U.S. Department of the Interior
Bureau of Land Management

# BLM WATER SUPPORT DOCUMENT FOR OIL AND GAS DEVELOPMENT IN OKLAHOMA, KANSAS, AND TEXAS

BLM WSD 2025

2025

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## Mission statement

The Bureau of Land Management sustains the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations.

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| µg/L | micrograms per liter |
| AF | acre-feet |
| APD | Application for Permit to Drill |
| bbl | barrel(s) |
| BIA | Bureau of Indian Affairs |
| BLM | Bureau of Land Management |
| CAS | Chemical Abstracts Service |
| CWA | Clean Water Act |
| EPA | U.S. Environmental Protection Agency |
| GWPC | Ground Water Protection Council |
| HF | hydraulic fracturing |
| HUC | Hydrologic Unit Code |
| ID | identifier |
| KCC | Kansas Corporation Commission |
| KDHE | Kansas Department of Health and Environment |
| KGS | Kansas Geological Survey |
| KWO | Kansas Water Office |
| KWP | Kansas Water Plan |
| lbs | pounds |
| MCL | maximum contaminant level |
| mg/L | milligrams per liter |
| NEPA | National Environmental Policy Act of 1969 |
| NMSO | New Mexico State Office |
| Non-HF | non-hydraulic fracturing |
| NORM | naturally occurring radioactive material |
| OCC | Oklahoma Corporation Commission |
| OCWP | Oklahoma Comprehensive Water Plan |
| ODEQ | Oklahoma Department of Environmental Quality |
| OFO | Oklahoma Field Office |
| OWRB | Oklahoma Water Resources Board |
| PFAS | per- and polyfluoroalkyl substances |
| PFOA | perfluorooctanoic acid |

| | |
|---|---|
| PFOS | perfluorooctane sulfonate |
| RFD | reasonably foreseeable development |
| RRC | Texas Railroad Commission |
| SOFB | Southern Oklahoma Fold Belt |
| TCEQ | Texas Commission on Environmental Quality |
| TDS | total dissolved solids |
| TENORM | technologically enhanced naturally occurring radioactive material |
| TWDB | Texas Water Development Board |
| UIC | Underground Injection Control |
| USGS | U.S. Geological Survey |
| WSD | Water Support Document |

# 1 INTRODUCTION

## 1.1 PURPOSE AND SCOPE

The intent of this Water Support Document (WSD) is to collect and present the data and information needed for water resources analyses to be incorporated by reference into National Environmental Policy Act (NEPA) documents, most specifically NEPA analyses related to federal oil and gas leasing and development under the jurisdiction of the Bureau of Land Management (BLM) New Mexico State Office (NMSO). The NMSO jurisdiction includes federally managed oil and gas leases within the Oklahoma Field Office (OFO) area, which comprises portions of the states of Oklahoma, Kansas, and Texas.

The content of this report focuses on existing water uses across multiple water use categories (agricultural, domestic, mining, etc.) and future water use projections associated with oil and gas development based on past and current water uses. The report also provides information regarding existing water quality within the OFO, and the potential causes of water contamination related to oil and gas leasing and development.

This document does not include analysis of the following data types and sources:

- Surface water and groundwater quality impacts from leasing and development: The states will have previously approved surface water use sources according to their own statutes (see Kan. Stat. Ann. § 82a-705; Okla. Stat. Ann. tit. 82, § 105.9; Tex. Water Code Ann. §§ 11.121, 11.142). Although this report summarizes existing water quality and potential sources of surface water and groundwater contamination from oil and gas spills, surface water and groundwater quality impacts will be analyzed by the BLM at the leasing stage with consideration of the site-specific conditions and stipulations that are applied to protect them. Surface water and groundwater quality impacts from leasing and development will also be analyzed by the BLM during site-specific development when specific facility placement details are known.
- Surface water quality assessment information: The Oklahoma Department of Environmental Quality (ODEQ), Kansas Department of Health and Environment (KDHE), and Texas Commission on Environmental Quality (TCEQ) administer Clean Water Act (CWA) Sections 303(d), 305(b), and 314 related to surface water quality assessment and reporting in their respective states. These entities define surface water quality beneficial uses and water quality criteria to evaluate if these uses are being attained. Only these entities have the authority to determine use attainment based on water chemistry data; the BLM does not have this jurisdiction.
- Water quality information for areas managed by the NMSO outside the OFO: The NMSO also manages federal oil and gas leasing and development within the state of New Mexico, specifically the Pecos District Office (Carlsbad Field Office and Roswell Field Office), Farmington Field Office, and Rio Puerco Field Office. Water quality and quantity information for these field offices is gathered, evaluated, and presented in the BLM WSD for Oil and Gas Development in New Mexico (BLM 2025a), which is updated annually.
- Environmental impacts of hydraulic fracturing: While the environmental impacts of hydraulic fracturing are relevant to the focus of this report, the fate and transport of chemicals used during hydraulic fracturing are complicated and have been the subject of human health and environmental concerns as oil and gas development continues throughout the United States. As such, the complexity of this subject would require substantial discussion that exceeds the scope of this report. Readers interested in understanding the environmental impacts of hydraulic fracturing should review the comprehensive U.S. Environmental Protection Agency (EPA) report *Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States (Final Report)* (EPA 2016). In summary, this

report presents scientific evidence that drinking water resources can be impacted by hydraulic fracturing under six conditions: 1) water withdrawals during periods of low water availability; 2) spills of hydraulic fracturing fluids, chemicals, or produced water, which refers to fluid that returns to the surface following hydraulic fracturing activities and includes both flowback water and formation water; 3) release of hydraulic fracturing fluids from wells with inadequate casing; 4) direct injection of hydraulic fracturing fluids into groundwater; 5) discharge of insufficiently treated wastewater to surface water; and 6) contamination of groundwater from unlined storage/disposal pits (EPA 2016). The BLM and States of Oklahoma, Kansas, and Texas have put in place numerous requirements for oil and gas producers to prevent the contamination of surface water and groundwater resources in states of the OFO.

## 1.2 SCALE OF ANALYSIS

The BLM OFO is responsible for the management of 4,810,900 acres of federal minerals across the 269,650,000-acre OFO planning area, which encompasses the states of Kansas, Oklahoma, and Texas, as well as one county in Nebraska (BLM 2020). The BLM OFO also assists the Bureau of Indian Affairs (BIA) with oil and gas permitting on 2,667,800 acres of BIA-managed mineral estate in the OFO planning area. The analysis area for this WSD is the approximately 270 million-acre OFO planning area. Given the large geographic scale of the OFO planning area, a subset of targeted counties was identified within the planning area to allow for more focused data analysis efforts for this WSD. Targeted counties include those where oil and gas development is currently happening, or is likely to happen (e.g., based on historic activity and/or resource potential) in the future, and are therefore most relevant to this WSD analysis. Targeted counties were selected through review of the following two data sources: 1) BLM OFO oil and gas lease sales over the last 10 years (BLM 2025b) and 2) BLM OFO applications for permit to drill (APDs) over the last 10 years. Based on review of these two data sources, 74 counties across Kansas, Oklahoma, and Texas were identified as having oil and gas lease sales or APDs over the last 10 years (Table 1-1, Figure 1-1). These 74 counties were used to facilitate a more focused analysis of sub-state geographies (i.e., active oil and gas plays) in this WSD. The list of targeted counties will be revisited and updated, as needed, during subsequent WSDs to capture any changes in oil and gas developmental trends within the planning area.

**Table 1-1. Targeted Counties for the 2025 OFO WSD**

| State | Lease Sale Occurrence Counties (2014–2025) | APD Occurrence Counties (2014–2025) | Lease Sale and APD Occurrence Counties (2014–2025) |
|---|---|---|---|
| Kansas | Cheyenne, Decatur, Greeley, Lane, Logan, Meade, Norton | Finney, Franklin, Montgomery, Sherman, Woodson | Not applicable |
| Oklahoma | Alfalfa, Beaver, Beckham, Cimarron, Custer, Harper, Le Flore, Payne, Woods, Woodward | Blaine, Caddo, Canadian, Garvin, Hughes, Seminole, Tillman | Coal, Creek, Dewey, Ellis, Grady, Jackson, Kingfisher, Major, McClain, Pittsburg, Roger Mills |
| Texas | Andrews, Burleson, Cherokee, Culberson, Gaines, Grayson, Hemphill, Houston, Jackson, Lee, Loving, Montgomery, San Jacinto, Tarrant, Trinity, Walker, Washington, Winkler, Zapata | Calhoun, Comal, Delta, Denton, Galveston, Guadalupe, Hutchinson, Karnes, Kenedy, San Augustine | Jasper, Live Oak, McMullen, Sabine, Shelby, Wise |

Source: BLM (2025a)

## 1.3 REPORT ORGANIZATION

This report is organized by state, and then further broken down by the regional oil and gas plays that coincide with the targeted counties in each state (see Figure 1-1; BLM 2025c). This WSD evaluates two oil and gas plays in Oklahoma, one oil and gas play in Kansas, which covers the entire state, and two oil and gas plays in the Texas portion of the OFO (see Figure 1-1). The regional oil and gas plays referenced throughout this WSD represent neighboring and contiguous geologic stratigraphies[1] which also exhibit similar trends in water use for oil and gas development and are therefore appropriate to combine for the purpose of analyzing water use trends and projections.

For each state within the OFO (see Chapters 2, 3, and 4), data is organized by

- water-specific planning efforts for the state or region,
- water quantity at the state level,
- water quality at the state level, and
- water quality and quantity for each regional oil and gas play evaluated in the state, excluding Kansas.

Chapter 5 contains a summary of data at the OFO scale concerning area-specific issues such as water use sources for potential development, induced seismicity, per- and polyfluoroalkyl substances (PFAS), and radiological materials. Chapter 5 also details future water use scenarios associated with oil and gas activity for the OFO and a drought and water availability analysis through the use of a variety of regional and state-specific tools. Finally, Chapter 6 contains the references pertinent to the analysis.

This report is organized so that authors and data analysts may use and reference state-and-play-specific chapters as stand-alone reports when evaluating impacts to water resources associated with proposed future federal oil and gas leasing and development under the jurisdiction of the BLM.

[1] The geologic stratigraphies referenced in this report are based on the BLM's 2016 *Reasonably Foreseeable Development Scenario for Kansas, Oklahoma, and Texas* (BLM 2016:Figure 54).

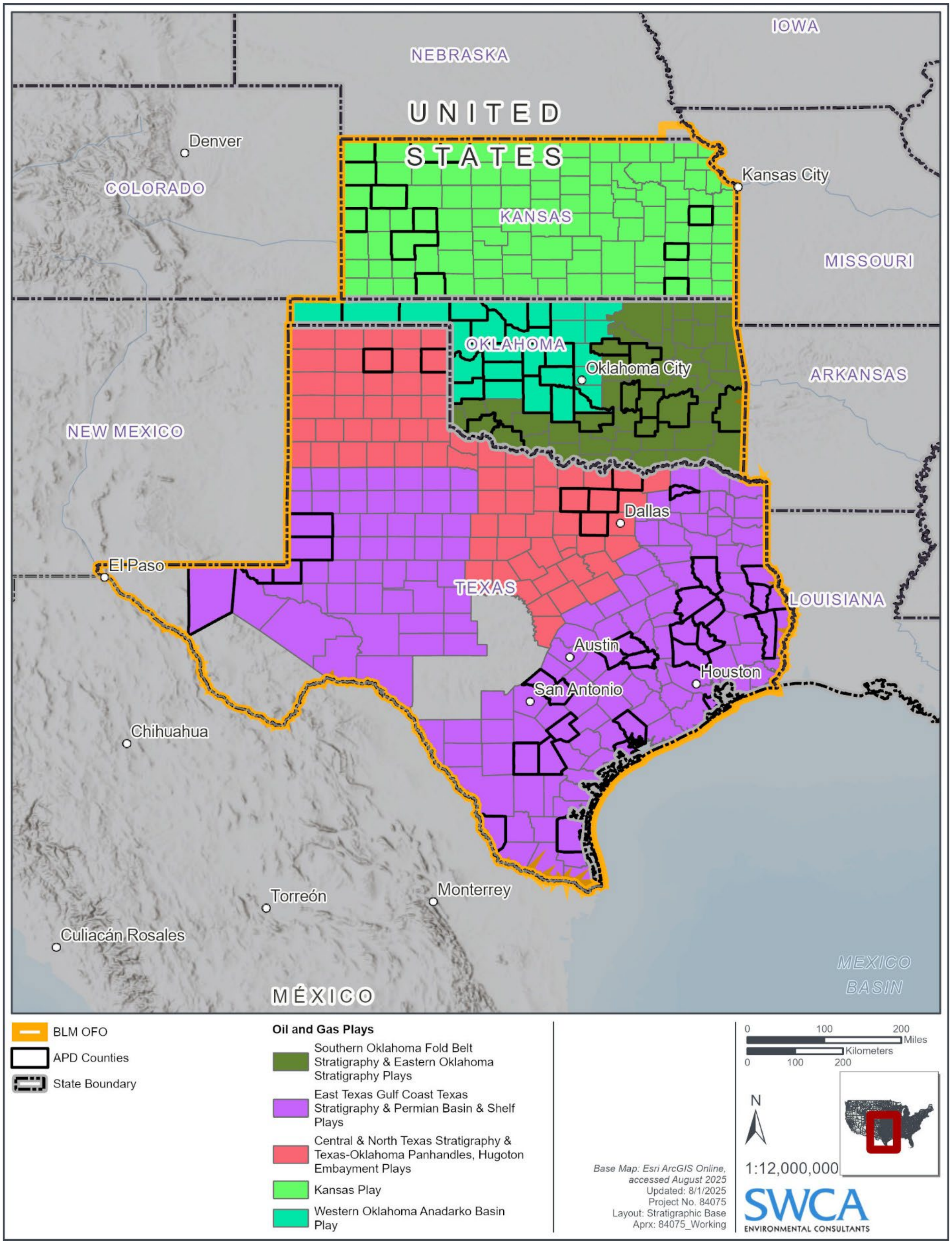


**Figure 1-1. OFO oil and gas plays based on regional stratigraphy.**

# 1.4 DATA SOURCES

An in-depth description of the data sources used in the development of the WSD is presented in the *Data Inventory and Analysis Methodology Memorandum for the Oklahoma Water Support Document,* included as Appendix A. The memorandum details the methodology employed to identify an appropriate spatial scale for the WSD data collection effort and analysis.

