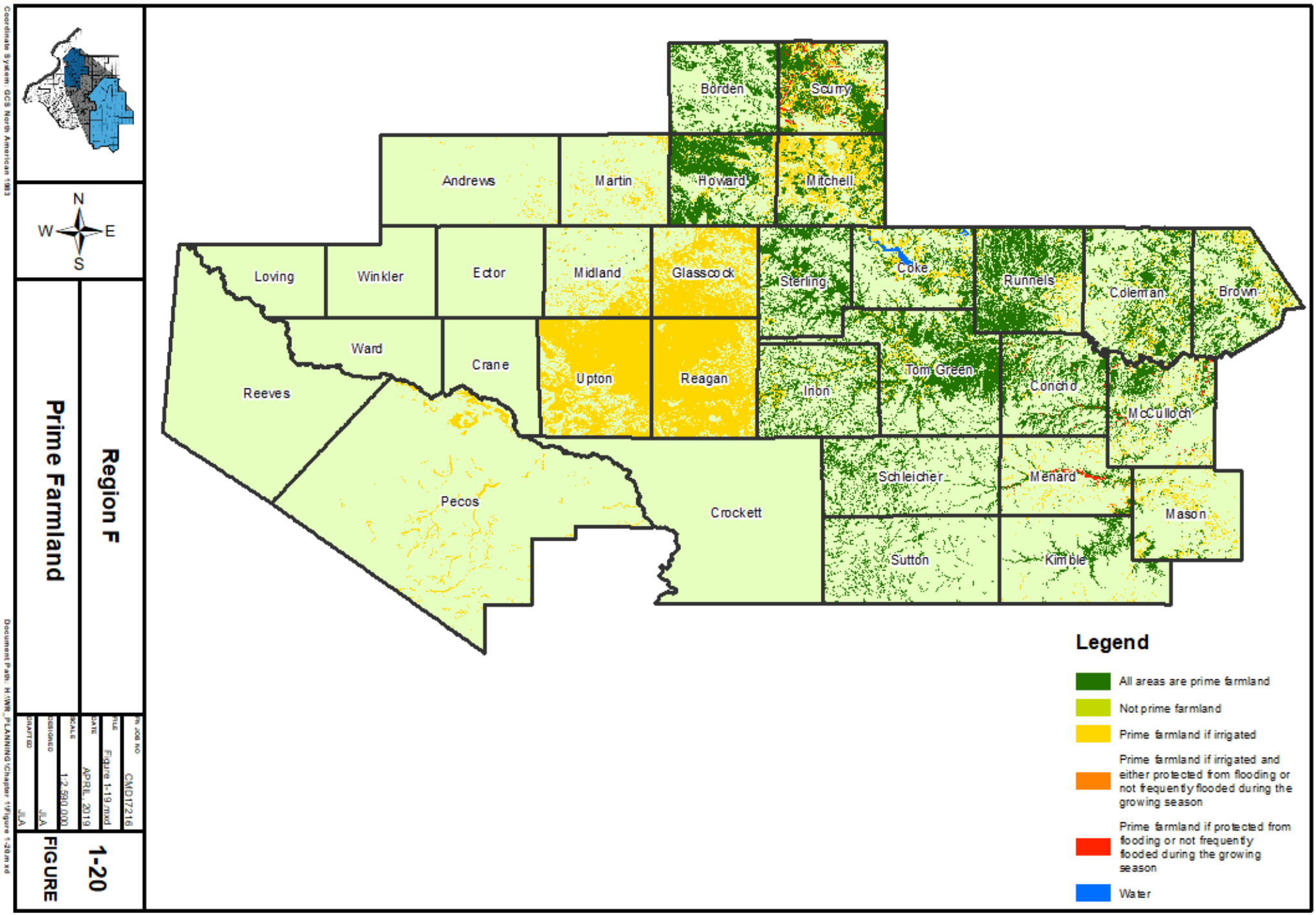
Borden
Scurry
Andrews
Martin
Howard
Mitchell
Loving
Winkler
Ector
Midland
Glasscock
Sterling
Coke
Runnels
Coleman
Brown
Ward
Crane
Upton
Reagan
Irion
Tom Green
Concho
McCulloch
Reeves
Pecos
Crockett
Schleicher
Menard
Mason
Sutton
Kimble
N
W
E
S
Legend
All areas are prime farmland
Not prime farmland
Prime farmland if irrigated
Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
Prime farmland if protected from flooding or not frequently flooded during the growing season
Water
Prime Farmland
Region F
FIGURE
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A number of counties in Region F have significant prime farmland acreage. Those with the largest acreage include Andrews, Crockett, Pecos, Reeves, Sutton, and Tom Green Counties. These six counties accounted for about 18 percent of the total land in farms and 44 percent of the total crop value for Region F in 2017.

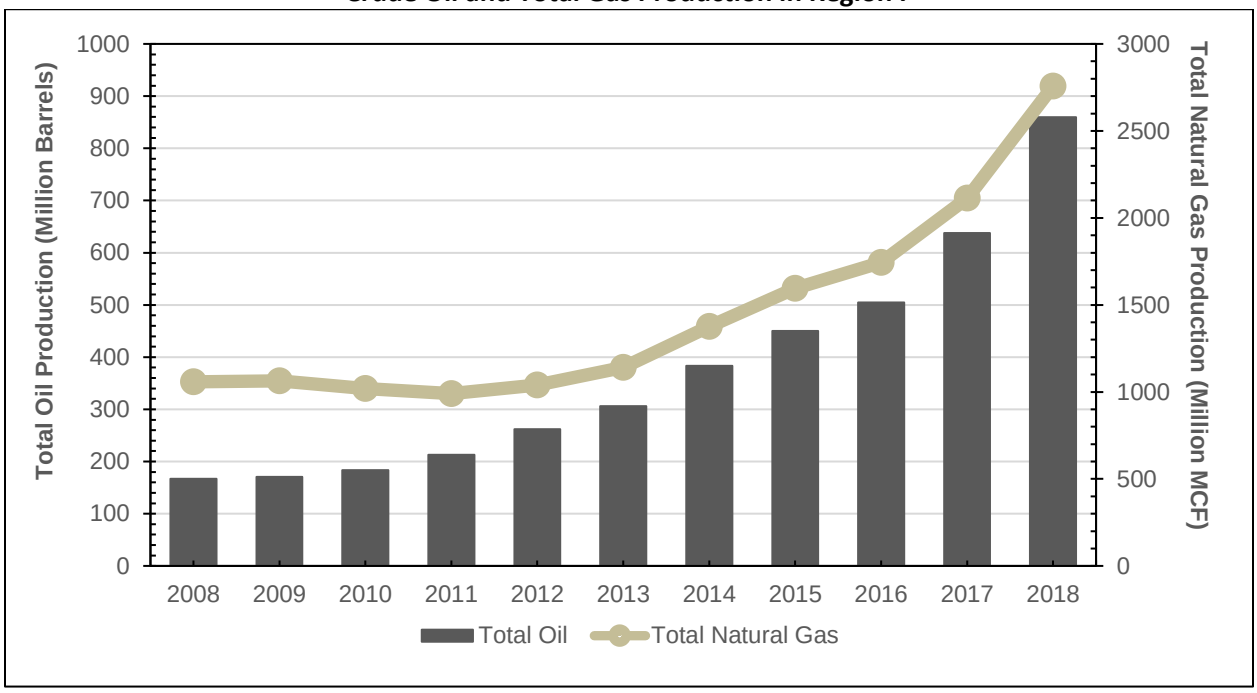
It is interesting to note that major agricultural production also occurs in some counties with a relatively small amount of prime farmland. For example, Brown, Glasscock, Martin, Runnels, and Scurry Counties have 10 percent or less acreage identified as prime farmland. However, these five counties combined accounted for approximately 24 percent of the total land in farms and 24 percent of the crop value for the region in 2017.

1.4.3 Mineral Resources

Oil and natural gas fields are significant natural resources throughout Region F. Recent developments in drilling technology along with increased commodity prices have led to significant oil and gas production in the Permian Basin. Other significant mineral resources in Region F include bituminous coal resources in Brown, Coleman, and McCulloch Counties, and stone, sand and gravel in various parts of the region.

