies recommended in the 2016 Region K Plan, there are no anticipated impacts to navigation.

6.6 SUMMARY OF UNMET IDENTIFIED WATER NEEDS

While the goal of the LCRWPG has been to recommend water management strategies to meet all water needs in the region, the 2016 Region K Plan does have some remaining unmet needs.

Irrigation water needs in Colorado County, Matagorda County, and Wharton County were not able to be fully met by recommended strategies. *Table 6-4* provides a summary of the recommended strategies and the remaining unmet water needs as a total for the region. Remaining unmet needs range from approximately 120,500 ac-ft in 2020 to approximately 19,000 ac-ft in 2070. The current drought conditions and the surface water availability modeling that was performed with the inclusion of those conditions created much larger water needs than previous Region K plans. In addition, the main strategy to meet Irrigation water needs in previous Region K plans (the LCRA-SAWS Water Project) is no longer a strategy in the 2016 Region K Plan. The limiting factors for new water management strategies that can be recommended for Irrigation are water availability and cost of new infrastructure.

Table 6-4: Recommended Strategies for Irrigation and Remaining Unmet Irrigation Needs

WMS	2020 Needs	2030 Needs	2040 Needs	2050 Needs	2060 Needs	2070 Needs
	(334,884)	(319,009)	(303,561)	(288,528)	(273,900)	(259,664)
	Strategy Yields (AFY)					
Drought Management	94,641	92,080	89,588	87,163	84,805	82,510
On-Farm Conservation	20,000	26,000	32,000	38,000	44,000	50,000
Irrigation Conveyance Improvements	5,200	17,000	29,000	41,000	53,000	64,300
Sprinkler Irrigation	1,430	7,150	14,300	17,875	17,875	17,875
Return Flows	15,193	15,820	19,038	20,893	22,907	26,044
LCRA WMP Interruptible Water (2010 WMP)	77,880	48,664	19,448	9,724	0	0
(Future LCRA WMP, including OCR supplies)	*	*	*	*	*	*
Remaining Unmet Needs	(120,540)	(112,295)	(100,187)	(73,873)	(51,313)	(18,935)

* Availability of interruptible water will be increased using the Lane City OCR and other recommended OCRs; the estimated quantity is subject to WMP amendments through TCEQ and the hydrologic outcome of the current drought.

There is also identified unmet Mining needs in the 2016 Region K Plan. These needs were identified in Bastrop County in coordination with Region G. The mining industry in that area pumps groundwater to lower the water table in order to allow access to mining activities. It was determined that the Mining demands were not true demands, and therefore did not need to have recommended water management strategies. The unmet Mining WUG needs are as follows:

Table 6-5: Unmet Mining Needs in Region K

WUG Name	County	River Basin	Unmet Needs (ac-ft/yr)					
			2020	2030	2040	2050	2060	2070
Mining	Bastrop	Brazos	(173)	(409)	(450)	(496)	(545)	(600)
Mining	Bastrop	Colorado	(449)	(3,947)	(4,556)	(5,235)	(5,967)	(6,777)

6.6.1 Socioeconomic Impacts of Not Meeting Water Needs

The following excerpts are taken directly from the Introduction to the TWDB report entitled *Socioeconomic Impacts of Projected Water Shortages for the Region K Regional Water Planning Area*, dated September 2015. The full report, which includes the information below as well as additional sociological impacts, such as reduction in population, school enrollment, and consumer surplus loss, is provided as *Appendix 6A* to this chapter:

"Administrative rules (31 Texas Administrative Code §357.33 (c)) require that regional water planning groups evaluate the social and economic impacts of not meeting water needs as part of the regional water planning process, and rules direct the TWDB staff to provide technical assistance upon request. Staff of the TWDB's Water Use, Projections, & Planning Division designed and conducted this analysis in support of the Region K Regional Water Planning Group."

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

Table 6-6 summarizes estimated economic impacts. Variables shown include:[3]

- **Regional income** – total payroll costs (wages and salaries plus benefits) paid by industries, corporate income, rental income, and interest payments for the region
- **Jobs** – number of full and part-time jobs required by a given industry including self-employment
- **Business taxes** – sales, excise, fees, licenses, and other taxes paid during normal operation of an industry (does not include any type of income tax)

If drought of record conditions occur and water supplies are not developed, study results indicate that the Region K Water Planning Area would suffer significant losses. If such conditions occurred in 2020, lost income to residents in the region could total $1.56 billion with associated job losses as high as 9,877. State and local governments could lose nearly $234 million in tax receipts. If such conditions occurred in 2070, income losses could run $3.57 billion, and job losses could total 45,282. Approximately $257 million worth of State and local taxes would be lost. Reported figures are probably conservative because they are based on estimated costs for a single year; however, in much of Texas, the drought of record lasted several years. For example, in 2040, models indicate that shortages would cost residents and businesses in the region $1.09 billion in lost income. Thus, if shortages lasted for three years, total losses related to unmet needs could easily approach $3.3 billion.

---

[3] Regional income plus business taxes are a suitable measure of economic prosperity because they are a better measure of net economic returns.

Table 6-6: Single Year Economic Impacts of Unmet Water Needs for Region K

Year	Income ($ millions)[1]	Jobs	State and Local Taxes ($ millions)[1]
2020	$1,560	9,877	$234
2030	$1,557	11,880	$216
2040	$1,233	10,414	$160
2050	$1,093	11,894	$114
2060	$1,975	24,184	$150
2070	$3,568	45,282	$257

Source: TWDB, Water Use, Projections, & Planning Division

[1] In year 2013 dollars

APPENDIX 6A

TWDB SOCIOECONOMIC IMPACT ANALYSIS OF PROJECTED WATER SHORTAGES