## 1.4.1 State and Regional Water Use by Category

Since 1950, the U.S. Geological Survey (USGS) has published a comprehensive report every 5 years that compiles water use data across the United States. The most recent report (Dieter et al. 2018) is the fourteenth circular report published as part of the National Water Census and contains the average daily withdrawals for all 50 states by source (groundwater and surface water), quality (fresh and saline), and category (public supply, domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric power). The mining category includes water used for oil and gas development (such as hydraulic fracturing), as well as quarrying, milling, and other types of mining activities; all mining water is assumed to be self-supplied. Saline water is defined in Dieter et al. (2018:4) as "water containing dissolved solids of 1,000 milligrams per liter or more." Specific to the mining category, nearly all saline water is withdrawn from groundwater sources.

The Dieter et al. (2018) report uses reported, estimated, or calculated water withdrawals to enable the estimation of water use trends and patterns across different geographies and water use categories over time. While the terms "use" and "withdrawal" are sometimes used interchangeably, it is important to recognize that these terms can represent different concepts. "Withdrawals" represent the total amount of water removed from the water source for a particular category of use (e.g., irrigation or mining) regardless of whether the water is consumed, returned, or reused. "Use" either refers to the specific purpose that water is withdrawn for (e.g., domestic, irrigation, or mining) or it refers to the portion of withdrawn water that is actually used for that specific purpose. Further, water use can be either consumptive or non-consumptive. Non-consumptive water use occurs when the water that is withdrawn is eventually returned to the water source after use (e.g., through soil infiltration or release of treated wastewater into a river) and will be available for other subsequent uses. Consumptive water use, however, represents the amount of water that is not returned to the source because it has evaporated, transpired, been incorporated into products or crops, consumed by livestock or humans, or otherwise removed from the immediate water environment. The distinction between consumptive and non-consumptive water use is particularly important when assessing water availability, sustainability, and management practices.

Dieter at al. (2018) uses water withdrawal estimates as a proxy for water use estimates but does not differentiate between consumptive and non-consumptive water use for most categories of water use (with the exceptions being thermoelectric and irrigation) due to resource and data constraints. Although Dieter at al. (2018) does not differentiate between consumptive and non-consumptive water use for the mining category, it is possible that some portion of the water withdrawals for the mining category are used in non-consumptive ways and returned to the source through the injection or beneficial reuse of produced water.

In 2023, the USGS made an update to water usage estimates for the Dieter et al. 2018 water use analysis for the United States. Updates were made to water use estimate categories of public supply water, thermoelectric power, and irrigation water use. The update in 2023 was a reanalysis of water usage for years 2000 to 2020, providing 5 additional years (years 2016 to 2020) to the original 2018 USGS water use data set. The updated water use estimates are delineated at the Hydrologic Unit Code (HUC)-12 boundary level rather than by county as found in the original 2018 USGS report. Due to this variance in reporting between years, and since all categories were not updated in 2024, analysis for the updated years of data has not been included in this WSD. It is expected that new data for all water use categories will be released in September 2025 (self-supplied industrial, domestic, mining, livestock, and aquaculture). The updated USGS water use data will be incorporated into the next update of the OFO Water Support Document (currently planned for 2027) and all analysis will be completed at the HUC-12 level. See Appendix A for details regarding how USGS water use data are obtained, organized, and analyzed for use in this report.

### 1.4.2 FracFocus Data

FracFocus is a national hydraulic fracturing chemical registry managed by the Ground Water Protection Council (GWPC) and Interstate Oil and Gas Compact Commission. FracFocus was initially created to provide a place for publicly available information regarding chemicals used during hydraulic fracturing.

The FracFocus registry is updated throughout each year, and updates may include changes to well data for previous years. To maintain consistency in data included in annual WSD updates, FracFocus data is pulled in May every year. For example, the 2025 WSD includes all data from January 1, 2014, through December 31, 2024. Historic data from FracFocus (from years 2014 to 2023) was then recalculated using the new dataset. Thus, the FracFocus data presented in this WSD for the years 2014–2023 may differ slightly from previous years' Water Support Documents due to updates to historical FracFocus data made throughout 2024. Ingredient disclosure data provides valuable insights into regional trends; however, many chemicals' recordings represent the same chemicals recorded differently (FracFocus 2025). Ingredient names and Chemical Abstracts Service (CAS) numbers are not standardized in FracFocus, leading to widespread differences and discrepancies in CAS numbers, number of disclosures, and ingredient names. For this reason, the values and ingredients presented in Table 2-4 of Section 2.3.3 are for general information only. Appendix A contains information on how FracFocus data are analyzed and summarized. See Appendix A for details regarding how FracFocus data were obtained, organized, and analyzed for use in this report.

### 1.4.3 Spill Data

In Oklahoma, the Oklahoma Corporation Commission (OCC) regulates oil and gas activity and enforces its rules and the state's oil and gas statutes. In addition, OCC manages well production data, permits new wells, ensures that abandoned wells are properly plugged, and manages spills and reported spill data. The data contains reported incidents, reported wildlife casualties, and reported waters impacted. OCC spill reporting does not include sufficient detail to report on quantities of each spill and recovery efforts, reported incidents are based on the number of unique incident identifiers (IDs) during each calendar year. Each reported incident may include an oil spill, a water spill, or both. In the statewide and regional sections of the Oklahoma chapter of this report (see Chapter 2) 2024 spill data from the OCC database (OCC 2024a) are used to evaluate potential impacts to surface water quality from oil and gas development. Spills from oil and gas development can reach surface water directly during the spill event or indirectly through stormwater runoff. Due to many ambiguous or anomalous entries in the OCC dataset, numerical values for each spill and recovery are omitted from this analysis and each record is counted as a distinct spill entry with a non-zero quantity spilled. Additionally, each record includes two binary fields ("yes" or "no") that indicate whether the spill impacted water sources and whether it caused wildlife casualties.

In Kansas, the Kansas Corporation Commission (KCC), is responsible for the management of reported spills and spill data. The statewide water quality sections of the Kansas chapter of this report (see Chapter 3) 2024 spill data from the KCC database (KCC 2025a) are used to evaluate potential impacts to surface water quality from oil and gas development.

The TCEQ manages spills that involve hazardous materials, chemicals, and other pollutants that affect state waters and land, including but not limited to oil-related spills. In the statewide and regional sections of the Texas chapter of this report (see Chapter 4) 2024 spill data from the TCEQ database (TCEQ 2025a) are used to evaluate potential impacts to surface water quality from oil and gas development.

To update the spill data in the WSD, data for the previous year are downloaded in May of the publication year in order to include post-dated entries. For example, this 2025 WSD discusses calendar year 2024 spill data downloaded from the state entity databases. Appendix A contains specific details on how spill data are obtained, organized, and analyzed for use in this report.

## 1.5 UPDATING THE REPORT

During subsequent WSD updates, the list of targeted counties identified in Table 1-1 will be revisited and revised, as needed, to capture any changes in oil and gas developmental trends within the planning area. This 2025 Water Support document includes one county, Tillman County, Oklahoma, not included in the 2024 WSD. It was added to the targeted counties in Oklahoma in 2024 as the result of an APD in Tillman Co. in 2024.

As new data become available throughout the states of Oklahoma, Kansas, and Texas, it will be necessary to update water use (water use by category data from the USGS and FracFocus), spill data (data from the OCC, KCC, and the TCEQ), water quality information, and drought and water availability information included and analyzed throughout this report. Updates to data within this report will also include additional data, updates to the reasonably foreseeable development (RFD), and regional studies and reports as they are made available.

At the time of drafting this 2025 report, updates to the Dieter et al. (2018) water use estimates were published for three out of eight water use categories, including public supply water, thermoelectric power, and irrigation. The updates were made in 2023, including a reanalysis of water use for years 2000 to 2020, providing 5 additional years (years 2016 to 2020) to the original 2018 USGS water use data set. The updated water use estimates for the three categories are delineated at the HUC-12 boundary level rather than by county as found in the original 2018 USGS report. Due to this variance in spatial reporting between years, and since all categories were not updated at the time of developing this WSD, analysis for the updated years and water use categories of data has not been included in this WSD. It is expected that new data for the remaining six water use categories will be released in 2025 (self-supplied industrial, domestic, mining, livestock, and aquaculture) (USGS 2023). The updated USGS water use data will be incorporated into the next WSD, and analyses will be completed at the HUC-12 level through this report. See Appendix A for details regarding how USGS water use data are obtained, organized, and analyzed for use in this 2025 report.

The FracFocus registry is updated throughout each year, and updates may include changes to well data for previous years. To maintain consistency in data included in annual WSD updates, FracFocus data will be pulled during May of each year. This 2025 WSD includes all data from January 1, 2014, through December 31, 2024. The data used for this report were pulled from the FracFocus database during May 2025. Each subsequent iteration of the WSD will incorporate the latest FracFocus data and the previous year’s data will be re-downloaded and reanalyzed to account for changes to well data. Thus, the FracFocus data presented in this WSD for the years 2014–2024 may differ slightly from previous iterations of the WSD due to updates to FracFocus data made throughout 2024.

# 2 OKLAHOMA

This chapter provides an analysis and summary of available water use and water quality data for the state of Oklahoma and its two regional oil and gas plays: 1) the Western Oklahoma Anadarko Basin Stratigraphy and 2) the Southern Oklahoma Fold Belt and Eastern Oklahoma Stratigraphies (see Figure 1-1). The chapter is organized into several sections that address key aspects of water use, planning, and quality across the state and within specific oil and gas plays:

- **Section 2.1:** Offers an overview of the state's water planning process and related documentation.
- **Section 2.2:** Presents estimates for all categories of consumptive water use, such as public water supply, irrigation, and thermoelectric power. This section also addresses water use specific to hydraulic fracturing for the state.
- **Section 2.3:** Discusses issues related to surface water and groundwater quality, including data on spills and the chemical constituents used in hydraulic fracturing for the state.
- **Sections 2.4.1** and **2.5.1** Contains a description of the hydrogeologic setting including major and principal aquifers.
- **Sections 2.4.2** and **2.5.2:** Cover surface water and groundwater quality issues for the oil and gas plays.
- **Sections 2.4.3** and **2.5.3:** Provide estimates for consumptive water use and hydraulic fracturing specific to the two regional oil and gas plays.

## 2.1 STATE OF OKLAHOMA WATER PLANNING AND PERMITTING

The State of Oklahoma's approach to water resources management is primarily guided by the Oklahoma Comprehensive Water Plan (OCWP), developed and managed by the Oklahoma Water Resources Board (OWRB), which provides direction for water management across all categories of water use. The OCWP provides comprehensive water planning regarding supply, 50-year projected demands, projected surface water gaps and groundwater depletions, assessment of infrastructure needs, and analyses of local issues as reported by water experts in every sector for each of Oklahoma's 13 planning regions (OWRB 2012a, 2025a). The current OCWP was published in 2012, and the next iteration of the OCWP is underway; however, as of May 2025, the 2025 OCWP has not been released. However, a factsheet for the 2025 plan is available and presents the three primary topics of the 2025 OCWP as 1) supply and demand as evidenced by synthesis and analysis of water use data and projected population growth, industrial needs, and extreme weather, 2) water supply reliability as related to regional assessments to bolster supply and recommendations for policy adjustments, 3) developing solutions for local water management strategies, policies, infrastructure needs, study needs, and funding gaps (OWRB 2025b).

In Oklahoma, several state agencies play key roles in regulating oil and gas development, protecting groundwater, reporting spills, and managing produced water. At the state level, the OCC is responsible for permitting oil and gas wells in accordance with the Commission's rules under Title 165, Volume 41, Chapter 10. The OCC's Oil and Gas Conservation Division regulates oil and gas development activities—including the operation of injection and disposal wells—under the authority of the Underground Injection Control (UIC) program granted to Oklahoma by the EPA. The EPA provides additional oversight under the Safe Drinking Water Act, particularly for UIC where authority is not delegated to the OCC. Spill data for Oklahoma is maintained by the OCC, with all major and minor release reports (spills) archived in the OCC spills database (OCC 2024b). The OCC also monitors groundwater near oil and gas spill sites and may initiate additional monitoring in response to citizen complaints, helping to ensure the protection of groundwater resources during drilling and production activities.

## 2.2 STATE WATER QUANTITY

### 2.2.1 Surface Water and Groundwater Use

In 2015, the combined fresh and saline water withdrawals for all water use categories across the state of Oklahoma totaled 2,729,536 acre-feet (AF) (Table 2-1, Figure 2-1) (Dieter et al. 2018). Irrigation accounted for the greatest water withdrawals within the state of Oklahoma at 1,042,874 AF (38%) in 2015. Public water supply and industrial water use represented the second and third greatest withdrawal within the state of Oklahoma at 684,676 AF (25%) and 509,247 AF (19%), respectively. Mining operations[2] (this includes oil and gas development, among other mining-related uses) used approximately 215,224 AF of water in 2015, 8% of the total water withdrawal within the state. Of the 215,224 AF of total mining water withdrawal, 178,024 AF (83% of total mining water withdrawal) was via groundwater withdrawals and 37,200 AF (17% of total mining water use) was fresh surface water. Groundwater withdrawals for mining were primarily saline water, which accounted for 97% of all groundwater withdrawals.

Surface water and groundwater withdrawals are almost evenly split, with surface water representing 54% of the total withdrawals and groundwater representing 46% of the total water withdrawals. Irrigation represented the greatest source of groundwater withdrawals at 881,686 AF. Public water sourced approximately 570,156 AF of water from surface water resources, representing the largest source of surface water withdrawals in 2015 (see Table 2-1 and Figure 2-1).

It is important to consider the impacts of groundwater well pumping on surface water availability, especially since Oklahoma uses surface water to meet over half of its water withdrawal demands (Dieter et al. 2018). Groundwater pumping impacts the storage capacity of an aquifer, and this reduction affects groundwater discharge zones, where groundwater naturally flows out of the aquifer, often connecting to surface water bodies like rivers, lakes, and streams. Altering aquifer storage capacity through groundwater pumping can change the local hydraulic gradient, the slope of the water table surface that determines groundwater flow direction and speed, and significant changes in this gradient can reduce groundwater discharge into surface water systems, thereby decreasing surface water availability (Barlow and Leake 2012).