Petroleum Production. Oil and gas fields are a valuable natural resource throughout most of Region F. As discussed previously in Section 1.1.1, the petroleum industry heavily influences the Region F economy. Over the last decade, Region F has experienced a notable increase in oil and gas production, as technological advancements have made it feasible for companies to develop petroleum in the continental United States. In particular, the Permian Basin (Figure 1-5), which underlies a significant portion of the counties in Region F, has experienced a rapid growth and has become the second largest producer of oil and gas shale in the world[20]. According to data from the Railroad Commission of Texas, annual total oil production (including crude oil and condensate) has increased by over 400% and annual total natural gas (including gas well gas and casinghead gas) production has increased by over 150% in Region F since 2008 (Figure 1-21)[21].

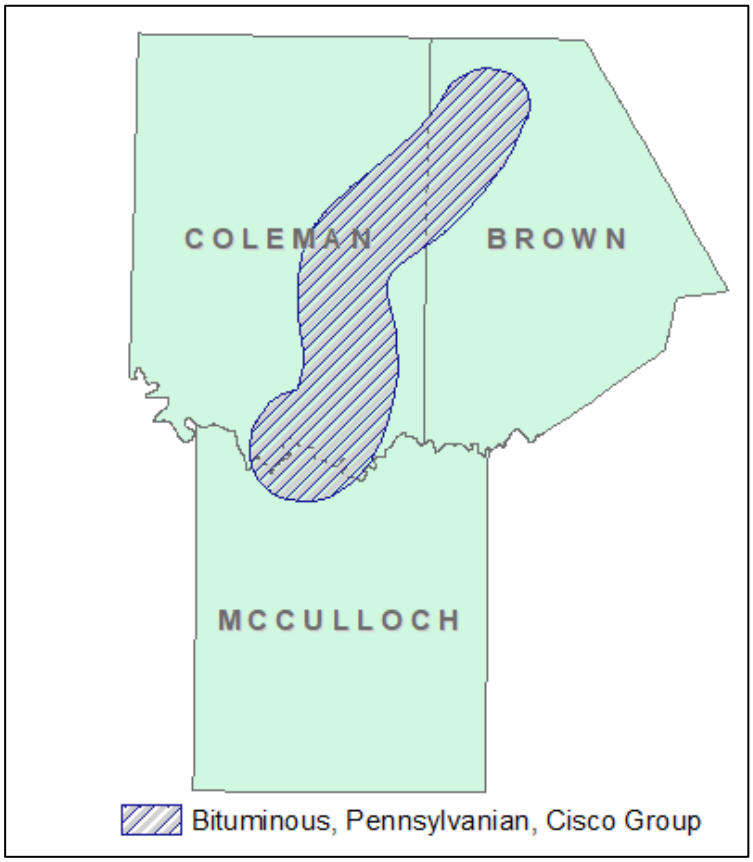
Figure 1-21
Crude Oil and Total Gas Production in Region F

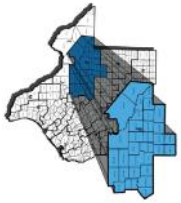


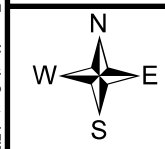
Counties in Region F play an integral role in oil and gas production throughout the state of Texas. In fact, in the year 2018, Region F counties accounted for over 55% of the state's total oil production and over 30% of state's total natural gas production[21]. Six of the top ten largest total oil producing counties (Midland, Reeves, Loving, Martin, Upton, Howard) and three of the top ten largest total natural gas producing counties (Reeves, Loving and Midland) in the state of Texas are located in Region F. In 2018, Midland County alone produced 144.2 million barrels (BBL) of crude oil, which accounted for over 10% of the crude oil production in the entire state.

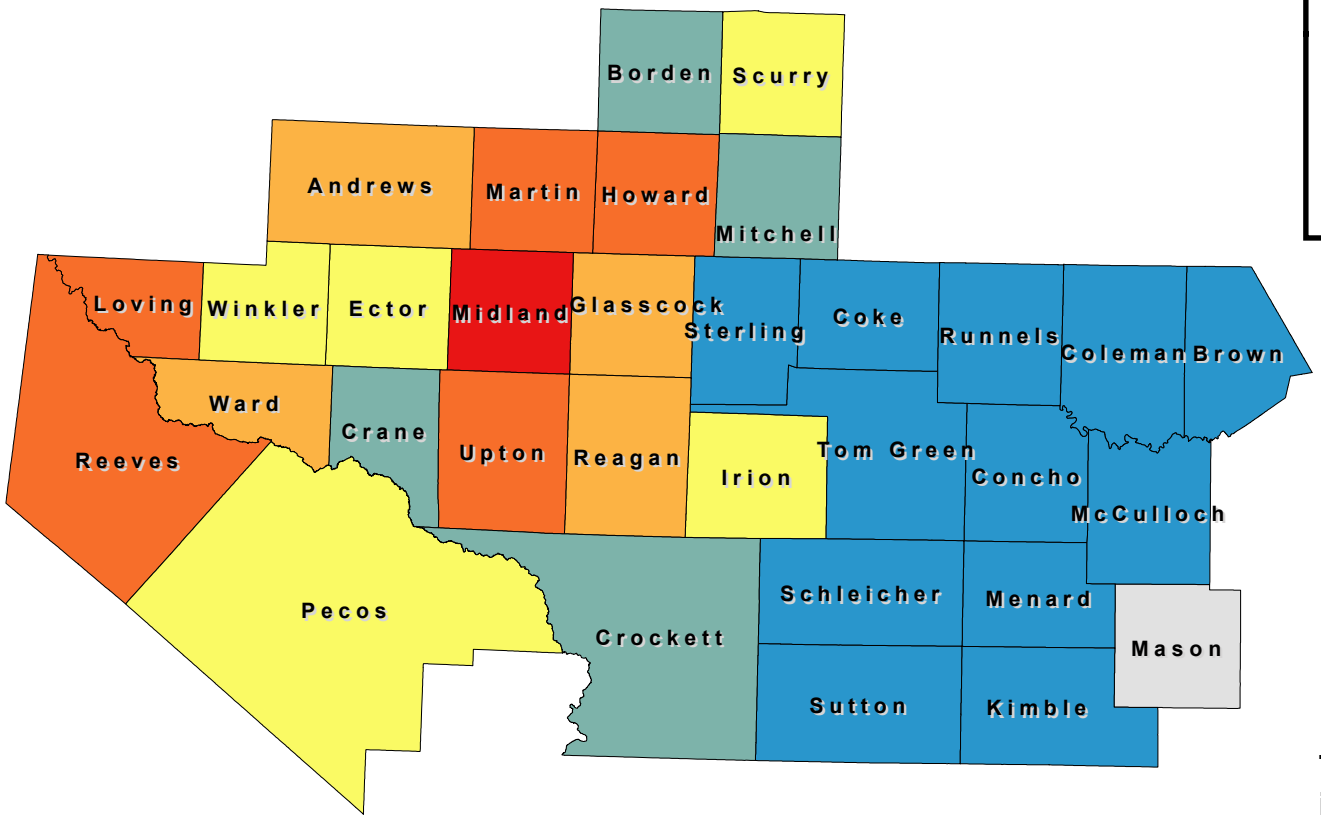
In 2018, every county in Region F, with the exception of Martin County, produced some form of oil (crude oil or condensate). Furthermore, in 2018, every county, with the exception of Martin and McCulloch Counties, produced some form of natural gas (gas well gas and/or casinghead gas). Figure 1-22 and Figure 1-23 illustrate the distribution of total oil (BBL) and total natural gas (MCF) production in each Region F county during the year 2018, respectively.

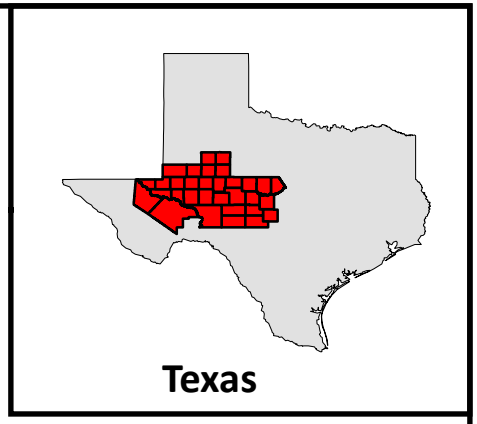
Coal Mining. Mining activity for bituminous coal resources have historically occurred in Coleman, Brown, and McCulloch Counties in Region F[22]. The coal resources are historically mined in the Cisco Group, which consists of shale, lenticular sandstone, many thin beds of limestone, and minor amounts of coal. The group has a thickness of about 350 feet in outcrops along the west side of the Llano region in Brown and Coleman Counties. According to the Railroad Commission (RRC), there are a total of seven, five, and three historical mining sites in McCulloch, Coleman, and Brown Counties, respectively. These mining sites are now part of the Abandoned Mine Land (AML) Program, which aims to reclaim and restore the land and water resources within previous mining areas. There are no active coal mining permits in Region F.











Total Oil Production in BBL (2018)

- Data Not Available
- <1,000,000
- 1,000,000 - 10,000,000
- 10,000,000 - 25,000,000
- 25,000,000 - 50,000,000
- 50,000,000 - 100,000,000
- >100,000,000

Total Oil Production (including Crude Oil and Condensate) by County (2018)

Region F

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FIGURE 1-22

Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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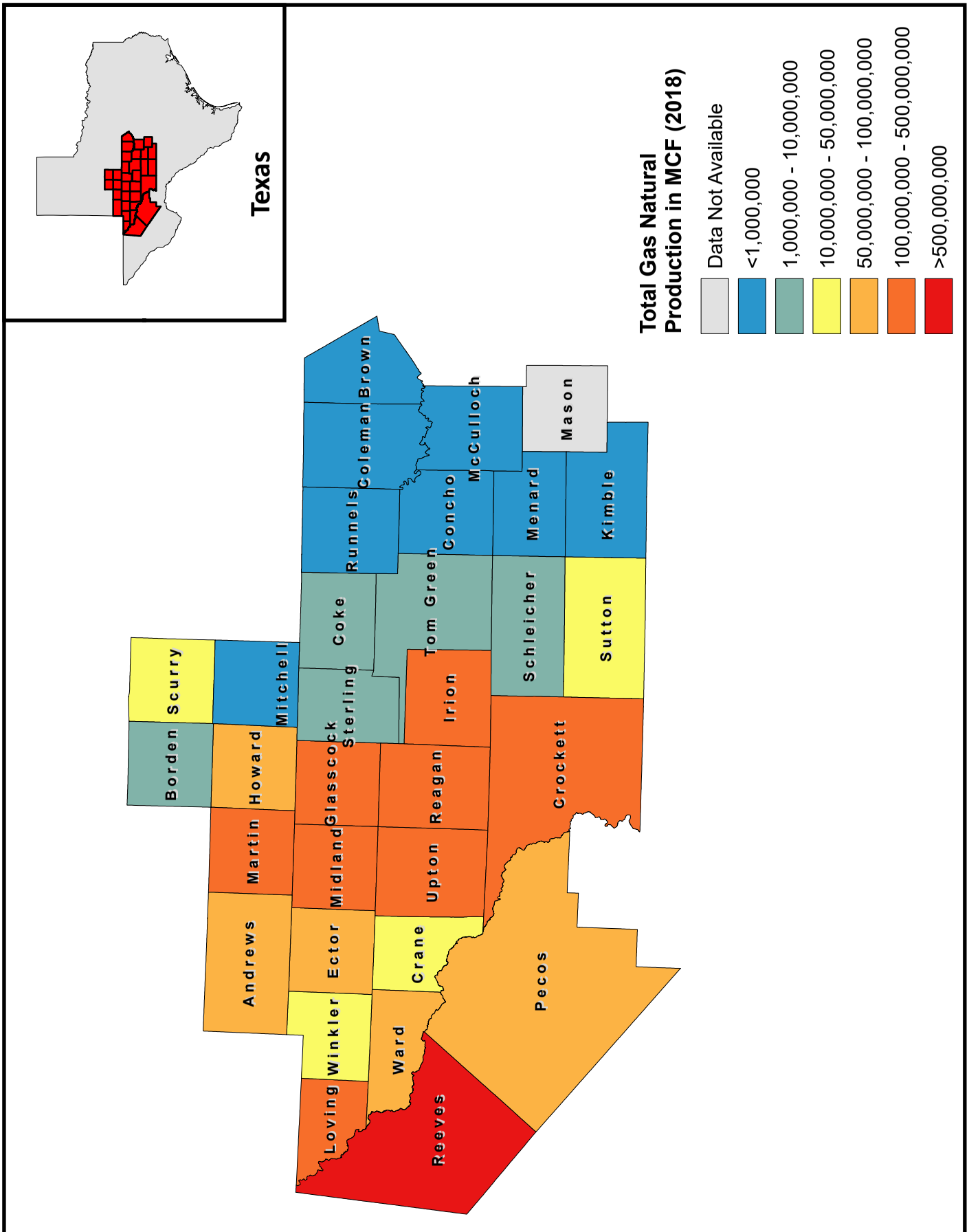

Region F

Total Natural Gas Production (including Gas Well and Casinghead Gas) by County (2018)

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FIGURE

Coordinate System: NAD 1983 StatePlane Texas North Central FIPS 4202 Feet

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1.5 Water Providers in Region F

Water providers in Region F include regional providers and retail suppliers. Regional water providers include river authorities and water districts. Retail water suppliers include cities and towns, water supply corporations, special utility districts, and private water companies.

1.5.1 Major Water Providers

The TWDB defines the term major water provider (MWP) as "a water user group or wholesale water provider of particular significance to the regions' water supply as determined by the RWPG."[23] Six major water providers have been identified by the Region F RWPG:

- Colorado River Municipal Water District (CRMWD)
- Brown County Water Improvement District Number One (BCWID)
- City of Odessa
- City of Midland
- City of San Angelo
- City of Fort Stockton

There are no implications of designation as a "major water provider" except for the additional data required by TWDB. The major water provider designation provides a different way of grouping water supply information.

Colorado River Municipal Water District (CRMWD)

CRMWD is the largest water supplier in Region F. CRMWD member cities include Big Spring, Odessa and Snyder. CRMWD also supplies water to Midland, San Angelo and Abilene, as well as several smaller cities in Ward, Martin, Howard and Coke Counties. CRMWD owns and operates Lake J.B. Thomas, E.V. Spence Reservoir, and O.H. Ivie Reservoir, as well as several chloride control reservoirs. The district's water supply system also includes well fields in Ward, Scurry, Ector and Martin Counties.

Brown County Water Improvement District Number One (BCWID).

BCWID supplies raw water and treated water from Lake Brownwood to the Cities of Brownwood, Early, Bangs and Santa Anna, and rural areas of Brown and Coleman Counties, as well as irrigation water in Brown County.

City of Midland

The City of Midland has several well fields for groundwater supply and purchases water from CRMWD. As the largest city in Region F, Midland provides retail surface water to over 134,000 municipal users and small quantities of water to manufacturing within city limits. In addition, Midland has a contract to sell treated wastewater effluent to the mining industry. Increased oil and gas activities in the Permian Basin (discussed in Section 1.4.3) around Midland have caused a rapid growth in city population and water service areas.

City of Odessa

The City of Odessa is a member city of CRMWD. Odessa sells treated water to the Ector County Utility District, Ector County Other, the Odessa Country Club, and manufacturing users. In addition, Odessa sells raw wastewater to the Gulf Coast Water Authority (GCA) to treat and sell to the mining industry, as well as treated wastewater directly to the mining industry.

City of San Angelo

The City of San Angelo's sources of supply are Lake O.C. Fisher (water is purchased from Upper Colorado River Authority), Twin Buttes Reservoir, Lake Nasworthy, local surface water rights, and O.H. Ivie Reservoir (purchased from CRMWD). San Angelo also developed a groundwater supply from the Hickory Aquifer near Melvin, Texas (McCullough County). As part of an agreement with UCRA, San Angelo treats water for customers of UCRA. San Angelo also provides water to the Goodfellow Air Force Base.