Total annual water use associated with the hydraulic fracturing of oil and gas wells throughout Oklahoma varied from 2014 to 2024, ranging from 16,125.34 AF to 62,993.46 AF (Table 2-2). Between 2017 and 2019, water use was markedly higher than most years, ranging from 50,829.96 AF to 62,993.46 AF, in contrast to other years when hydraulic fracturing water use was less than 33,000 AF. Throughout Oklahoma, most of the wells and associated water use are reported as non-federal and non-tribal; hydraulic fracturing water use for these wells totaled 385,986.4 AF from 2014 to 2024. During the same time period, hydraulic fracturing water use for federal wells and tribal wells totaled 6,067.20 AF and 3,160.30 AF, respectively. Federal hydraulic fracturing water use (6,067.20 AF) represented around 1.62% of the cumulative hydraulic fracturing water use since 2014 (374,265.3 AF), with 225 wells reported from 2014 to 2024. In total, 14,294 wells were reported across Oklahoma from 2014 to 2024 with an average 3-year water use (2022 to 2024) of 39.7 AF per well for hydraulic fracturing water purposes (see Table 2-2) (FracFocus 2025).

[2] Mining water use is defined in Dieter at al. (2018:39) as "…water used for the extraction of minerals and rocks that may be in the form of solids, such as coal, iron, sand, and gravel; liquids, such as crude petroleum; and gases, such as natural gas.
The category includes quarrying, milling of mined materials, injection of water for secondary oil recovery or for unconventional oil and gas recovery (such as hydraulic fracturing), and other operations associated with mining activities."

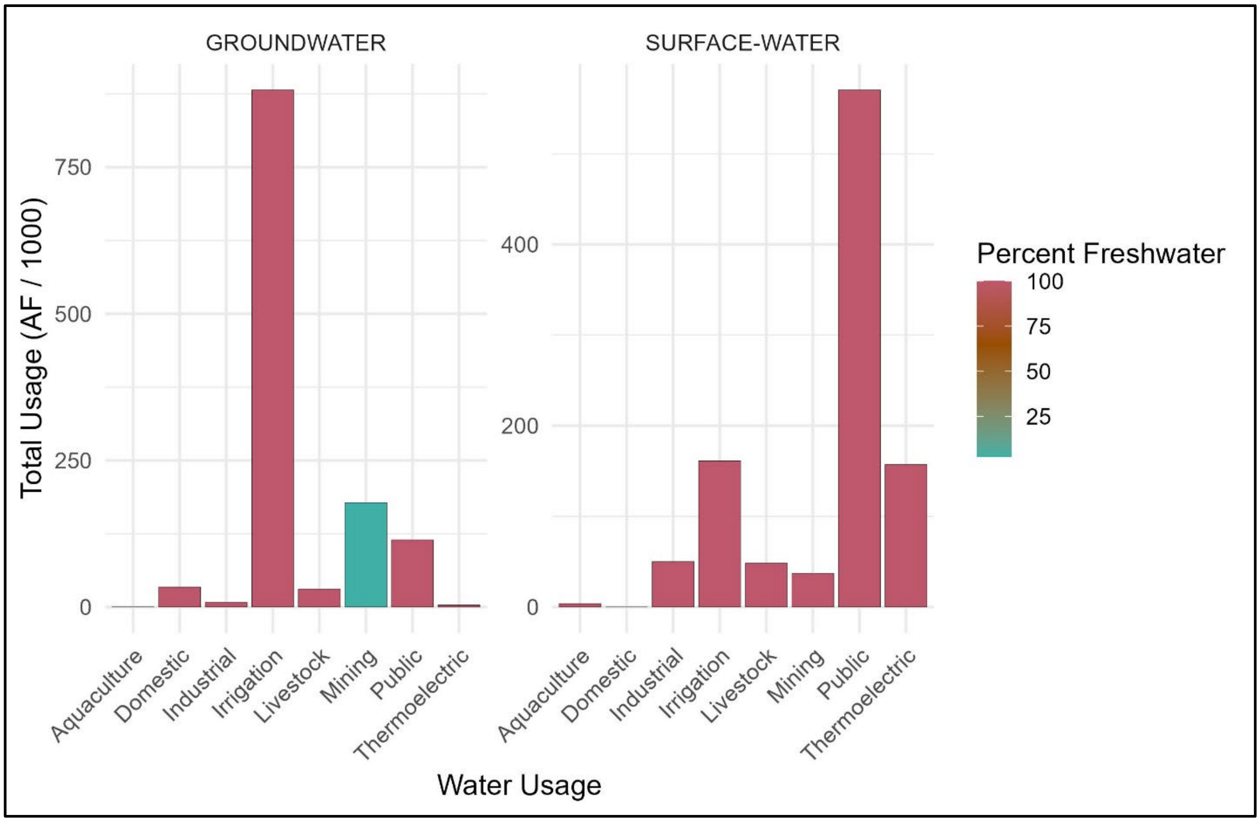


**Figure 2-1. Water withdrawal by category for the state of Oklahoma in 2015, colored by the percentage of freshwater withdrawal out of the total water withdrawal (freshwater plus saline water withdrawal) (Dieter et al. 2018).**

**Table 2-1. State of Oklahoma Water Withdrawal by Category in 2015**

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Total Withdrawal (%) | Saline* | Total Withdrawal (%) | | |
| Aquaculture | 3,618 | 0 | 3,618 | <1% | 67.2 | 0 | 67.2 | <1% | 3,685 | <1% | 0 | 0% | 3,685 | <1% |
| Domestic | 0 | – | 0 | 0% | 33,974 | – | 33,974 | 1% | 33,974 | 2% | – | 0% | 33,974 | 2% |
| Industrial | 50,104 | 0 | 50,104 | 2% | 8,143 | 0 | 8,143 | <1% | 58,247 | 3% | 0 | 0% | 509,247 | 3% |
| Irrigation | 161,188 | – | 161,188 | 7% | 881,686 | – | 881,686 | 39% | 1,042,874 | 46% | – | 0% | 1,042,874 | 46% |
| Livestock | 48,502 | – | 48,502 | 2% | 30,636 | – | 30,636 | 1% | 79,138 | 3% | – | 0% | 79,138 | 3% |
| Mining | 37,200 | 0 | 37,200 | 2% | 4,727 | 173,297 | 178,024 | 8% | 41,927 | 2% | 173,297 | 7% | 215,224 | 9% |
| Public Water Supply | 570,298 | 0 | 570,298 | 25% | 114,378 | 0 | 114,378 | 5% | 684,676 | 30% | 0 | 0% | 684,676 | 30% |
| Thermoelectric Power | 157,156 | 0 | 157,156 | 7% | 3,562 | 0 | 3,562 | <1% | 160,718 | 7% | 0 | 0% | 160,718 | 7% |
| **Total** | **1,028,066** | **0** | **1,028,066** | **45%** | **1,077,173** | **173,297** | **1,250,470** | **55%** | **2,105,239** | **93%** | 173,297 | 7% | **2,729,536** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water withdrawal data are in AF/year unless otherwise indicated.

* Saline water is defined as water containing dissolved solids of 1,000 milligrams per liter (mg/L) or more. Saline water withdrawals are not reported for domestic, irrigation, or livestock water withdrawal (Dieter et al. 2018).

–: no data available

**Table 2-2. Water Use by Oil and Gas Wells for Hydraulic Fracturing and Non-Hydraulic Fracturing in Oklahoma from 2014 through 2024**

| Year | Federal HF Water Use (AF) | Tribal HF Water Use (AF) | Non-Federal/ Non-Tribal HF Water Use* (AF) | Total HF Water Use (AF) | Federal HF Water Use (%) | Federal HF Cumulative Water Use (AF) | Total HF Cumulative Water Use (AF) | Average HF Water Use per Well* (AF) | Total No. of Federal Wells | Total No. of Wells | Total Non-HF Water Use† (AF) | Total Water Use (HF plus non-HF) (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 | 550 | – | 29,824.7 | 30,374.7 | 2% | 550.00 | 30,374.7 | 10.0 | 53 | 3,043 | 2,495.26 | 32,869.96 |
| 2015 | 1,403.7 | 0.1 | 24,044.0 | 25,447.8 | 6% | 1,953.7 | 55,822.5 | 15.2 | 58 | 1,675 | 1,372.68 | 26,820.48 |
| 2016 | 204.0 | 148.9 | 28,906.8 | 29,259.7 | <1% | 2,157.7 | 85,082.20 | 25.7 | 13 | 1,137 | 932.34 | 30,192.04 |
| 2017 | 375.1 | 676.2 | 48,521.6 | 49,572.9 | <1% | 2,532.8 | 134,655.1 | 32.3 | 17 | 1,533 | 1,257.06 | 50,829.96 |
| 2018 | 799.0 | 788.2 | 59,849.9 | 61,437.1 | 1% | 3,331.8 | 196,092.2 | 32.4 | 34 | 1,898 | 1,556.36 | 62,993.46 |
| 2019 | 1,442.2 | 560.3 | 50,786.0 | 52,788.5 | 3% | 4,774.0 | 248,880.7 | 34.2 | 27 | 1,544 | 1,266.08 | 54,054.58 |
| 2020 | 418.1 | – | 15,303.8 | 15,721.9 | 3% | 5,192.1 | 264,602.6 | 32.0 | 7 | 492 | 403.44 | 16,125.34 |
| 2021 | – | – | 19,240.3 | 19,240.3 | – | 5,192.1 | 283,842.9 | 30.5 | – | 631 | 517.42 | 19,757.72 |
| 2022 | 56.9 | 197.5 | 31,717.6 | 31,972.0 | <1% | 5,249.0 | 315,814.9 | 33.3 | 2 | 960 | 787.20 | 32,759.20 |
| 2023 | 531.9 | 230.4 | 29,415.9 | 30,178.2 | 2% | 5,780.9 | 345,993.1 | 38.4 | 10 | 785 | 643.70 | 31,821.90 |
| 2024 | 286.3 | 558.7 | 27,427.2 | 28,272.2 | 1% | 6,067.2 | 374,265.3 | 47.4 | 4 | 597 | 489.54 | 28,761.74 |
| **Total** | **6,067.2** | **3,160.3** | **365,037.8** | **374,265.3** | **2%** | **6,067.2** | **374,265.3** | **39.7‡** | **225** | **14,294** | **11,721.08** | **385,986.38** |

Source: FracFocus (2025). Data only for those wells that reported water use to FracFocus are presented; well data may be incomplete due to state reporting requirements and may not reflect total active wells and exact water use.

Note: Produced water is naturally occurring water that exists in a formation that is being targeted for mineral extraction and is produced as a byproduct.

* Includes both non-federal and non-tribal wells.

† Non-HF water use estimates were calculated using 0.82 AF multiplied by total number of wells.

‡ 3-year average (2022–2024)

–: no data available

HF = hydraulic fracturing; Non-HF = non-hydraulic fracturing

FracFocus reports on water use directly associated with hydraulic fracturing jobs only, which represents the majority of water use per well across the planning area (see Table 2-2). The amount of water used in fracturing operations varies significantly depending on the well configuration (vertical or horizontal), the number of fractured stages, and the specific characteristics of the formation. In vertical wells with a single fractured stage, water use associated with hydraulic fracturing can be less than 50,000 gallons of water per fracture job, or approximately 0.15 AF. In contrast, a multi-stage fracture job in a horizontal well can require several million to tens of millions of gallons or 10 AF to about 150 AF of water (FracFocus 2025). Although direct water usage associated with hydraulic fracturing jobs represents the majority of water usage for well development, there are other direct and indirect types of water use that are not associated with the hydraulic fracturing process (i.e., non-hydraulic fracturing water usage).

FracFocus does not report on non-hydraulic fracturing water use, which primarily includes indirect uses such as water for drilling and other well construction activities. Non-hydraulic fracturing water use represents a small fraction of the total water use per well; however, this amasses to a substantial sum of additional water use across the planning area. Estimates for non-hydraulic fracturing water use are detailed in *Estimates of Water Use Associated with Continuous Oil and Gas Development in the Permian Basin, Texas and New Mexico, 2010–19* (Valder et al. 2021). Valder et al. (2021) characterize non-hydraulic fracturing water uses as either direct or indirect water uses, which are defined as follows:

- **Direct non-hydraulic fracturing water usage:** This includes water used directly in a wellbore for activities such as drilling, cementing, and maintaining the well during production.
- **Indirect non-hydraulic fracturing water usage:** This encompasses water used at or near the well site, including water for dust abatement, equipment cleaning, materials washing, worker sanitation, and site preparation.

Valder et al. (2021) provides the following estimates for direct and indirect non-hydraulic fracturing water use:

- Direct – cementing (0.043 AF per well)
- Direct – drilling (0.439 AF per well)
- Indirect (0.341 AF per well)

Total non-hydraulic fracturing water use is approximately 0.82 AF per well. The value of 0.82 AF per well is an estimate based on the best available data on water use for non-hydraulic fracturing operations. It is intended to serve as a reasonable approximation for estimating water use per well. It is estimated that non-hydraulic fracturing water use in the state of Oklahoma totaled 11,721.08 AF for 14,294 wells between the years 2014 and 2024 (see Table 2-2).

In Oklahoma, total hydraulic fracturing, and non-hydraulic fracturing water use between the years 2014 and 2024 is estimated to be 385,986.4 AF (see Table 2-2). The reported total is an estimation and does not consider variables such as differences in water use between vertical and horizontal wells and local geology; additionally, this total assumes that FracFocus data is accurate and represents the total number of wells across Oklahoma.

### 2.2.2 Produced Water

In 2021, Oklahoma reported a total produced water volume of approximately 1,744,894,591 barrels, as tracked by the OCC. This figure was derived from management practice data, since oil and gas production data provided by the Oklahoma Tax Commission did not distinguish between conventional sources associated with standard vertical drilling and unconventional sources, which typically involve horizontal drilling and hydraulic fracturing. The state had 48,942 hydrocarbon wells producing 148,337,394 barrels of crude oil and 2,544,913 million cubic feet of natural gas. Notably, the largest portion of produced water—about 975,571,994 barrels, or 55.91%—was managed through injection for enhanced oil recovery projects. The remainder was either injected for disposal by operators (30.07%) or handled at commercial facilities (14.01%). No beneficial reuse of produced water was reported in 2021 (GWPC 2021a).

Examining long-term trends, Oklahoma's produced water volumes have fluctuated significantly over the past decade. Between 2012 and 2017, produced water volumes increased by 22%, from 2,325,153,000 barrels to 2,844,485,617 barrels. However, from 2017 to 2021, there was a marked decrease of about 39% in produced water volumes, dropping to 1,744,894,591 barrels. This decline coincided with a substantial reduction in the number of hydrocarbon-producing wells, which fell by approximately 73% (a decrease of 128,508 wells) over the same period, though reporting discrepancies may have contributed to this sharp drop. Despite these changes, Oklahoma ranked fourth in total produced water volume among U.S. states in 2021, highlighting its continued significance in national oil and gas production and water management (GWPC 2021a).

## 2.3 STATE WATER QUALITY

### 2.3.1 Surface Water

In the state of Oklahoma, the ODEQ administers CWA Sections 303(d), 305(b), and 314 related to surface water quality assessment and reporting. The ODEQ defines surface water quality beneficial uses and water quality standards to evaluate if these uses are being attained. The ODEQ prepares an Integrated Report every two years to assess the quality of surface waters, such as rivers, lakes, and streams, and to fulfill federal requirements under the CWA. Data are assessed using criteria established in Oklahoma's water quality standards (Oklahoma Administrative Code 252:730). If a parameter does not meet the water quality standards in a waterbody, the waterbody is considered impaired, the associated beneficial use is classified as "not supporting," and the waterbody is placed on the 303(d) list. The most recent approved Integrated Report was published in 2022 (ODEQ 2022); however, in May 2025, a Draft 2024 Integrated Report was made available by the ODEQ for a 30-day public comment period (ODEQ 2025). Only the ODEQ has the authority to determine use attainment based on water chemistry data; the BLM does not have this jurisdiction.

Within the Draft 2024 Integrated Report for Oklahoma, beneficial uses in Oklahoma are assigned for both rivers and lakes. Uses identified as aesthetic, agriculture, fish consumption, warm water aquatic community, navigation, primary contact, public/private water supply, and emergency water supply are applied to both rivers and lakes (ODEQ 2025). Additionally, cool water aquatic community, habitat limited aquatic community, trout fishery, and secondary body contact uses are identified for rivers.

According to the Draft 2024 Integrated Report, attainment status for each beneficial use is categorized as supporting, not supporting, insufficient information, or not assessed. For lakes across the state, common pollutants include turbidity (63.2% of assessed lakes, affecting 394,178 acres), mercury (63.7%, 397,223 acres), and dissolved oxygen (27.3%, 170,178 acres). For rivers, top pollutants include *Enterococcus* (4.8% of assessed rivers, affecting 7,993 miles), *Escherichia coli* (3.1%, 5,209 miles), and turbidity (2.9%, 4,850 miles) ((ODEQ 2025); OWRB 2012b). Several sources are identified as potential contributors to water quality degradation, including mine tailings, grazing, septic systems, wildlife waste, pet waste, animal feeding operations, non-construction-related runoff, and petroleum/natural gas activities (EPA 2024a).

### 2.3.2 Groundwater

The OWRB defines a major groundwater basin as a distinct underground body of water with consistent geological and hydrological characteristics, where wells yield at least 50 gallons per minute on average from bedrock aquifers or 150 gallons per minute from alluvium and terrace aquifers. Basins that do not meet these criteria are classified as minor groundwater basins. Oklahoma has 21 major and approximately 150 minor groundwater basins (ODEQ 2022). The state also classifies groundwater uses based on total dissolved solids (TDS): groundwater with TDS less than 3,000 milligrams per liter (mg/L) is suitable for drinking, agriculture, and industry, while groundwater with TDS between 3,000 and 10,000 mg/L is primarily used for agriculture and industrial purposes (ODEQ 2025).

The OCC monitors groundwater near oil and gas spill sites and may monitor in response to citizen complaints. To investigate possible groundwater pollution, samples may be collected from domestic wells, existing monitoring wells, springs, and other sources. These samples are tested for a variety of parameters that could include TDS, chlorides, sulfates, petroleum, and metals. The levels and location of contaminants will determine necessary actions to be taken to reduce pollution; however, because sampling often targets specific issues rather than providing a general overview, it may not fully represent statewide groundwater quality. The OWRB has also conducted statewide monitoring of samples of ambient groundwater quality across the state since 1937 (ODEQ 2025). They have an active statewide network of approximately 800 wells to assess long-term trends in groundwater quality, levels, and aquifers storage (ODEQ 2025).

The 2024 Draft Integrated Report provides a list of major and minor aquifers that are experiencing degraded water quality due to anthropogenic activities. Table 2-3 presents 16 major aquifers and seven minor aquifers and their associated water quality concerns. Agricultural activities, such as fertilizer application and animal feedlots, are the primary causes of groundwater quality degradation in Oklahoma, although other factors such as mining and natural processes also impact some aquifers (Table 2-3). Other contributing sources include drainage wells, storage tanks, waste piles, injection wells, septic systems, hazardous waste sites, mining, spills, and urban runoff. Notably, oil and gas activities are listed as a source of degradation for only one aquifer (ODEQ 2025).

**Table 2-3. Major and Minor Aquifers with Water Quality Degradation**

| Aquifer | Aquifer Type | Primary Water Quality Concern | Potential Source of Degradation |
|---|---|---|---|
| Alluvium and terrace deposits of the Salt Fork of the Arkansas River | Major | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Alluvium and terrace deposits of the Arkansas River | Major | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Alluvium and terrace deposits of the Enid isolated terrace deposits | Major | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Alluvium and terrace deposits of the Cimarron River | Major | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Alluvium and terrace deposits of the Beaver-North Canadian River | Major | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Alluvium and terrace deposits of the Canadian River | Major | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Alluvium and terrace deposits of the Washita River | Major | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Alluvium and terrace deposits of the North Fork of the Red River | Major | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |

| Aquifer | Aquifer Type | Primary Water Quality Concern | Potential Source of Degradation |
|---|---|---|---|
| Alluvium and terrace deposits of the Red River | Major | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Ogallala Formation | Major | Nitrate, selenium | Nitrate: Agricultural activities (animal feedlots, fertilizer application), septic systems<br>Selenium: Naturally occurring |
| Antlers Sandstone | Major | Nitrate, low pH | Nitrate: Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Rush Springs Sandstone | Major | Nitrate, hydrocarbons, chloride | Historic oil and gas activities |
| Garber Sandstone and Wellington formations | Major | Gross alpha, selenium, industrial solvents, nitrate, chloride, arsenic | Gross alpha: Naturally occurring<br>Selenium: Naturally occurring<br>Nitrate: Agricultural activities (animal feedlots, fertilizer application), septic systems<br>Arsenic: Naturally occurring |
| Roubidoux Formation | Major | Iron, sulfate, TDS | Mine water contamination |
| Vamoosa Formation | Major | Fluoride, chloride | Naturally occurring |
| The Arbuckle Formation | Major | Fluoride, hardness | Naturally occurring |
| The Boone Formation/Boone Chert/Keokuk and Reeds Springs formations | Minor | Low pH, heavy metals | Historic mining |
| The Oscar "A" Formation | Minor | Nitrate, gross alpha | Nitrate: Agricultural activities (animal feedlots, fertilizer application), septic systems<br>Gross alpha: Naturally occurring |
| McAlester and Hartshorne formations–Savanna Formation/McAlester Formation/Hartshorne Sandstone Formation | Minor | Low pH, heavy metals, chlorides, industrial waste | Historic mining |
| Walnut Creek alluvium deposits | Minor | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| Tillman terrace deposits | Minor | Nitrate, selenium | Nitrate: Agricultural activities (animal feedlots, fertilizer application), septic systems<br>Selenium: Naturally occurring |
| Little Sandy Creek alluvium deposits | Minor | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |
| West Cache Creek terrace | Minor | Nitrate | Agricultural activities (animal feedlots, fertilizer application), septic systems |

Source: ODEQ (2025)

### 2.3.3 Potential Sources of Contamination

Oil and gas development spills have the potential to impact surface water directly by inadvertent discharge into a waterbody or indirectly by surface runoff, soil contamination, and ensuing transport during rainfall, or migration into groundwater and subsequent discharge from a spring into surface water. The chemical composition of water used during the hydraulic fracturing process varies due to differences in fracturing techniques used by oil and gas companies. A typical oil/gas well uses approximately 20 to 25 unique chemicals during the hydraulic fracturing process, but in some cases, more than 60 distinct chemicals can be used.

According to FracFocus, from 2014 through 2024, most entries (64,224) did not include an ingredient name, CAS number, or volume used, but were still entered into the FracFocus registry as unnamed ingredients used for some purpose during the hydraulic fracturing process. For the purpose of this report, these entries that lack any details on ingredient names or volumes are referred to as “unnamed” ingredients. Unnamed ingredients represented 11.51% of all FracFocus entries from 2014 through 2024; however, given that they do not have reported volumes, it is unknown what percentage of the total hydraulic fracturing jobs (volume by percent mass) they represent. Unnamed ingredients are distinct from those reported as “proprietary,” which may lack details on specific chemical constituents, but still include information on suppliers, trade names, chemical properties (e.g., additives or mass), and reported volumes used for hydraulic fracturing. Proprietary disclosures have been grouped into a single ingredient category in Table 2-4.

Not including unnamed ingredients, water is the most commonly disclosed ingredient in hydraulic fracturing operations with 54,336 entries, representing 9.74% of all FracFocus entries and 21.13% of the total hydraulic fracturing jobs (chemical volume by percentage mass) from 2014 through 2024. Methanol (23,692 disclosures), isopropanol (11,242 disclosures), and crystalline silica (11,226 disclosures) represent the next most commonly reported chemicals constituents of hydraulic fracturing operations (see Table 2-4). In total, 557,917 unique chemical constituent disclosures in Oklahoma were entered in the FracFocus database (FracFocus 2025). For a detailed explanation of how FracFocus data are analyzed and summarized, please refer to Appendix A.

The OCC is responsible for managing water quality concerns related to oil and gas activities and petroleum storage tanks. The OCC monitors soils, well water, and surface water resources at spill sites, other potential pollution sources, and historic oilfield areas to address the impact of both current and historic oil and gas activities on water quality (ODEQ 2025). According to OCC Rule Oklahoma Administrative Code 165:10-7-5, any non-permitted discharge (spill) involving crude oil, condensate, salt water, or drilling mud must be reported to the OCC if it amounts to ten or more barrels on land. Additionally, spills of any quantity that come into contact with water are required to be reported. A verbal spill report must be made to the appropriate OCC District Office or Field Inspector within 24 hours of discovery. For specific reporting requirements and definitions, it is recommended to consult the OCC’s official regulations or contact the agency directly for clarification (OCC 2024b).

Spill data for Oklahoma was retrieved from the OCC (OCC 2024a). The data includes information on the quantity of each reported spill and the amount recovered. The dataset reports do not specify if impacts to waters are surface water or groundwater, suggesting that impacts may be either. However, determining impacts to groundwater likely requires a more comprehensive evaluation of each spill, indicating that spill impacts to waters are most likely surface water impacts. As a result, impacts to groundwater from spills are not readily discernible from the dataset. In total, 38,678 spills were reported to the OCC between 2014 and 2024. Between 2014 and 2024, 1,575 spills (approximately 4% of all reported spills) were documented to have affected groundwater sources, surface water sources, or both. Additionally, spills since 2014 were associated with 22 wildlife casualties. Between 2014 and 2024, 2023 was the highest spill year on record. 2024 saw a slight decrease in spills with 4,112 spills reported. Of these 4,112 spills, 116 (3%) of those affected either surface water or groundwater resources. Estimated quantities of wildlife casualties and waters impacted reported to OCC are included in Table 2-5 (OCC 2024a).

**Table 2-4. Most Frequently Disclosed Ingredients Reported to FracFocus within Oklahoma from 2014 through 2024**

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Entries‡ (%) |
|---|---|---|---|---|
| Unnamed | N/A | 64,224 | Unknown | 11.51 |

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Entries‡ (%) |
|---|---|---|---|---|
| Water | 7732-18-5 | 54,336 | 21.13 | 9.74 |
| Methanol | 67-56-1 | 23,692 | 0.07 | 4.25 |
| Isopropanol | 67-63-0 | 11,242 | 0.04 | 2.01 |
| Crystalline Silica (Quartz) | 14808-60-7 | 11,226 | 7.54 | 2.01 |
| Hydrochloric Acid | 7647-01-0 | 10,035 | 0.50 | 1.80 |
| Sodium Chloride | 7647-14-5 | 9,812 | 0.25 | 1.76 |
| Ethylene Glycol | 107-21-1 | 7,196 | 0.06 | 1.29 |
| Guar Gum | 9000-30-0 | 7,104 | 0.17 | 1.27 |
| Citric Acid | 77-92-9 | 6,309 | 0.04 | 1.13 |
| Ethanol | 64-17-5 | 6,293 | 0.02 | 1.13 |
| Acetic Acid | 64-19-7 | 6,239 | 0.01 | 1.12 |
| Propargyl Alcohol | 107-19-7 | 5,167 | 0.00 | 0.93 |
| 2-Butoxyethanol | 111-76-2 | 5,145 | 0.01 | 0.92 |
| Glutaraldehyde | 111-30-8 | 5,108 | 0.23 | 0.92 |
| Ammonium Chloride | 12125-02-9 | 4,639 | 0.01 | 0.83 |
| Ammonium Persulfate | 7727-54-0 | 4,506 | 0.06 | 0.81 |
| Sodium Hydroxide | 1310-73-2 | 3,418 | 0.01 | 0.61 |
| Sodium Perborate Tetrahydrate | 10486-00-7 | 3,415 | 0.02 | 0.61 |
| Proprietary | N/A | 3,176 | 0.12 | 0.57 |
| Hydrotreated Light Petroleum Distillate | 64742-47-8 | 2,977 | 0.05 | 0.53 |
| Didecyl Dimethyl Ammonium Chloride | 7173-51-5 | 2,735 | 0.06 | 0.49 |
| Carbon-11 to Carbon-14 n-Alkanes (Mixed) | 64742-47-8 | 2,729 | 0.33 | 0.49 |
| Chlorine Dioxide | 10049-04-4 | 2,675 | 0.06 | 0.48 |
| Alcohol Ethoxylate | 68439-50-9 | 2,586 | 0.01 | 0.46 |

Source: FracFocus (2025)

Note: Ingredient names and CAS numbers are not standardized in FracFocus, leading to widespread differences and discrepancies in CAS numbers, number of disclosures, and ingredient names. For this reason, the values and ingredients presented in this table are for general information only.