City of Fort Stockton

The City of Fort Stockton is supplied by groundwater from Pecos and Reeves Counties. Fort Stockton provides retail water to municipal users and plans to supply water to a new refinery (manufacturing) in Pecos County. In addition, Fort Stockton signed a water purchase agreement to supply up to 18,000 acre-feet of water per year for mining purposes in Pecos, Reeves, and possibly Ward Counties.

1.6 Existing Plans for Water Supply Development

In 2017, the Texas Water Development Board released the State Water Plan, Water for Texas – 2017, which was a compilation of the 16 regional water plans developed under SB1.[24] The Region F Water Planning Group published the Region F Regional Water Plan in January 2016. Some of the findings of the 2016 Region F plan included:

- Approximately 70 water user groups had projected water shortages over the planning period

(through 2070). In the event of a drought Region F was projected to have a total water supply shortage of 183,000 acre-feet by 2020 and 237,000 acre-feet by 2070. Many of these shortages were associated with diminishing supplies under new drought of record conditions and decreased groundwater due to a new definition of availability. In total, 291 water management strategies and 145 projects were developed to address these needs.

- Groundwater availability was significantly lower in the 2016 plan compared to previous plans due to the new definition of groundwater availability. In accordance with TWDB rules, the groundwater availability in the 2016 plan was determined by estimates from the Modeled Available Groundwater (MAG). This was the first cycle of planning that required groundwater estimates developed through the state-sponsored groundwater joint planning process.
- Decreases in surface water availability were attributed to ongoing drought of record conditions, which reduced reservoir yields from the TCEQ WAM priority analysis of surface water supplies. Also, the priority analysis does not reflect actual surface water operation in the Upper Colorado River Basin. Subordination of Lower Colorado River Basin water rights provide a significant amount of surface water supplies to Region F. However, these supplies were less in the 2016 regional plan than previous plans, due to ongoing drought of record conditions.
- The majority of water supply deficits were associated with irrigated agriculture. Sixteen counties had a collective irrigation need of nearly 114,000 acre-feet per year by 2020 and 110,000 acre-feet by 2070. No water supply is readily available to meet this need. Improved irrigation efficiency strategies were recommended to reduce the irrigation demands. This strategy would significantly reduce the demands and eliminate projected shortages in several counties. However, some counties in Region F still had significant irrigation water needs.
- A relatively small volume of municipal needs remained unmet in Region F in large cities, e.g., Midland and Andrews. Studies are planned to assess potential options for future water supplies. Additionally, conservation was recommended as a strategy to reduce unmet needs and protect human health and safety.
- General water management strategies recommended in the plan included: subordination, water conservation, brush control, weather modification, wastewater reuse, and desalination.
- Water conservation strategies accounted for 48 percent of the total volume associated with all recommended strategies in 2070. The majority of this volume is associated with irrigation demand reduction. Conservation strategies were also recommended for discrete municipal and other (rural municipal) water users.
- Innovative technologies, such as direct potable reuse, aquifer storage and recovery (ASR), and groundwater desalination accounted for approximately 7 percent of the total volume of recommended strategies in 2070.

The City of San Angelo recently completed a Water Supply Engineering Feasibility Study.[25] The study considered twenty-four possible water supply options, and completed a detailed assessment of four options. One of those options was groundwater and three were different versions of potable reuse. The study recommended a potable reuse strategy termed the “Concho River Water Supply” which entailed potable reuse of Concho River water. This option provided the lowest unit cost, the highest yield, and improves the treatment infrastructure of the City.

The cities of Abilene, Midland, and San Angelo formed the West Texas Water Partnership (the Partnership) to evaluate long-term water supplies the Partnership could develop jointly. The Partnership is conducting a separate study to determine the most feasible water management strategies for these cities, but the results were not available at the writing of this plan.

There are no known publicly available plans for agricultural, manufacturing, and commercial water users in Region F. To the extent these types of plans are known, they are considered by the Region F Water Planning Group in the development of the Regional Water Plan.

1.6.1 Conservation Planning in Region F

The Texas Water Code requires that certain entities develop, submit, and implement a water conservation plan (Texas Water Code § 11.1271). Those entities include holders of an existing permit, certified filing, or certificate of adjudication for the appropriation of surface water in the amount of 1,000 acre-feet per year or more for municipal, industrial, and other uses, as well as 10,000 acre-feet per year or more for irrigation uses. These plans must be consistent with the appropriate approved regional water plan(s). Water conservation plans must include specific, quantified 5-year and 10-year targets for water savings. Goals must be set for water loss programs and for municipal per capita water use. In 2007, § 13.146 of the Texas Water Code was amended requiring retail public suppliers with more than 3,300 connections to submit a water conservation plan by May 1, 2009 to the TWDB.

Many entities around the state have already developed conservation plans and/or drought contingency plans. These plans have improved the awareness of the need for water conservation in Texas. In its projections of water use, the TWDB has assumed reductions in per capita municipal use due to the implementation of the plumbing code requiring the use of low flow plumbing fixtures in all new development and renovation. The TWDB also considers expected reductions in municipal water use due to energy efficiency requirements for dish washers and clothes washers.

Many cities in Region F have developed water conservation plans. Water conservation education is stressed in most cities. These cities plan to provide educational brochures to new and existing customers. Other measures to conserve water include retrofit programs, leak detection and repair, recycling of wastewater, water conservation landscaping, and adoption of the plumbing code. This plan recommends water conservation for all cities including those without shortages. As part of this plan, model water conservation plans can be accessed online at www.regionfwater.org and clicking on the Documents tab

(http://regionfwater.org/index.aspx?id=Documents). These models can serve as templates for entities to develop or update their water conservation plan. More information on water conservation planning, including recommended strategies to conserve water may be found in Subchapter 5B.

1.6.2 Water Loss Audits

Retail public water utilities are required to complete and submit a water loss audit form to the Texas Water Development Board every five years. The first water loss audit reports were submitted to the TWDB by March 31, 2006. The water audit reporting requirements follow the International Water Association (IWA) and American Water Works Association (AWWA) Water Loss Control Committee methodology.[26]

The primary purposes of a water loss audit are to account for all of the water being used and to identify potential areas where water can be saved. Water losses are classified as either apparent loss or real loss. Apparent loss is the water that has been used but has not been tracked. It includes losses associated with inaccurate meters, billing adjustment and waivers, and unauthorized consumption. Real loss is the actual water loss of water from the system, and includes main breaks and leaks, customer service line breaks and leaks, and storage overflows. The sum of the apparent loss and the real loss make up the total water loss for a utility.

In the Region F planning area, 24 public water suppliers submitted a water loss audit to TWDB[27]. The average total water loss for Region F is 14.5 percent. The amount of reported losses in Region F totaled 1.1 billion gallons in 2017. This represents 6.8 percent of the total estimated municipal water demand for the region. This information was used in developing municipal conservation strategies. Table 1-14 summarizes the water loss audit information that was collected by the TWDB for 2017. The region encourages the reduction in water loss where feasible.

Table 1-14
Summary of TWDB Water Loss Audits

Total Water Loss	WUGS	SUDS/WSCs
≤ 10%	14	0
10% - 25%	4	0
≥ 25%	2	4

Source: 2017 Water Loss Audit Dataset from TWDB[27]

1.6.3 Assessment of Current Preparations for Drought in Region F

Drought is a fact of life in Region F. Periods of low rainfall are frequent and can extend for a long period of time. Most of the area has been in drought-of-record conditions since the mid-1990s. Many Region F water suppliers have already made or are currently making improvements to increase their capacity to

deliver raw and treated water under drought conditions. Some smaller suppliers in Region F have faced a shortage of supplies within the last few years and have had to restrict water use. The Lower Colorado River Authority (LCRA) determined that the 2008-2016 drought surpassed the historic drought-of-record from the 1950s for LCRA's Highland Lakes and the lower basin and is now the new drought of record. This is significant for Region F because some of the eastern portion of Region F is in the watershed for the Highland Lakes System, which is located in Region K, east of Region F. The low inflows into the Highland Lakes parallels the lower than normal runoff that has occurred in Region F as well. A detailed discussion of the impact of drought on water supplies and water suppliers is included in Chapter 7.