Table includes only the top 25 most frequently disclosed ingredients, along with their percentages relative to the total list of ingredients; because all ingredients are not listed, percentages will not sum to 100%.

N/A = Not applicable.

* FracFocus lists certain chemicals as proprietary, and no additional information is available regarding ingredient contents.

† The amount of the ingredient in the total hydraulic fracturing volume by percent mass (definition from FracFocus [2025] data dictionary).

‡ Percentage represents the number of documented chemical disclosures out of the total number of disclosures.

### Table 2-5. Summary of Spills in the State of Oklahoma from 2014 through 2024

| Year | Total No. of Wells | Reported Incidents | Reported Wildlife Casualties | Reported Waters Impacted |
|---|---|---|---|---|
| 2014 | 3,043 | 2,960 | 16 | 133 |
| 2015 | 1,675 | 3,148 | 19 | 170 |
| 2016 | 1,137 | 2,796 | 25 | 141 |
| 2017 | 1,533 | 2,876 | 16 | 113 |

| Year | Total No. of Wells | Reported Incidents | Reported Wildlife Casualties | Reported Waters Impacted |
|---|---|---|---|---|
| 2018 | 1,898 | 3,775 | 24 | 155 |
| 2019 | 1,544 | 3,837 | 28 | 220 |
| 2020 | 492 | 3,380 | 21 | 150 |
| 2021 | 631 | 3,644 | 29 | 124 |
| 2022 | 960 | 3,991 | 45 | 107 |
| 2023 | 785 | 4,159 | 31 | 146 |
| 2024 | 597 | 4,112 | 22 | 116 |
| **Total** | **14,294** | **38,678** | **276** | **1,575** |

Source: OCC (2024a)

Note: OCC spill reporting does not include sufficient detail to report on quantities of each spill and recovery efforts. Reported incidents are based on the number of unique incident IDs during each calendar year. Each reported incident may include an oil spill, a water spill, or both.

## 2.4 WESTERN OKLAHOMA ANADARKO BASIN PLAY

This section focuses on the Western Oklahoma Anadarko Basin Play, a region renowned for its extensive oil and gas production from deep, multi-stacked reservoirs. This play spans the following target counties: Alfalfa, Beaver, Beckham, Blaine, Caddo, Canadian, Cimarron, Custer, Dewey, Ellis, Grady, Harper, Kingfisher, Major, McClain, Roger Mills, Woods, and Woodward counties. This section presents water quality and water quantity data for these targeted counties, providing insights into resource demands and management considerations associated with oil and gas development.

### 2.4.1 Hydrogeologic Setting

The Anadarko Basin is a prolific sedimentary basin known for its rich petroleum resources, located primarily in western Oklahoma and extends into parts of Texas, Kansas, and Colorado. This basin is deeply buried, bounded by the Wichita and Amarillo Uplift to the south and the Nemaha Uplift to the east, and was formed during the late Paleozoic as a result of tectonic subsidence (Ball et al. 1991). Historically recognized as a major natural gas province, the basin has also evolved into a key target for oil and condensate production, particularly in the last two decades (Higley et al. 2014). Advances in horizontal drilling and hydraulic fracturing have enabled the development of stacked pay zones (multiple, vertically layered productive reservoir intervals within a single geographic area), most notably in the Woodford Shale, Meramec, Springer, Sycamore, and Goddard formations (Cardott 2017). The Anadarko Basin continues to be a dynamic petroleum province with significant resource potential across a wide range of depths and reservoir types.

Mississippian formations such as the Caney Shale are notable source and reservoir rocks in the region. These formations are typically developed using hydraulic fracturing, a process that demands large volumes of water and generates wastewater requiring proper treatment or disposal (Higley et al. 2014). These important source rocks are overlain by the Arbuckle Group, a thick carbonate formation commonly used for Class II disposal wells in Oklahoma (Murray 2015). Across most of the basin, usable freshwater aquifers, such as the Rush Springs Aquifer or shallow alluvial deposits, are at depths less than approximately 2,000 feet and overlie the oil and gas reservoir rocks in this play. These aquifers are essential for agricultural, municipal, and domestic use, and can easily be contaminated if oil and gas wells are not developed correctly. Proper sealing and casing of all wells is essential to protect these groundwater resources. Understanding the vertical separation between freshwater aquifers and oil- and gas-bearing formations is vital for safeguarding water resources while enabling responsible energy development.

## 2.4.2 Water Quality

According to FracFocus, from 2014 through 2024, most entries (1,162) within the Western Oklahoma Anadarko Basin Play were unnamed (i.e., did not include an ingredient name, CAS number, or volume used, but were still entered into the FracFocus registry as unnamed ingredients used for some purpose during the hydraulic fracturing process). Unnamed ingredients represented 12.74% of all FracFocus entries within the Western Oklahoma Anadarko Basin Play; however, given that they do not have reported volumes, it is unknown what percentage of the total hydraulic fracturing jobs (volume by percent mass) they represent. Unnamed ingredients are distinct from those reported as “proprietary,” which may lack details on specific chemical constituents, but still include information on suppliers, trade names, chemical properties (e.g., additives or mass), and reported volumes used for hydraulic fracturing. Proprietary disclosures have been grouped into a single ingredient category in Table 2-6.

Not including unnamed ingredients, water is the most commonly disclosed ingredient in hydraulic fracturing operations within the Western Oklahoma Anadarko Basin Play with 912 entries, representing 10.0% of all FracFocus entries and 27% of the total hydraulic fracturing jobs (chemical volume by percentage mass) from 2014 through 2024. Methanol (336 disclosures), crystalline silica (196 disclosures), and hydrochloric acid (181 disclosures) represent the next most commonly reported chemical constituents of hydraulic fracturing operations (see Table 2-6) (FracFocus 2025). For a detailed explanation of how FracFocus data are analyzed and summarized, please refer to Appendix A.

**Table 2-6. Most Frequently Disclosed Ingredients Reported to FracFocus for Targeted Counties within Western Oklahoma Anadarko Basin Play from 2014 through 2024**

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Entries‡ (%) |
|---|---|---|---|---|
| Unnamed | N/A | 1,162 | Unknown | 12.74 |
| Water | 7732-18-5 | 912 | 27.00 | 10.00 |
| Methanol | 67-56-1 | 336 | 0.21 | 3.68 |
| Crystalline Silica (Quartz) | 14808-60-7 | 196 | 9.36 | 2.15 |
| Hydrochloric Acid | 7647-01-0 | 181 | 0.49 | 1.98 |
| Isopropanol | 67-63-0 | 151 | 0.10 | 1.65 |
| Sodium Chloride | 7647-14-5 | 132 | 0.44 | 1.45 |
| Acetic Acid | 64-19-7 | 125 | 0.00 | 1.37 |
| Guar Gum | 9000-30-0 | 112 | 0.13 | 1.23 |
| Ethanol | 64-17-5 | 107 | 0.01 | 1.17 |
| Ethylene Glycol | 67-63-0 | 102 | 0.01 | 1.12 |
| Citric Acid | 77-92-9 | 101 | 0.11 | 1.11 |
| Glutaraldehyde | 111-30-8 | 96 | 0.11 | 1.05 |
| Propargyl Alcohol | 107-19-7 | 86 | 0.00 | 0.94 |
| 2-Butoxyethanol | 111-76-2 | 84 | 0.00 | 0.92 |
| Ammonium Chloride | 12125-02-9 | 82 | 0.00 | 0.90 |
| Ammonium Persulfate | 7727-54-0 | 81 | 0.02 | 0.89 |
| Sodium Perborate Tetrahydrate | 10486-007 | 80 | 0.02 | 0.88 |
| Didecyl Dimethyl Ammonium Chloride | 7173-51-5 | 76 | 0.03 | 0.83 |

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Entries‡ (%) |
|---|---|---|---|---|
| Proprietary | N/A | 58 | 0.03 | 0.64 |
| Chlorine Dioxide | 10049-04-4 | 56 | 0.01 | 0.61 |
| Sodium Hydroxide | 1310-73-2 | 48 | 0.00 | 0.53 |
| Hydrotreated Light Petroleum Distillate | 64742-47-8 | 43 | 0.02 | 0.47 |
| Ethoxylated Alcohols | 68439-50-9 | 39 | 0.76 | 0.43 |
| Sodium Persulfate | 7775-27-1 | 39 | 0.00 | 0.43 |

Source: FracFocus (2025)

Note: Ingredient names and CAS numbers are not standardized in FracFocus, leading to widespread differences and discrepancies in CAS numbers, number of disclosures, and ingredient names. For this reason, the values and ingredients presented in this table are for general information only.
The data summarized in this table represent the targeted counties, listed in Section 1.2, within the boundary of the Western Oklahoma Anadarko Basin Play. Table includes only the top 25 most frequently disclosed ingredients, along with their percentages relative to the total list of ingredients; because all ingredients are not listed, percentages will not sum to 100%

N/A = Not applicable.

* FracFocus lists certain chemicals as proprietary, and no additional information is available regarding ingredient contents.

† The amount of the ingredient in the total hydraulic fracturing volume by percent mass (definition from FracFocus [2025] data dictionary).

‡ Percentage represents the number of documented chemical disclosures out of the total number of disclosures.

Spill data for Western Oklahoma Anadarko Basin Play was retrieved from the OCC (OCC 2025) and can be found in Table 2-7. Since 2014, 9,900 spill incidents have been reported. Of the 9,900 spills, 64 have resulted in wildlife casualties, and 275 waters were reported to be impacted. The peak year for reported incidents (1,167), wildlife casualties (12), and impacted waters (26) was in 2022. Spills in 2024 decreased from 2023 by 63 for a total of 815, wildlife casualty-associated spills were halved to five, and impacted waters decreased from 38 in 2023 to 18 in 2024.

**Table 2-7. Summary of Spills in the Western Oklahoma Anadarko Basin Play**

| Year | Total No. of Wells | Reported Incidents | Reported Wildlife Casualties | Reported Waters Impacted |
|---|---|---|---|---|
| 2014 | 1,389 | 794 | 4 | 18 |
| 2015 | 881 | 910 | 5 | 16 |
| 2016 | 779 | 716 | 9 | 21 |
| 2017 | 1,098 | 880 | 2 | 20 |
| 2018 | 1,424 | 1,103 | 4 | 37 |
| 2019 | 1,081 | 998 | 2 | 34 |
| 2020 | 311 | 662 | 3 | 20 |
| 2021 | 394 | 977 | 8 | 27 |
| 2022 | 597 | 1,167 | 12 | 26 |
| 2023 | 514 | 878 | 10 | 38 |
| 2024 | 412 | 815 | 5 | 18 |
| **Total** | 8,880 | **9,900** | **64** | **275** |

Source: OCC (2025)

Note: OCC spill reporting does not include sufficient detail to report on quantities of each spill and recovery efforts. Reported incidents are based on the number of unique incident IDs during each calendar year. Each reported incident may include an oil spill, a water spill, or both. The data summarized in this table represent the targeted counties, listed in Section 1.2, within the boundary of the Western Oklahoma Anadarko Basin Play

### 2.4.3 Water Quantity

In 2015, the combined fresh and saline water withdrawals for all water use categories in the Western Anadarko Basin Play totaled 565,201 AF (Table 2-8, Figure 2-2) (Dieter et al. 2018). Of the 565,201 AF, 448,137 AF or 79% of total water withdrawal in the Anadarko Basin Play was used for irrigation purposes in 2015 which was also top consumer of both groundwater and surface water. Other categories are nominal in comparison with the second largest user being public water withdrawal at 45,702 AF or 8%. In addition to mining withdrawal being the third largest consumer at 32,607 AF or 6%, it was also the exclusive user of saline groundwater and the second largest consumer of fresh surface water. In 2015, livestock used 23,053 AF or 4% of the total water in this region. All other uses such as domestic, thermoelectric power, industrial, and aquaculture used 1% or less of the total water.

Total annual water use associated with hydraulic and non-hydraulic fracturing of oil and gas wells in the Western Anadarko Basin Play totaled 285,579 AF from 2014 to 2024 (Table 2-9) (FracFocus 2025). Water use for hydraulic fracturing in 2024 was 1,788 AF less than 2023 and was reported as 20,702.10 AF. While there are no observable data trends in water use for hydraulic fracturing from 2014 to 2024, peak use was in 2018 at 49,712.6 AF and has since decreased significantly, with decreases in hydraulic fracturing water use between 17% to 75% from 2018 water use values. Water use for non-hydraulic fracturing also peaked in 2018 at a value 1,167.68 AF and has been declining since. The lowest recorded value for this category was 337.84 AF in 2024. Along with 2018 having the highest non-hydraulic and hydraulic fracturing water use, it also had the highest number of wells at 1,424 which starkly contrasts with the number of wells in 2024 which was recorded as 412.

Total non-hydraulic fracturing water use is approximately 0.82 AF per well. The value of 0.82 AF per well is an estimate developed using the best available data on non-hydraulic fracturing water use and serves to provide an estimate by which an approximation can be derived. It is estimated that non-hydraulic fracturing water use in the Western Anadarko Basin Play totaled 7,281.6 AF for 8,880 wells between the years 2014 and 2024 (see Table 2-9).

The reported totals outlined in this summary are estimations and do not consider variables such as differences in water use between vertical and horizontal wells and local geology; additionally, these totals assumes that FracFocus data is accurate and represents the total number of wells in the region of interest.

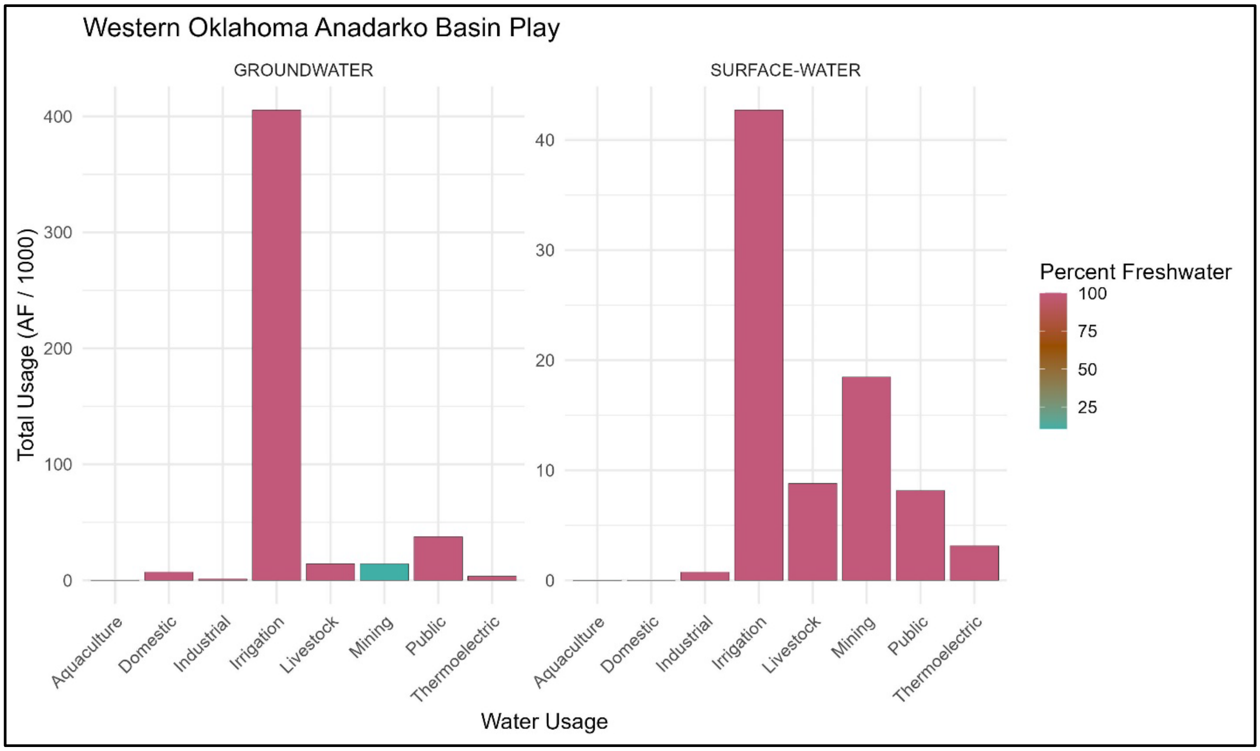


**Figure 2-2. Water withdrawal by category for targeted counties in Western Oklahoma Anadarko Basin Play in 2015, colored by the percentage of freshwater withdrawal out of the total water withdrawal (freshwater plus saline water withdrawal) (Dieter et al. 2018).**

**Table 2-8. Targeted Counties within the Western Oklahoma Anadarko Basin Play Water Withdrawal by Category in 2015**

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Withdrawal (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Total Withdrawal (%) | Saline* | Total Withdrawal (%) | | |
| Aquaculture | 22 | – | 22 | <1% | 0 | – | 0 | <1% | 22 | <1% | 0 | <1% | 22 | <1% |
| Domestic | 0 | – | 0 | <1% | 7,135 | – | 7,135 | 1% | 7,135 | 1% | 0 | <1% | 7,135 | 1% |
| Industrial | 750 | – | 750 | <1% | 1,087 | – | 1,087 | <1% | 1,837 | <1% | 0 | <1% | 1,837 | <1% |
| Irrigation | 42,722 | – | 42,722 | 8% | 405,424 | – | 405,424 | 72% | 448,147 | 79% | 0 | <1% | 448,147 | 79% |
| Livestock | 8,793 | – | 8,793 | 2% | 14,259 | – | 14,259 | 3% | 23,053 | 4% | 0 | <1% | 23,053 | 4% |
| Mining | 18,471 | – | 18,471 | 3% | 1,512 | 12,624 | 14,136 | 3% | 19,983 | 4% | 12,624 | 2% | 32,607 | 6% |
| Public Water Supply | 8,155 | – | 8,155 | 1% | 37,547 | – | 37,547 | 7% | 45,702 | 8% | 0 | <1% | 45,702 | 8% |
| Thermoelectric Power | 3,136 | – | 3,136 | <1% | 3,562 | – | 3,562 | <1% | 6,698 | 1% | 0 | <1% | 6,698 | 1% |
| **Total** | **82,049** | **–** | **82,049** | **15%** | **470,526** | **12,624** | **483,150** | **85%** | **552,577** | **98%** | **12,624** | **2%** | **565,201** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water withdrawal data are in AF/year unless otherwise indicated. The data summarized in this table represent the targeted counties, listed in Section 1.2, within the boundary of the Western Oklahoma Anadarko Basin Play.

* Saline water is defined as water containing dissolved solids of 1,000 mg/L or more. Saline water withdrawals are not reported for domestic, irrigation, or livestock water withdrawal (Dieter et al. 2018).

–: no data available

**Table 2-9. Water Use by Oil and Gas Wells for Hydraulic Fracturing and Non-Hydraulic Fracturing for Targeted Counties in the Western Oklahoma Anadarko Basin Play from 2014 through 2024**

| Year | Federal HF Water Use (AF) | Tribal HF Water Use (AF) | Non-Federal/ Non-Tribal HF Water Use* (AF) | Total HF Water Use (AF) | Federal HF Water Use (%) | Federal HF Cumulative Water Use (AF) | Total HF Cumulative Water Use (AF) | Average HF Water Use per Well* (AF) | Total No. of Federal Wells | Total No. of Wells | Total Non-HF Water Use† (AF) | Total Water Use (HF plus non-HF) (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 | 104.1 | – | 14,143 | 14,247.2 | 1% | 104.1 | 14,247.2 | 10.3 | 22 | 1,389 | 1,138.98 | 15,386.18 |
| 2015 | 1,273.7 | 0.1 | 13,867 | 15,141.0 | 8% | 1,377.8 | 29,388.2 | 17.2 | 47 | 881 | 722.42 | 15,863.42 |
| 2016 | 74.2 | 137.6 | 23,406 | 23,617.5 | 0% | 1,452.0 | 53,005.7 | 30.3 | 5 | 779 | 638.78 | 24,256.28 |
| 2017 | 375.1 | 675.7 | 38,677 | 39,727.8 | 1% | 1,827.1 | 92,733.5 | 36.2 | 17 | 1,098 | 900.36 | 40,628.16 |
| 2018 | 569.2 | 788.2 | 48,355 | 49,712.6 | 1% | 2,396.3 | 142,446.1 | 34.9 | 20 | 1,424 | 1,167.68 | 50,880.28 |
| 2019 | 1,174.1 | 513.7 | 39,448 | 41,135.5 | 3% | 3,570.4 | 183,581.6 | 38.1 | 23 | 1,081 | 886.42 | 42,021.92 |
| 2020 | 418.1 | – | 12,417 | 12,834.9 | 3% | 3,988.5 | 196,416.5 | 41.3 | 7 | 311 | 255.02 | 13,089.92 |
| 2021 | – | – | 14,101 | 14,101.4 | – | 3,988.5 | 210,517.9 | 35.8 | – | 394 | 323.08 | 14,424.48 |
| 2022 | 56.9 | 197.5 | 24,333 | 24,587.2 | 0% | 4,045.4 | 235,105.1 | 41.2 | 2 | 597 | 489.54 | 25,076.74 |
| 2023 | 404.9 | 230.4 | 21,855 | 22,490.1 | 2% | 4,450.3 | 257,595.2 | 43.8 | 8 | 514 | 421.48 | 22,911.58 |
| 2024 | 286.3 | 558.7 | 19,857 | 20,702.1 | 1% | 4,736.6 | 278,497.3 | 50.2 | 4 | 412 | 337.84 | 21,039.94 |
| **Total** | **4,736.6** | **3,101.9** | **270,458.8** | **278,297.3** | **2%** | **4,736.6** | **278,297.3** | **45.1‡** | **155** | **8,880** | **7,281.60** | **285,578.90** |

Source: FracFocus (2025). Data only for those wells that reported water use to FracFocus are presented; well data may be incomplete due to state reporting requirements and may not reflect total active wells and exact water use.

Note:. Produced water is naturally occurring water that exists in a formation that is targeted for mineral extraction and is produced as a byproduct. The data summarized in this table represent the targeted counties, listed in Section 1.2, within the boundary of the Western Oklahoma Anadarko Basin Play

* Includes both non-federal and non-tribal wells.

† Non-HF water use estimates were calculated using 0.82 AF multiplied by total number of wells.

‡ 3-year average (2022–2024)

–: no data available

HF = hydraulic fracturing; Non-HF = non-hydraulic fracturing

# 2.5 SOUTHERN OKLAHOMA FOLD BELT AND EASTERN OKLAHOMA PLAY

This section examines key oil and gas plays within the Southern Oklahoma Fold Belt and Eastern Oklahoma regions, which are characterized by complex geologic structures and significant hydrocarbon production. These plays extend across Coal, Creek, Garvin, Hughes, Jackson, Le Flore, Payne, Pittsburg, Seminole, and Tillman counties. This section presents water quality and water quantity data for these targeted counties, providing insights into resource demands and management considerations associated with oil and gas development.

## 2.5.1 Hydrogeologic Setting

Southern and eastern Oklahoma are home to two of the state's most significant oil and gas plays: the Southern Oklahoma Fold Belt (SOFB) and the Arkoma Basin. Both regions have a rich and complex history of hydrocarbon development that is closely intertwined with water resource management challenges and opportunities.

The SOFB, encompassing 11 counties, emerged as a major oil and gas province in the early 1910s, with initial commercial production occurring in fields such as Redden and McGee Valley (USGS 1987). The region's petroleum resources are largely attributed to tectonic activity, which created conduits for petroleum migration and accumulation. Source rocks in the SOFB include the Woodford Shale, Caney Shale, and the Spring Formation (Henry 1988). Despite its prolific history, recent development in the SOFB has been relatively constrained due to the area's structural complexity, deep drilling requirements, and limited infrastructure (USGS 1987).

Water management in the SOFB is shaped by the presence of several major aquifers. The province contains two alluvial aquifers—the Red River and Washita River aquifers—and two bedrock aquifers—the Arbuckle-Simpson and Antlers aquifers (OWRB n.d.; Henry 1988). The Red River Aquifer, particularly the reach in the southeastern corner of Oklahoma, consists of quaternary alluvial sands, silts, clays, and gravels underlain by Cretaceous and Permian-age bedrock (OWRB 2025c). The Arbuckle-Simpson Aquifer, spanning approximately 520 square miles in the uplifted Arbuckle Mountains, and the Cretaceous Antlers Aquifer, which becomes confined beneath the Goodland-Walnut clay unit, both serve as critical water sources for the region (Fetkovich et al. 2025; Rogers et al. 2023). Oil and gas development in the SOFB has the potential to impact these aquifers through increased water demand for drilling and hydraulic fracturing as well as risks associated with produced water disposal and potential contamination.

In contrast, the Arkoma Basin in eastern Oklahoma has supported continuous hydrocarbon production for over a century. This region is geologically defined by three provinces: the Ozark Uplift, the Arkoma Basin itself, and the Ouachita Mountain Uplift. The Arkoma Basin, a Pennsylvanian-age sedimentary foreland basin, formed as a result of subsidence and high sedimentation rates related to orogenic activity in the Ouachita Mountains (Fay et al. 1979). The Arkoma Basin is the primary source of petroleum, natural gas, and coal in eastern Oklahoma, with development shifting over time from shallow anticlinal traps to deeper Pennsylvanian-age sandstone reservoirs.

Major aquifers in the Arkoma Basin region include the Roubidoux and Arkansas River aquifers (OWRB n.d.). The Roubidoux aquifer, composed of cherty dolomite with sandstone interbeds, provides high yields of 100–1,000 gallons per minute (Christenson et al. 1990). The Arkansas River Aquifer is a productive alluvial aquifer that supplies over 100 gallons per minute in most areas and supports irrigation, public supply, and domestic use (OWRB 2025d).

The long history of oil and gas development in both the SOFB and Arkoma Basin highlights the importance of understanding regional hydrogeology for effective water resource management. Oil and gas operations can place significant demands on local aquifers and pose risks of contamination through drilling, hydraulic fracturing, and produced water disposal.

### 2.5.2 Water Quality

According to FracFocus, from 2014 through 2024, most entries (238) within the SOFB and Eastern Oklahoma Play were unnamed (i.e., did not include an ingredient name, CAS number, or volume used, but were still entered into the FracFocus registry as unnamed ingredients used for some purpose during the hydraulic fracturing process). Unnamed ingredients represented 12.80% of all FracFocus entries within the SOFB and Eastern Oklahoma Play; however, given that they do not have reported volumes, it is unknown what percentage of the total hydraulic fracturing jobs (volume by percent mass) they represent. Unnamed ingredients are distinct from those reported as “proprietary,” which may lack details on specific chemical constituents, but still include information on suppliers, trade names, chemical properties (e.g., additives or mass), and reported volumes used for hydraulic fracturing. Proprietary disclosures have been grouped into a single ingredient category in Table 2-10.

Not including unnamed ingredients, water is the most commonly disclosed ingredients in hydraulic fracturing operations within the SOFB and Eastern Oklahoma Play with 202 entries, representing 10.86% of all FracFocus entries and 24.91% of the total hydraulic fracturing jobs (chemical volume by percentage mass) from 2014 through 2024. Methanol (80 disclosures), crystalline silica (55 disclosures), and isopropanol (53 disclosures) represent the most commonly reported chemical constituents of hydraulic fracturing operations (see Table 2-10) (FracFocus 2025). For a detailed explanation of how FracFocus data are analyzed and summarized, please refer to Appendix A.