Model drought contingency plans were developed for Region F and can be accessed online at www.regionfwater.org. Each plan identifies four drought stages: mild, moderate, severe and emergency. The recommended responses range from notification of drought conditions and voluntary reductions in the "mild" stage to mandatory restrictions during an "emergency" stage. Entities using the model plan can select the trigger conditions for the different stages and appropriate responses for each stage.

1.6.4 Other Water-Related Programs

In addition to the SB1 regional planning efforts, there are a number of other significant water-related programs that affect water supply in Region F. Perhaps the most significant are Texas Commission on Environmental Quality's water rights permitting, the Clean Rivers Program, the Clean Water Act, the Safe Drinking Water Act, Water Supply Enhancement Program, and precipitation enhancement programs.

Texas Commission on Environmental Quality (TCEQ) Water Rights Permitting - Surface water in Texas is a public resource, and the TCEQ is empowered to grant water rights that allow beneficial use of that resource. Any major new surface water supply source will require a water right permit. In recent years, TCEQ has increased its scrutiny of the environmental impacts of water supply projects, and permitting has become more difficult and complex. Among its many other provisions, SB1 set out formal criteria for the permitting of interbasin transfers for water supply.

Texas Pollutant Discharge Elimination System (TPDES) Program

The TPDES is the state program to carry out the National Pollutant Discharge Elimination System (NPDES) promulgated under the Clean Water Act. The Railroad Commission of Texas maintains authority in Texas over discharges associated with oil, gas, and geothermal exploration and development activities. The TPDES program covers all permitting, inspection, public assistance, and enforcement associated with:

- discharges of industrial or municipal waste;
- discharges and land application of manure from concentrated animal feeding operations;
- discharges of industrial and construction site storm water;
- discharges of storm water associated with city storm sewers;
- oversight of municipal pretreatment programs; and
- disposal and use of sewage sludge.

Wellhead Protection Areas **-** The Texas Water Code provides for a wellhead source water protection zone around public water supply wells extending to activities within a 0.25 mile radius. Specific types of sources of potential contamination within this wellhead/source water protection zone may be further restricted by TCEQ rule or regulation. For example, wellhead/source water protection zones have been designated for many public water supply wells within or near Pantex (May and Block, 1997). More specific information on well head protection zones is available from TCEQ.

The Texas Water Code further provides for all wells to be designed and constructed according to TCEQ well construction standards (30 TAC 290). These standards require new wells to be encased with concrete extending down to a depth of 20 feet, or to the water table or a restrictive layer, whichever is the lesser. An impervious concrete seal must extend at least 2 feet laterally around the well head and a riser installed at least 1 foot high above the impervious seal.

Clean Rivers Program **-** The Texas Clean Rivers Program (CRP) is a state-fee funded water quality monitoring, assessment, and public outreach program. The CRP is a collaboration of 15 partner agencies and the TCEQ. The CRP provides the opportunity to approach water quality issues within a watershed or river basin at the local and regional level through coordinated efforts among diverse organizations. In Region F, the program is carried out by the Lower Colorado River Authority, with assistance from CRMWD and UCRA, in the Colorado Basin, and by the International Boundary and Water Commission in the Rio Grande Basin.[28]

Clean Water Act **-** The Clean Water Act is a federal law designed to protect water quality. The Act does not directly address groundwater nor water quantity issues. The statute employs a variety of regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's

waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water." [29]

The parts of the act which have the greatest impact on water supplies are the NPDES permitting process, which affects water quality, and the Section 404 permitting process for dredging and filling in the waters of the United States, which affects reservoir construction and infrastructure projects that may affect wetlands or rivers. In Texas, the state oversees the NPDES permitting system, which sets the operating requirements for wastewater treatment plants. The Section 404 permitting process is facilitated by the Corps of Engineers.

The TCEQ administers a Total Maximum Daily Load (TMDL) Program for surface water bodies in the state of Texas. TMDL programs are a result of the Clean Water Act. In this program, water quality analyses are performed for water bodies to determine the maximum load of pollutants the water body can handle and still support its designated uses. The load is then allocated to potential sources of pollution in the watershed, and implementation plans are developed which contain measures to reduce the pollutant loads. The Implementation Plan for Sulfate and Total Dissolved Solids (TDS) TMDLs in the E.V. Spence Reservoir (Segment 1411) was established in August 2001. The TCEQ has completed analyzing the Colorado River below E.V. Spence Reservoir (Segment 1426) for chloride, sulfate, and TDS concentrations and updated the Implementation Plan (further information on the updated plan is included in Section 1.7.1).

Safe Drinking Water Act **-** The Safe Drinking Water Act (SDWA) was originally passed by Congress to protect public health by regulating the nation's public drinking water supply. The law requires many actions to protect drinking water and its sources – rivers, lakes, reservoirs, springs, and groundwater wells. To ensure that drinking water is safe, SDWA sets up multiple barriers against pollution including source water protection, treatment, distribution system integrity, and public information.[30] Some of the initiatives that will most likely have significant impacts in Region F are the reduction in allowable levels of trihalomethanes in treated water, the requirement for reduction of total organic carbon levels in raw water, and the reduction in the allowable level of arsenic and radionuclides in drinking water. The allowable limit on arsenic has been reduced from 50 micrograms per liter to 10 micrograms per liter.

Water Supply Enhancement Program **-** The Water Supply Enhancement Program, formerly known as the State Brush Control Program, was developed pursuant to Chapter 203 of the Texas Agricultural Code.

Feasibility studies have been conducted for six watersheds in the region including Lake Brownwood, O.C. Fisher, O.H. Ivie, E.V. Spence, Lake J.B. Thomas and Twin Buttes Reservoir. Two additional feasibility studies for O.H. Ivie Reservoir (salt cedar specific) and the Upper Llano River are in progress at the time of writing of this plan. These projects are discussed further in Subchapter 5C.

Precipitation Enhancement Programs - In Region F, there are several ongoing weather modification programs, including the West Texas Weather Modification Association (WTWMA) project, and the Trans Pecos Weather Modification Association (TPWMA) program. The Southern Ogallala Aquifer Rain (SOAR) program is being conducted in Region O counties bordering Region F to the north. Precipitation enhancement is discussed in more detail in Chapter 5C.

Bio-Terrorism Preparedness and Response Act

Following the events of September 11th, Congress passed the Bio-Terrorism Preparedness and Response Act. Drinking water utilities serving more than 3,300 people were required and have completed vulnerability preparedness assessments and response plans for their water, wastewater, and stormwater facilities. The U.S. Environmental Protection Agency (EPA) funded the development of three voluntary guidance documents, which provide practical advice on improving security in new and existing facilities of all sizes. The guidance document for water utilities can be found through the American Water Works Association.

1.7 Summary of Threats and Constraints to Water Supply in Region F

1.7.1 Threats to Water Supply

Threats to water supply in Region F include:

- Water quality concerns in several areas of the region,
- The impact of drought,
- Changes in groundwater regulation,
- Rainfall/runoff patterns in the Upper Colorado River Basin, and
- Strict enforcement of State's Priority System for Surface Water.

Brief discussions of each of these concerns is presented in this section. The water quality concerns are discussed by source. The TCEQ publishes The State of Texas Water Quality Inventory every two years. The Water Quality inventories indicate whether public water supply use is supported in the stream segments designated for public water supply in Region F. Surface water quality concerns identified by the

TCEQ within Region F are summarized in Table 1-15. The Region F Plan was developed under the guiding principal that the designated water quality and related water uses shall be improved or maintained.

Rio Grande Basin Water Quality

The high levels of chlorides, sulfates and TDS present in the Pecos River below Red Bluff Reservoir appear to originate from geologic formations and oil and gas production activities. The cause of the toxic algae blooms is unknown. However, their occurrence has been linked to salinity and nutrient concentrations. The elevated levels of arsenic have been attributed to agricultural activities. Red Bluff Reservoir contains elevated levels of mercury, chlorides, and sulfates. The heavy metals present in the surface water in this region represent the most serious public health concern. The high chloride and TDS levels in the surface water preclude most agricultural uses. Instead, agricultural water users rely heavily on the groundwater supply.