**Table 2-10. Most Frequently Disclosed Ingredients Reported to FracFocus in Targeted Counties within the SOFB and Eastern Oklahoma Play from 2014 through 2024**

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Disclosures‡ (%) |
|---|---|---|---|---|
| Unnamed | N/A | 238 | Unknown | 12.80 |
| Water | 7732-18-5 | 202 | 24.91 | 10.86 |
| Methanol | 67-56-1 | 80 | 0.03 | 4.30 |
| Crystalline Silica (Quartz) | 14808-60-7 | 55 | 6.54 | 2.96 |
| Isopropanol | 67-63-0 | 53 | 0.02 | 2.85 |
| Hydrochloric Acid | 7647-01-0 | 44 | 0.30 | 2.37 |
| Sodium Chloride | 7647-14-5 | 27 | 0.19 | 1.45 |
| Hydrotreated Light Petroleum Distillate | 64742-47-8 | 25 | 0.52 | 1.34 |
| Citric Acid | 77-92-9 | 22 | 0.00 | 1.18 |
| Guar Gum | 9000-30-0 | 20 | 0.13 | 1.08 |
| Ethylene Glycol | 107-21-1 | 19 | 0.01 | 1.02 |
| Ammonium Chloride | 12125-02-9 | 18 | 0.00 | 0.97 |
| Ethanol | 64-17-5 | 18 | 0.00 | 0.97 |
| Glutaraldehyde | 111-30-8 | 16 | 0.01 | 0.86 |

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Disclosures‡ (%) |
|---|---|---|---|---|
| Sodium Hydroxide | 1310-73-2 | 16 | 0.00 | 0.86 |
| Propargyl Alcohol | 107-19-7 | 15 | 0.00 | 0.81 |
| Ammonium Persulfate | 7727-54-0 | 14 | 0.01 | 0.75 |
| Acetic Acid | 64-19-7 | 13 | 0.00 | 0.70 |
| Proprietary | N/A | 13 | 0.04 | 0.70 |
| 2-Butoxyethanol | 111-76-2 | 12 | 0.01 | 0.65 |
| Cinnamaldehyde | 104-55-2 | 12 | 0.00 | 0.65 |
| Olefins | Variable | 12 | 0.00 | 0.65 |
| Hydrogen Chloride | 7647-01-0 | 11 | 0.05 | 0.59 |
| Sodium Perborate Tetrahydrate | 10486-00-7 | 11 | 0.01 | 0.59 |
| Acetic Anhydride | 108-24-7 | 10 | 0.01 | 0.54 |

Source: FracFocus (2025)

Note: Ingredient names and CAS numbers are not standardized in FracFocus, leading to widespread differences and discrepancies in CAS numbers, number of disclosures, and ingredient names. For this reason, the values and ingredients presented in this table are for general information only. The data summarized in this table represent the targeted counties, listed in Section 1.2, within the boundary of the SOFB and Eastern Oklahoma Play. Table includes only the top 25 most frequently disclosed ingredients, along with their percentages relative to the total list of ingredients; because all ingredients are not listed, percentages will not sum to 100%.

N/A = Not applicable.

* FracFocus lists certain chemicals as proprietary, and no additional information is available regarding ingredient contents.

† The amount of the ingredient in the total hydraulic fracturing volume by percent mass (definition from FracFocus [2025] data dictionary).

‡ Percentage represents the number of documented chemical disclosures out of the total number of disclosures.

Spill data from the SOFB and Eastern Oklahoma Play was retrieved from the OCC (OCC 2024a). The data included in Table 2-11 includes the number of reported incidents, wildlife casualties, and reported waters impacted. OCC spill reporting does not include sufficient detail to report on quantities of each spill and recovery efforts. Reported incidents are based on the number of unique incident IDs during each calendar year. Each reported incident may include an oil spill, a water spill, or both. Since 2014, 8,683 spills have been reported. Out of those spills, 471 impacted waters and 61 reported wildlife casualties. The peak year for both reported incidents, wildlife casualties, and impacted waters was in 2018, and 2024 had 104 less reported incidents than 2023 totaling 770, three reported wildlife casualties, and 26 reports of impacted waters.

**Table 2-11. Summary of Spills in Targeted Counties in SOFB Stratigraphy and Eastern Oklahoma Stratigraphy Plays from 2014 through 2024**

| Year | Total No. of Wells | Reported Incidents | Reported Wildlife Casualties | Reported Waters Impacted |
|---|---|---|---|---|
| 2014 | 394 | 578 | 4 | 41 |
| 2015 | 272 | 648 | 2 | 45 |
| 2016 | 169 | 655 | 2 | 41 |
| 2017 | 211 | 722 | 3 | 36 |
| 2018 | 206 | 1,022 | 14 | 56 |
| 2019 | 163 | 931 | 8 | 71 |
| 2020 | 46 | 911 | 10 | 54 |
| 2021 | 78 | 842 | 7 | 38 |

| Year | Total No. of Wells | Reported Incidents | Reported Wildlife Casualties | Reported Waters Impacted |
|---|---|---|---|---|
| 2022 | 129 | 730 | 7 | 32 |
| 2023 | 75 | 874 | 1 | 31 |
| 2024 | 60 | 770 | 3 | 26 |
| **Total** | 1,803 | **8,683** | **61** | **471** |

Source: OCC (2025)

Note: OCC spill reporting does not include sufficient detail to report on quantities of each spill and recovery efforts. Reported incidents are based on the number of unique incident IDs during each calendar year. Each reported incident may include an oil spill, a water spill, or both. The data summarized in this table represent the targeted counties, listed in Section 1.2, within the boundary of the SOFB and Eastern Oklahoma Play.

### 2.5.3 Water Quantity

In 2015, the combined fresh and saline water withdrawals for all water use categories within the Southern Oklahoma Fold Belt and Eastern Oklahoma Play totaled 232,867 AF (Table 2-12, Figure 2-3) (Dieter et al. 2018). Irrigation accounted for 108,004 AF (46%) of the total water withdrawals and represented the largest consumer of water in both the total quantity and surface water categories. Public water withdrawal was the second largest user of water at 59,009 AF (25%). Usage for mining purposes made up 33,896 AF (15%) of the total usage and was the only major consumer of saline water. Irrigation was the largest user of groundwater. Water for domestic uses, thermoelectric power, livestock, and aquaculture represented less than 13% of the total water withdrawal.

Total annual water use associated with the hydraulic fracturing of oil and gas wells throughout the Southern Fold Belt and Eastern Oklahoma Play from 2014 to 2024 totaled 47,401.2 AF (Table 2-13; see Figure 2-3). This region has a recorded peak of 7,264.8 AF of total water used for hydraulic fracturing in oil and gas wells in 2018 and displays no obvious trend. 2024 recorded a 599.8 AF increase from 2023 for a total of 3,859.20 AF which is comparable to the value from 2015. Cumulative federal water use for hydraulic fracturing in oil and gas wells has remained relatively stable since 2019 but saw a 127 AF increase from 2022 to 2023 and has remained at 1,094.30 AF since. Water use for non-hydraulic fracturing in oil and gas wells has generally decreased since 2014 excluding a slight rise in 2017. Total water use for both hydraulic fracturing and non-hydraulic fracturing totaled 3,908.40 AF in 2024 which is a slight increase from the 2023 value of 3,320.90 While total water use considering both non-hydraulic fracturing and hydraulic fracturing data displays no temporal trends, the values peaked in 2018 at 7,433.72 AF and have decreased significantly, between 12% and 80% in subsequent years following 2018. The total number of wells used in both hydraulic and non-hydraulic fracturing has steadily decreased since 2014 and has a lowest recorded value of 60 for 2024 which is 15 less than the value for 2023.

Total non-hydraulic fracturing water use is approximately 0.82 AF per well. The value of 0.82 AF per well is an estimate based on the best available data on water use for non-hydraulic fracturing operations. It is intended to serve as a reasonable approximation for estimating water use per well. It is estimated that non-hydraulic fracturing water use in the state of Oklahoma totaled 1,478.46 AF for 1,803 wells between the years 2014 and 2024 (see Table 2-13).

The reported totals outlined in this summary are estimations and do not consider variables such as differences in water use between vertical and horizontal wells and local geology; additionally, this total assumes that FracFocus data is accurate and represents the total number of wells across the SOFB and Eastern Oklahoma Play.

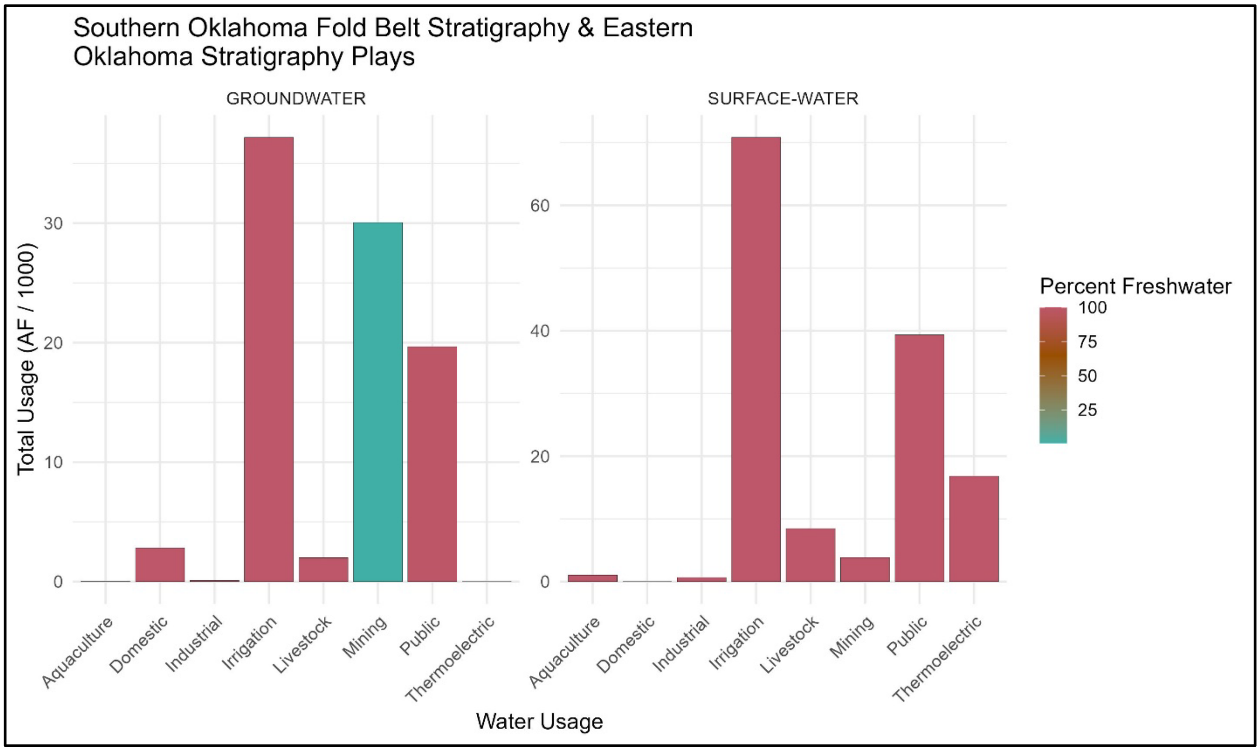


**Figure 2-3. Water withdrawal by category for the SOFB and Eastern Oklahoma Plays in 2015, colored by the percentage of freshwater withdrawal out of the total water withdrawal (freshwater plus saline water withdrawal) (Dieter et al. 2018).**

**Table 2-12. SOFB and Eastern Oklahoma Play Water Withdrawal by Category in 2015**

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Withdrawal (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Total Withdrawal (%) | Saline* | Total Withdrawal (%) | | |
| Aquaculture | 1,031 | – | 1,031 | <1% | 11 | – | 11 | <1% | 1,042 | <1% | – | <1% | 1,042 | <1% |
| Domestic | 0 | – | 0 | <1% | 2,823 | – | 2,823 | 1% | 2,823 | 1% | – | <1% | 2,823 | 1% |
| Industrial | 672 | – | 672 | <1% | 101 | – | 101 | <1% | 773 | <1% | – | <1% | 773 | <1% |
| Irrigation | 70,827 | – | 70,827 | 30% | 37,178 | – | 37,178 | 16% | 108,004 | 46% | – | <1% | 108,004 | 46% |
| Livestock | 8,468 | – | 8,468 | 4% | 2,005 | – | 2,005 | <1% | 10,473 | 4% | – | <1% | 10,473 | 4% |
| Mining | 3,842 | – | 3,842 | 2% | 213 | 29,841 | 30,053 | 13% | 4,055 | 2% | 29,841 | 13% | 33,896 | 15% |
| Public Water Supply | 39,339 | – | 39,339 | 17% | 19,602 | 67 | 19,670 | 8% | 58,942 | 25% | 67 | <1% | 59,009 | 25% |
| Thermoelectric Power | 16,847 | – | 16,847 | 7% | 0 | – | 0 | <1% | 16,847 | 7% | – | <1% | 16,847 | 7% |
| **Total** | **141,026** | **–** | **141,026** | **61%** | **61,933** | **29,908** | **91,841** | **39%** | **202,959** | **87%** | **29,908** | **13%** | **232,867** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water withdrawal data are in AF/year unless otherwise indicated. The data summarized in this table represent the targeted counties, listed in Section 1.2, within the boundary of the SOFB and Eastern Oklahoma Play.

* Saline water is defined as water containing dissolved solids of 1,000 mg/L or more. Saline water withdrawals are not reported for domestic, irrigation, or livestock water withdrawal (Dieter et al. 2018).