Colorado River Basin Water Quality

The high levels of chlorides, sulfates and TDS present in the Upper Colorado River above O.H. Ivie Reservoir (including E.V. Spence Reservoir) are thought to originate from geologic formations and oil and gas production.[31] In August 2000, a Total Maximum Daily Load (TMDL) study was completed at E.V. Spence Reservoir. This TMDL study was approved by the Environmental Protection Agency (EPA) in May 2003. In 2007, the TCEQ adopted Two Total Maximum Daily Loads for Chlorides and Total Dissolved Solids for the Colorado River below the E.V. Spence Reservoir. Later that year, the TCEQ approved the Implementation plan (I-plan) to achieve the pollutant reduction identified in the TMDL report.[32] The Railroad Commission has since eliminated many potential sources of contamination and the Texas State Soil and Water Conservation Board removed salt cedar in the watershed. Prior to the current drought, the salinity levels in the segment of stream were improving. However, the drought has lowered water levels in Spence, leading to a re-concentration of chloride and TDS. In 2014, the Upper Colorado River Authority (UCRA) and TCEQ updated the I-plan. In 2016, stakeholders met to discuss progress of the I-Plan to evaluate actions taken, identify actions that may not be working, and make any changes necessary. Continued monitoring of the area should show improving water quality as the I- Plan is implemented.[33]

Infrequent low dissolved oxygen levels and elevated levels of chlorophyll a have been reported by the TCEQ within the lower 25 miles of Pecan Bayou above Lake Brownwood. There are no known point sources of water pollution within the segment that could be responsible for the problem. Low oxygen levels may be due to natural conditions and/or agricultural non-point source pollution. The TCEQ has not

given this a priority ranking on the 303(d) list, instead stating that more data will be collected before a TMDL is scheduled. No impairment to water use as a result of the water quality has been reported.

The high nitrate levels present in the Concho River east of San Angelo and the groundwater water in Runnels, Concho and Tom Green Counties appear to be from a combination of natural conditions, general agricultural activities (particularly as related to wide spread and intense crop production), and locally from confined animal feeding operations and/or industrial activities. Surface waters in the Concho River near Paint Rock have consistently demonstrated nitrate levels above drinking water limits during winter months. This condition has caused compliance problems for the city of Paint Rock, which uses water from the Concho River. It has been determined through studies funded by the Texas Clean Rivers Program that the elevated nitrates in the Concho River result from dewatering of the Lipan aquifer through springs and seeps to the river.[34] Further analysis of data collected near Paint Rock shows an increasing trend in chloride, which is likely attributed to lower inflows from the Lipan Aquifer due to drought, increased irrigation withdrawals, and brush infestation. [35]

The North Fork of the Concho River from O.C. Fisher Reservoir Dam to Bell Street in San Angelo is heavily impacted with non-point source urban runoff, which leads to oxygen depletion and a general water quality deterioration. Numerous fish kills have occurred along this 4.75 mile stretch of the Concho River since the late 1960's. In addition, toxics have been reported by the TCEQ within the same stream segment. Both of these problems are believed to result from non-point source water pollution. Since 1994, the Upper Colorado River Authority and the City of San Angelo have been involved in a comprehensive effort to mitigate these problems through the Federal Clean Water Act (CWA) 319(h) program. This program provides grant funds to implement Best Management Practices (BMPs) designed to mitigate non-point source water quality problems. The EPA 319(h) program is administered in Texas through the TCEQ. The implementation of this program has proved to be successful as water quality has shown significant improvement and fish kills have been virtually eliminated. In 2016, water quality data in the North Concho River indicate that concentrations of E. coli have decreased, and TCEQ proposed to remove the bacteria impairment from the list of impaired waters[36].

Table 1-15
Summary of Identified Surface Water Quality Problems in Region F

Segment ID	Segment Name	Concern Location	Water Quality Concern	Status
1411	E.V. Spence Reservoir	From Robert Lee Dam in Coke County to a point immediately upstream of the confluence of Little Silver Creek in Coke County, up to the normal pool elevation of 1898 feet (impounds Colorado River)	Chloride	Additional data and information will be collected before a TMDL is scheduled.
1412	Colorado River Below J.B Thomas	From the confluence of Beals Creek upstream to the dam below Barber Reservoir pump station	bacteria	Additional data and information will be collected before a TMDL is scheduled.
1412 B	Beals Creek (unclassified water body)	From the confluence of Gutherie Draw upstream to the confluence of Mustang Draw and Sulphur Springs Draw	bacteria	A review of the standards for one or more parameters will be conducted before a management strategy is selected, including the possible revision to the water quality standards.
1413	Lake J. B. Thomas	Entire water body	chloride	Additional data and information will be collected before a TMDL is scheduled.
			sulfate	
			total dissolved solids	
1416	San Saba River	From the confluence with the Colorado River in San Saba County upstream to the US 190	bacteria	Additional data and information will be collected before a TMDL is scheduled.
1416 A	Brady Creek (unclassified water body)	From the confluence of the San Saba River southwest of San Saba County to the Brady Lake Dam west of Brady in McCulloch County	depressed dissolved oxygen	Additional data and information will be collected before a TMDL is scheduled.
1421	Concho River	From a point 2 km (1.2 mi) above the confluence of Fuzzy Creek in Concho County to San Angelo Dam on the North Concho River in Tom Green County and to Nasworthy Dam on the South Concho River in Tom Green County	depressed dissolved oxygen	Additional data and information will be collected before a TMDL is scheduled.
1425	O.C. Fisher Lake	From San Angelo Dam in Tom Green County up to normal pool elevation of 1908 feet (impounds North Concho River)	chloride	Additional data and information will be collected before a TMDL is scheduled.
			total dissolved solids	Additional data and information will be collected before a TMDL is scheduled.
1432	Upper Pecan Bayou	From a point immediately upstream of the confluence of Willis Creek in Brown County to Lake Brownwood Dam in Brown County	bacteria	Additional data and information will be collected before a TMDL is scheduled.
2311	Upper Pecos River	From US Hwy 67 upstream to the Ward Two Irrigation Turnout	depressed dissolved oxygen	Additional data and information will be collected before a TMDL is scheduled.
2312	Red Bluff Reservoir	From Red Bluff Dam in Loving/Reeves County to New Mexico State Line in Loving/Reeves County up to normal pool elevation 2842 feet (impounds Pecos River)	chloride	Additional data and information will be collected before a TMDL is scheduled.
			sulfate	Additional data and information will be collected before a TMDL is scheduled.

Source: Data from 2016 Draft 303(d) list (October 17, 2018)[37]

Hickory Aquifer

Radionuclides present in the Hickory aquifer originate from geologic formations. Several of the public water systems that rely on this aquifer sometimes exceed the TCEQ's radionuclide limits, including limits on radon. Some users are blending water from other sources with Hickory supplies to reduce radionuclide concentrations while other users have implemented radionuclide removal systems. According to local representatives of Hickory aquifer users on the Region F Water Planning Group, water from the Hickory aquifer has been used for decades with no known or identified health risk or problems. Since the radioactive contaminants are similar chemically to water hardness minerals (with the exception of radon), removal techniques are well known within the water industry. Problems that have yet to be resolved in utilizing these techniques are the storage and disposal of the removed radioactive materials left over from the water treatment process, and the funding of treatment improvements for small, rural communities. Generally, agricultural use is not impaired by the presence of the radionuclides.

Dockum Aquifer

Water quality in the Dockum Aquifer ranges from fresh (TDS < 1,000 mg/L) in outcrop areas and the edges of the depositional basin to brines with over 50,000 mg/L TDS in the center of the basin. Upward movement of water in some areas, such as Andrews County, can result in poorer water quality in the overlying Ogallala Aquifer. In Ector County, Dockum wells produce groundwater with TDS concentrations between 2,000 and 7,000 mg/L and sulfate and chloride concentrations up to 2,500 mg/L from wells that are less than 750 feet deep. The presence of uranium minerals in the Dockum Group has long been recognized, and is the source of some radiological constituents (radium-226 and -228) reported in some Dockum Aquifer groundwater samples. The concentrations of some trace metals, including antimony, beryllium, cadmium, lead, mercury, selenium, and thallium, were reported to exceed drinking water regulatory limits in several counties.

Other Groundwater Quality Issues

Other groundwater quality issues in Region F include elevated levels of fluoride, nitrate, arsenic and perchlorate. Table 1-16 shows the percentage of water wells sampled by the TWDB that exceed drinking water standards for dissolved fluoride, dissolved nitrate (nitrogen as NO_3), and dissolved arsenic. The largest percentage of wells with excessive fluoride can be found in Andrews and Martin Counties. Elevated nitrate levels can be found throughout Region F, with a high percentage of wells exceeding standards in Borden, Howard, Martin, and Runnels Counties. The highest percentages of wells exceeding arsenic standards are found in Andrews, Borden, Howard, Midland, and Martin Counties. Perchlorate is

a growing water quality concern for water from the Ogallala aquifer in west Texas. Preliminary research found perchlorate levels exceeding drinking water standards in 35 percent of the public drinking water wells.[38] Texas has not established an MCL for perchlorate. However, in 2001, TCEQ did establish an Interim Action Level (IAL) of 0.004 mg/L for perchlorate, and in its 2006 guidance for assessing the health of surface waters for the purposes of drinking water quality, TCEQ required monitoring and reporting of perchlorate levels that exceed 0.022 mg/L.[39]

Table 1-16
Percentage of Sampled Water Wells Exceeding Drinking Water Standards for Fluoride, Nitrate (as NO_3) and Arsenic

County	Fluoride	Nitrate	Arsenic
Andrews	27%	6%	38%
Borden	13%	33%	48%
Brown	2%	16%	0%
Coke	0%	3%	0%
Coleman	4%	24%	0%
Concho	1%	17%	0%
Crane	7%	18%	24%
Crockett	0%	0%	0%
Ector	3%	5%	24%
Glasscock	3%	13%	7%
Howard	16%	33%	35%
Irion	0%	0%	3%
Kimble	0%	9%	0%
Loving	0%	2%	6%
Martin	45%	35%	71%
Mason	0%	11%	0%
McCulloch	1%	5%	0%
Menard	0%	5%	0%
Midland	10%	9%	32%
Mitchell	6%	21%	0%
Pecos	0%	0%	0%
Reagan	1%	0%	3%
Reeves	2%	6%	6%
Runnels	0%	9%	1%
Schleicher	2%	74%	0%
Scurry	2%	14%	5%
Sterling	0%	1%	0%
Sutton	0%	0%	0%
Tom Green	0%	1%	0%
Upton	0%	14%	0%
Ward	0%	4%	0%
Winkler	1%	9%	1%

Data are from the Texas Water Development Board 06-2019[40]

Regional Drought

Most of Region F has experienced drought-of-record conditions since the mid-1990s. These conditions have led to reduced inflow, high evaporation and low lake levels limiting the supply. Many suppliers in the region responded by implementing their drought contingency plans and in some cases expedited implementation of water supply strategies. Drought conditions also have a negative impact on water quality. As water levels decline, reservoirs tend to concentrate dissolved materials. Without significant freshwater inflows the water quality in a reservoir degrades. The lack of recharge to aquifers has a similar effect on groundwater. A detailed discussion of the impact of drought on water supplies and water suppliers is included in Chapter 7.

Changes in Groundwater Regulation

Changes in groundwater regulation can have a major impact on water supply in Region F, especially during drought conditions when surface water is not available. Recent droughts have helped identify the importance of groundwater supplies to Region F and how they serve to balance water supply sources and serve as a critical safety net for several major cities in the region. Many cities and wholesale water providers plan to use surface water and groundwater conjunctively to optimize and maximize water supplies in the region by using as much surface water as possible when it is available in order to reduce evaporation losses and to conserve groundwater. When surface water is not available, groundwater will be used as necessary to meet demands. This shift towards a fully-integrated conjunctive use approach is dependent upon adequate groundwater availability during drought conditions. If groundwater availability is reduced (either physically or through regulatory restrictions), the safety net for the region can be significantly impaired. Under current law, and in counties with GCDs to enforce Desired Future Conditions (DFCs), groundwater availability could be significantly reduced by adoption of more restrictive DFCs. Additionally, TWDB funding for water projects might be limited by DFCs and MAGs even in areas without GCDs where physical groundwater availability is adequate to meet projected demands.

Rainfall and Runoff Patterns in the Upper Colorado River Basin

Region F surface water supply is heavily dependent upon consistent streamflow (runoff) throughout the Colorado River Basin. In 2017, a detailed evaluation of historical rainfall-runoff patterns in the Upper Colorado River Basin determined that observed flow trends have declined over the period of record (1940-2016)[41]. Analysis of naturalized flows from the Colorado Basin WAM indicated that most of this diminishing trend is likely caused by construction of large reservoir systems and historical water use, which are both associated with existing water rights in the basin area. Additionally, all sites in the study

demonstrated some decline in naturalized flow, signifying that activities not accounted for in the naturalization flow process could have impacted observed flows. Further investigations determined that four activities had some effect on the trend of observed and naturalized flows over the study period: (1) the proliferation of noxious brush; (2) the construction of small reservoirs, not accounted for in naturalized flows; (3) groundwater use and aquifer water level declines; and (4) changes in average temperature in drought conditions. If this declining trend of observed and naturalized flows continue, and these activities continue to cause negative effects, then threats to surface water supplies in the Upper Colorado River Basin will likely persist and could potentially magnify.

Strict Enforcement of State's Priority System for Surface Water

Texas surface water is governed by a priority system, which means "first in time, first in right." The TCEQ is charged with regulating the state's surface water, including issuing water rights and enforcing those rights. Historically, the TCEQ has only enforced the priority system when there was a request for water from a senior downstream water right holder, referred to as a priority call. Even then, the TCEQ would consider public health and safety when requiring pass-through of inflows from upstream to downstream users. With the development of the Water Availability Models (WAMs), which models strict interpretation of the priority system, it became apparent that many of the Region F reservoirs have little to no reliable supply, given that assumption. The WAM interpretation applies to the priority system to both storage and diversion that results in more water passed through to downstream water right holders than previously modeled for supply analyses.

During the recent drought (2011-2013), there were several priority calls across the state. As part of the response to these calls, TCEQ considered public health and safety as a factor in requiring pass-throughs. However, recent judicial decisions have stated that the state must enforce the priority system without regard to the type of use. If the state enforces the priority system in accordance with the assumptions in the WAMs, surface water supplies in Region F would be significantly impacted. More discussions on these impacts is included in Chapter 3 and Subchapter 5C.

1.7.2 Constraints

A major constraint to enhancing water supply in Region F is a lack of appropriate locations for new surface water supply development and lack of available water for new and/or existing surface water supply projects. There are few sites in the region that have sufficient runoff to justify the cost of developing a new reservoir without having a major impact on downstream water supplies. Generally, the few locations

that do have promise are located far from the areas with the greatest needs for additional water. In addition, the Colorado and Rio Grande WAMs show very little available surface water for new appropriations in Region F. There is very little water available that has not already been allocated to existing water rights.

As previously discussed, much of the surface water and groundwater in the region contains high concentrations of dissolved solids, originating from natural and man-made sources. It is possible to make use of these resources, but the cost to treat this water can be high. Much of the region is rural with limited resources. Therefore, advanced treatment, system improvements or long distance transportation of water may not be economically feasible. Also, many of these smaller communities have experienced declining populations in recent years. More than one-half of the counties in the region have a population less than 5,000 people.

Finally, many of the municipal water supply needs in Region F are relatively small and are in locations that are far away from reliable water supplies of good quality. Transporting small quantities of water over large distances is seldom cost-effective. Desalination and reuse are good options for these communities. However, the high cost of developing and permitting these types of supplies is a significant constraint on water development. Also, finding a suitable means of disposing the reject concentrate from a desalination project may limit the feasibility of such projects in many locations.

1.8 Water-Related Threats to Agricultural and Natural Resources in Region F

Water-related threats to agricultural resources in Region F include water quality concerns and insufficient groundwater supplies. Water-related threats to natural resources include changes to natural flow conditions and water quality concerns.

1.8.1 Water Related Threats to Agriculture

Water quality concerns for agriculture are largely limited to salt water pollution, both from natural and man-made sources. In some cases, improperly abandoned oil and gas wells have served as a conduit for brines originating deep within the earth to contaminate the shallow groundwater supplies. Prior to 1977, the brines associated with oil and gas production were commonly disposed in open, unlined pits. In some cases these disposal pits have not been remediated and remain as sources of salt contamination. Current brine disposal practices involve repressurizing hydrocarbon-producing formations or disposing through deep well injection. These practices lead to the possibility of leaks into water supply aquifers since the

hydraulic pressure of the injected water routinely exceeds the pressure needed to raise the water to the ground's surface. In other aquifers, excessive pumping may cause naturally occurring poor quality water to migrate into fresh water zones.

Most of Region F depends on groundwater for irrigation. Based on current use, agricultural demand exceeds the available groundwater supply in several counties. Parts of three counties (Midland, Reagan and Upton) were declared a Priority Groundwater Management Area by the TCEQ in 1990. Since that time the Santa Rita GCD has formed for most of Reagan County with Glasscock GCD covering small portions of the county as well. In February 2017, the Executive Director of TCEQ provided a report for northeastern Upton and southeastern Midland Counties recommending these areas be added to the Glasscock GCD.

1.8.2 Water Related Threats to Natural Resources

Reservoir development and invasion by brush and giant reed have altered natural stream flow patterns in Region F. Spring flows in Region F have greatly diminished. Many springs have dried up because of groundwater development, the spread of high water use plant species such as mesquite and salt cedar, or the loss of native grasses and other plant cover. High water use plant species have reduced reliable flows for many tributary streams. Reservoir development also changes natural hydrology by diminishing flood flows and capturing low flows. It is unlikely that future changes to flow conditions in Region F will be as dramatic as those that have already occurred. If additional reservoirs are developed, they will be required to make low flow releases to maintain downstream conditions.

List of References

[1] U.S. Census Bureau. "Population Estimates for Texas Counties 1900 to 2010." <http://census.gov/>.

[2] Data USA. “Odessa, TX MSA”; “Midland, TX MSA”; “San Angelo, TX MSA.” <https://datausa.io/>

[3] U.S. Bureau of Labor Statistics. “Quarterly Census of Employment and Wages.” <https://www.bls.gov/cew/datatoc.htm>

[4] United States Department of Agriculture, Natural Resources Conservation Service. “Geospatial Data Gateway”. 2010. <https://datagateway.nrcs.usda.gov/> and < http://www.prism.oregonstate.edu/>.

[5] Texas Commission on Environmental Quality: Active Water Rights Database, electronic files, Austin. 2019.

[6] Texas Commission on Environmental Quality: Certificates of Adjudication, various dates.

[7] Texas Commission on Environmental Quality: Historical water use database, electronic files. 2019.

[8] Texas Water Development Board: Historical and Projected Population and Water Use Data, electronic files. 2019.

[9] Ashworth, J.B. and Hopkins, J. *Aquifers in Texas,* Texas Water Development Board, Report 345, 1995.

[10] Texas Agricultural Extension Service (TAES): *Managing Texas’ Groundwater Resources through Underground Water Conservation Districts*, College Station, 1996.

[11] Texas Commission on Environmental Quality: Priority Groundwater Management Areas, electronic files, Austin, 2019.

[12] Brune, Gunnar. “Major and Historical Springs of Texas”*,* Texas Water Development Board Report 189, 1975.

[13] Brune, Gunnar. *Springs of Texas.* Vol. I. Fort Worth: Branch-Smith, Inc., 1981.

[14] Texas Parks and Wildlife Department: *Evaluation of Selected Natural Resources in Parts of Loving, Pecos, Reeves, Ward and Winkler Counties, Texas,* Austin. 1998.

[15] Texas Nature Conservancy. "Sandia Springs Preserve." 2004. <http://nature.org/wherewework/northamerica/states/texas/preserves/art6622.html>.

[16] U.S. Fish and Wildlife Service (USFWS). "ESA Basics, 30 Years of Protecting Endangered Species”. May. 2019. <http://endangered.fws.gov/>.

[17] Texas Parks and Wildlife Department (TPWD). *Threated and Endangered Species*, May. 2019. <https://tpwd.texas.gov/landwater/land/habitats/cross_timbers/endangered_species/>

[18]United States Department of Agriculture, National Agricultural Statistics Service. “2017 Census of Agriculture, Texas State and County Profiles.” Rep. <http://www.agcensus.usda.gov/Publications/2012/>.

[19] National Resources Conservation Service: State Soil Geographic (STATSGO) Database. <http://www.ftw.nrcs.usda.gov/stat_data.html>.

[20] Midland Development Corporation, “Permian Basin Economic Indicators*.”* May. 2019.

<https://www.midlandtxedc.com/business-and-economy/our-economy/permian-basin-economic-indicators>

[21] Railroad Commission (RRC) of Texas: "Oil and Gas." 2019. <https://www.rrc.state.tx.us/oil-gas/> and <http://webapps.rrc.texas.gov/PDQ/generalReportAction.do>

[22] Mapel, W.J. "Bituminous Coal Resources of Texas." Contributions to Economic Geology, U.S. Geological Survey. 1967. <https://pubs.usgs.gov/bul/1242d/report.pdf>

[23] Texas Water Development Board. *Exhibit C Second Amended General Guidelines for Fifth Cycle of Regional Water Plan Development*. 2018. <http://www.twdb.texas.gov/waterplanning/rwp/planningdocu/2021/doc/current_docs/contract_docs/2ndAmendedExhibitC.pdf?d=11039.225000000442>

[24] Texas Water Development Board. *Water for Texas – 2017,* Austin, 2017.

[25] Alan Plummer Associates. *Water Supply Engineering Feasibility Study*, prepared for the City of San Angelo, September 2018.

[26] American Water Works Association. *Water Audits and Loss Control Programs Third Edition.* AWWA M36 Publication, 2009.

[27] Texas Water Development Board: Water Loss Audit, electronic files, Austin, 2019.

[28] Texas Commission on Environmental Quality (TCEQ): "The Texas Clean Rivers Program." May. 2019. <http://www.tnrcc.state.tx.us/water/quality/data/wmt>.

[29] Environmental Protection Agency (EPA): "Introduction to the Clean Water Act." 2003. <www.epa.gov/watertrain/cwa/rightindex.htm>.

[30] Environmental Protection Agency (EPA): "Safe Water Drinking Act (SDWA)." 2019. <https://www.epa.gov/sdwa>.

[31] Texas Clean Rivers Program: "2018 Colorado River Basin Highlights Report." 2018. <https://www.lcra.org/water/quality/texas-clean-rivers-program/Pages/default.aspx >.

[32] TCEQ, UCRA and the Stakeholder Committee for the Upper Colorado River below E.V. Spence Reservoir. "Revisions to the Implementation Plan for Two Total Maximum Daily Loads for Chloride and Total Dissolved Solids in the Colorado River below E.V. Spence Reservoir for Segment Number 1426." May. 2019. < https://www.tceq.texas.gov/waterquality/tmdl/nav/32-colorado>.

[33] TCEQ Total Maximum Daily Load Program. "Implementing TMDLs for Dissolved Solids." Oct. 2018. Web. May. 2019.

[34] Upper Colorado River Authority (UCRA): "North Concho River Watershed Brush Control Planning, Assessment and Feasibility Study." September 1999.

[35] Lower Colorado River Authority (LCRA): "2012 Basin Summary Report: A Summary of Water Quality in the Colorado River Basin – 2007-2011." 2012.

[36] U.S. Environmental Protection Agency (EPA): "Slowing, Detaining and Filtering Stormwater Reduces Bacteria Loads in the North Concho River." 2016.

[37] Texas Commission on Environmental Quality: "2016 Texas Integrated Report of Surface Water Quality." https://www.tceq.texas.gov/waterquality/assessment

[38] Christen, Kris. "Perchlorate Mystery Surfaces in Texas." Environmental Science & Technology 37.21 (2003): 376A-77A. 2003.

[39] The University of Texas at Austin School of Law, Environmental Clinic: *Securing Safe Drinking Water for Texans.* First Edition, Fall 2018.

[40] Texas Water Development Board. *Groundwater Database*. <http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWDatabaseReports>.

[41] Kennedy Resource Company: "Evaluation of Rainfall/Runoff Patterns in the Upper Colorado River Basin". Report to Texas Water Development Board. August 2017.