–: no data available

**Table 2-13. Water Use by Oil and Gas Wells for Hydraulic Fracturing and Non-Hydraulic Fracturing in SOFB and Eastern Oklahoma Play from 2014 through 2024**

| Year | Federal HF Water Use (AF) | Tribal HF Water Use (AF) | Non-Federal/ Non-Tribal HF Water Use* (AF) | Total HF Water Use (AF) | Federal HF Water Use (%) | Federal HF Cumulative Water Use (AF) | Total HF Cumulative Water Use (AF) | Average HF Water Use per Well* (AF) | Total No. of Federal Wells | Total No. of Wells | Total Non-HF Water Use† (AF) | Total Water Use (HF plus non-HF) (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 | 409.4 | – | 4,187 | 4,596.2 | 9% | 409.4 | 4,596.2 | 11.7 | 24 | 394 | 323.08 | 4,919.28 |
| 2015 | 100.5 | – | 3,690 | 3,790.2 | 3% | 509.9 | 8,386.4 | 13.9 | 5 | 272 | 223.04 | 4,013.24 |
| 2016 | 81.2 | 11.4 | 3,170 | 3,262.6 | 2% | 591.1 | 11,649.0 | 19.3 | 4 | 169 | 138.58 | 3,401.18 |
| 2017 | – | – | 6,431 | 6,430.5 | – | 591.1 | 18,079.5 | 30.5 | – | 211 | 173.02 | 6,603.52 |
| 2018 | 228.7 | – | 7,036 | 7,264.8 | 3% | 819.8 | 25,344.3 | 35.3 | 5 | 206 | 168.92 | 7,433.72 |
| 2019 | 147.5 | 46.6 | 6,178 | 6,371.8 | 2% | 967.3 | 31,718.4 | 39.1 | 2 | 163 | 133.66 | 6,505.46 |
| 2020 | – | – | 1,401 | 1,400.9 | – | 967.3 | 33,117.0 | 30.5 | – | 46 | 37.72 | 1,438.62 |
| 2021 | – | – | 2,542 | 2,542.2 | – | 967.3 | 35,659.2 | 32.6 | – | 78 | 63.96 | 2,606.16 |
| 2022 | – | – | 4,623 | 4,623.4 | – | 967.3 | 40,282.6 | 35.8 | – | 129 | 105.78 | 4,729.18 |
| 2023 | 127.0 | – | 3,123 | 3,259.4 | 4% | 1,094.3 | 43,542.0 | 43.5 | 2 | 75 | 61.50 | 3,320.90 |
| 2024 | – | – | 3,859 | 3,859.2 | – | 1,094.3 | 47,401.2 | 64.3 | – | 60 | 49.20 | 3,908.40 |
| **Total** | **1,094.3** | **58.0** | **46,249** | **47,401.20** | **2%** | **1,094.3** | **547,401.2** | **47.9‡** | **42** | **1,803** | **1,478.46** | **48,879.66** |

Source: FracFocus (2025). Data only for those wells that reported water use to FracFocus are presented; well data may be incomplete due to state reporting requirements and may not reflect total active wells and exact water use.

Note: Produced water is naturally occurring water that exists in a formation that is being targeted for mineral extraction and is produced as a byproduct. The data summarized in this table represent the targeted counties, listed in Section 1.2, within the boundary of the SOFB and Eastern Oklahoma Play.

* Includes both non-federal and non-tribal wells.

† Non-HF water use estimates were calculated using 0.82 AF multiplied by total number of wells.

‡ 3-year average (2021–2024)

–: no data available

HF = hydraulic fracturing; Non-HF = non-hydraulic fracturing

# 3 KANSAS

This chapter contains an analysis and summary of the available water use and water quality data for the state of Kansas that support the evaluation of water resource impacts from oil and gas leasing and development (as described in Chapter 1). Because Kansas is not considered a primary producer of natural gas and oil in this report, separating it into specific regional plays was deemed unnecessary. The chapter is organized into several sections that address key aspects of water use, planning, and quality across the state. State data associated with hydraulic fracturing water use, chemical usage, and oil and gas-related spill incidents are summarized in this chapter. The state of Kansas includes 13 targeted oil and gas counties, including: Cheyenne County, Decatur County, Finney County, Franklin County, Greeley County, Lane County, Logan County, Meade County, Montgomery County, Norton County, Sherman County, and Woodson County. Each county represents either a lease sale or APD county; however, hydraulic fracturing water use reported to FracFocus is negligible when summed across the 13 targeted counties. Therefore, this report does not include a breakdown of water use, chemical usage, or oil and gas-related spill incidents within the 13 targeted counties.

- **Section 3.1:** Presents an overview of the state's water planning process and associated documentation.
- **Section 3.2:** Offers estimates for all categories of consumptive water use (e.g., public water supply, irrigation, thermoelectric power) and contains the summarized FracFocus water use data so that water use from hydraulic fracturing can be compared with statewide water use.
- **Section 3.3:** Presents an overview of water quality for both surface water and groundwater and contains a summary of the chemicals used in hydraulic fracturing that are disclosed to FracFocus.

## 3.1 STATE OF KANSAS WATER PLANNING AND PERMITTING

The State of Kansas's approach to water resources management is primarily guided by the Kansas Water Plan (KWP) developed and managed by the Kansas Water Office (KWO). This plan is a comprehensive guide to water use in all categories. The most recent iteration of the KWP was published in 2022 and was developed as a collaborative effort between several state offices and academic institutions. The KWP is organized around five guiding principles (KWO 2022):

1) Conserve and extend the High Plains aquifer
2) Secure, protect, and restore Kansas reservoirs
3) Improve the state's water quality
4) Reduce vulnerability to extreme events
5) Increase awareness of Kansas water resources

There are 14 regional planning areas in the state, with each area characterized in the KWP by geology, topography, demographics, and consideration of the five guiding principles. The KWP highlights the importance of understanding water use for irrigation, stock water, municipal, recreation, and industrial use. In addition, the report outlines conservation and restoration efforts associated with riparian and wetland health. The plan indicates that agriculture is the largest consumer of water in Kansas, primarily for irrigation, which necessitates efficient practices to reduce wastage and ensure sustainability. The plan also emphasizes the need for accurate data collection and reporting to inform strategic decisions and ensure sustainable water management across all categories. In addition, the Kansas Water Authority, a section of the KWO, develops annual reports on water resources for submission to the Governor and State Legislature. The most recent annual report published in 2025, provides recommendations for state policies, funding updates, KWP status updates as well as aquifer initiatives, water supply and sediment management, water quality initiatives, and other water issues (Kansas Water Authority 2025). The KWP also outlines mining-related issues localized to east-southeast Kansas regarding contaminated surface reservoirs affecting native mussel populations due to lead, zinc, copper, and cadmium contaminants.

In Kansas, water planning and management responsibilities are shared across multiple state agencies. The KWO is the lead agency for water resource planning and policy development and administers the KWP. The KDHE is responsible for implementing water quality protection programs under the CWA, including management of surface water quality standards, impaired waters listings and pollutant load reductions (KDHE 2024a). In addition, KDHE also regulates discharges to waters of the state through permitting and monitoring programs. The KCC regulates oil and gas exploration, well development, and associated water management (KCC 2025b). Within the KCC, the Conservation Division oversees drilling permits, enforces groundwater protection standards during development, and regulates Class II injection wells for produced water disposal under the UIC program (KCC 2025c). The KCC also manages spill reporting and responses and maintains public databases related to oil and gas operations (KCC 2024).

## 3.2 STATE WATER QUANTITY

### 3.2.1 Surface Water and Groundwater Use

In 2015, the combined fresh and saline water withdrawals for all use categories across the state of Kansas totaled 8,417,399 AF (Table 3-1, Figure 3-1) (Dieter et al. 2018). In 2015, the majority of water withdrawals in the state of Kansas come from irrigation, totaling 6,001,610 AF (71% of total withdrawals). Thermoelectric and public water supply represent the second and third greatest withdrawals within the state of Kansas (1,829,663 AF [22%] and 393,338 AF [5%], respectively). Industrial (42,700 AF, 1%), mining (6,710 AF, 0.08%), livestock (116,416 AF, 1%), and aquaculture (7,158 AF, <1%) constituted relatively minor proportions of the cumulative water withdrawals. Groundwater resources totaled 6,056,923 AF (72% of the total water withdrawals) and surface water withdrawals resulted in 2,360,476 AF (28%) of withdrawals. Irrigation represented the greatest source of groundwater withdrawals at 5,729,057 AF (68%) (Dieter et al. 2018). Thermoelectric power withdrawals sourced approximately 1,812,166 AF (22%) of water from surface water resources, representing the largest source of surface water withdrawals in 2015 (see Table 3-1 and Figure 3-1).

Table 3-2 presents 2015 water withdrawal specific to the 13 targeted counties in Kansas. In 2015, water withdrawal in Kansas targeted counties was overwhelmingly driven by irrigation, which accounted for 96% of total usage—primarily sourced from groundwater, totaling 1,226,847 AF (Table 3-2; see Figure 2-3). All other categories each comprised 2% or less of overall withdrawal. Livestock was the second largest water user, consuming 13,767 AF (1%), while mining used only 224 AF in total, drawing from both surface water and groundwater sources.

It is important to consider the impacts of groundwater well pumping on surface water availability. Groundwater pumping impacts the storage capacity of an aquifer. This reduction affects groundwater discharge zones, where groundwater naturally flows out of the aquifer, often connecting to surface water bodies like rivers, lakes, and streams. Altering aquifer storage capacity through groundwater pumping can change the local hydraulic gradient—the slope of the water table surface that determines groundwater flow direction and speed. Significant changes in this gradient can reduce groundwater discharge into surface water systems, thereby decreasing surface water availability (Barlow and Leake 2012).

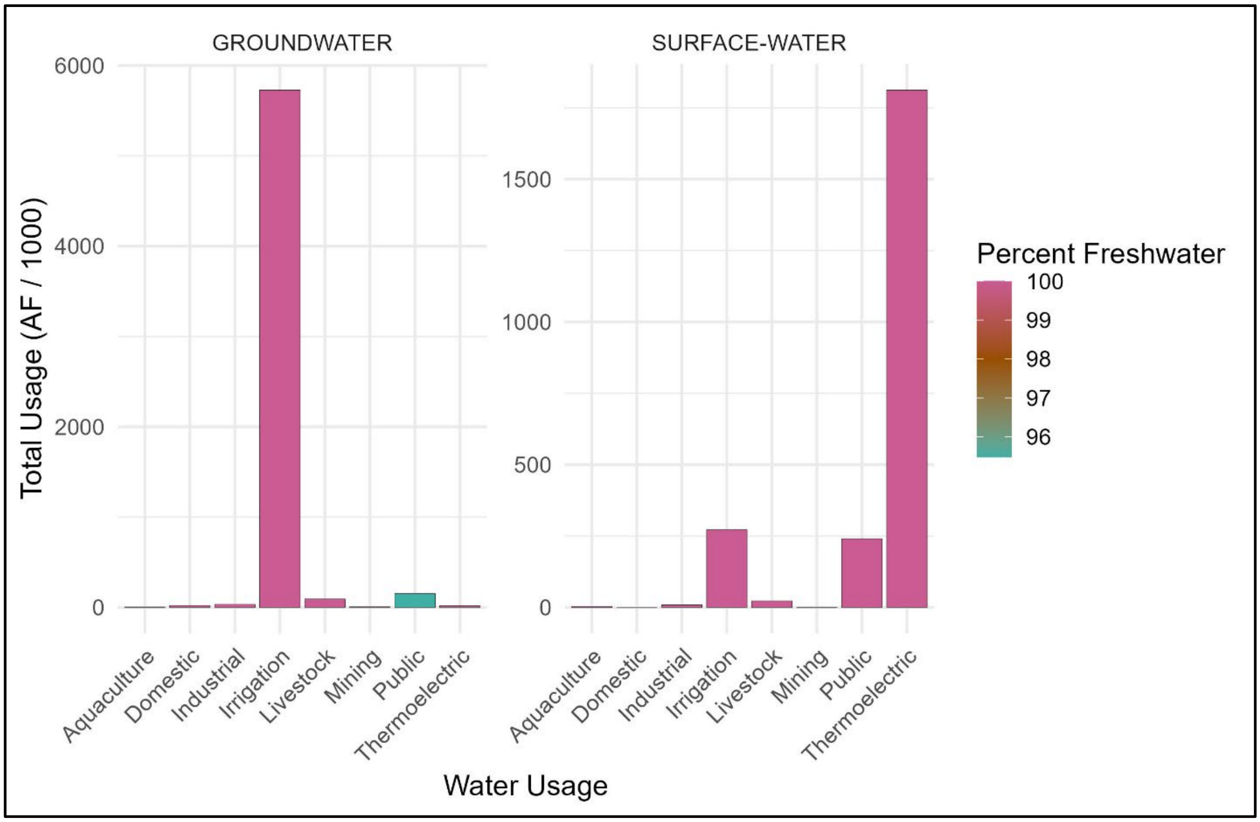


**Figure 3-1. Water withdrawal by category for the state of Kansas in 2015, colored by the percentage of freshwater withdrawal out of the total water withdrawal (freshwater plus saline water withdrawal) (Dieter et al. 2018).**

### Table 3-1. State of Kansas Water Withdrawal by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Withdrawal (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Total Withdrawal (%) | Saline* | Total Withdrawal (%) | | |
| Aquaculture | 3,618 | 0 | 3,618 | <1% | 3,540 | 0 | 3,540 | <1% | 7,158 | <1% | 0 | 0% | 7,158 | <1% |
| Domestic | 0 | – | 0 | 0% | 19,804 | – | 19,804 | <1% | 19,804 | <1% | – | 0% | 19,804 | <1% |
| Industrial | 8,547 | 0 | 8,547 | <1% | 34,153 | 0 | 34,153 | <1% | 42,700 | 1% | 0 | 0% | 42,700 | 1% |
| Irrigation | 272,553 | – | 272,553 | 3% | 5,729,057 | – | 5,729,057 | 68% | 6,001,610 | 71% | – | 0% | 6,001,610 | 71% |
| Livestock | 22,907 | – | 22,907 | <1% | 93,509 | – | 93,509 | 1% | 116,416 | 1% | – | 0% | 116,416 | 1% |
| Mining | 616 | 0 | 616 | <1% | 6,094 | 0 | 6,094 | <1% | 6,710 | <1% | 0 | 0% | 6,710 | <1% |
| Public Water Supply | 240,069 | 0 | 240,069 | 3% | 146,347 | 6,922 | 153,269 | 2% | 386,416 | 5% | 6,922 | <1% | 393,338 | 5% |
| Thermoelectric Power | 1,812,166 | 0 | 1,812,166 | 22% | 17,497 | 0 | 17,497 | <1% | 1,829,663 | 22% | 0 | 0% | 1,829,663 | 22% |
| **Total** | **2,360,476** | **0** | **2,360,476** | **28%** | **6,050,001** | **6,922** | **6,056,923** | **72%** | **8,410,477** | **>99%** | **6,922** | **<1%** | **8,417,399** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water withdrawal data are in AF/year unless otherwise indicated.

* Saline water is defined as water containing dissolved solids of 1,000 mg/L or more. Saline water withdrawals are not reported for domestic, irrigation, or livestock water withdrawal (Dieter et al. 2018).

–: no data available

**Table 3-2. State of Kansas Water Withdrawal by Category in 2015 for Targeted Counties**

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Withdrawal (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Total Withdrawal (%) | Saline* | Total Withdrawal (%) | | |
| Aquaculture | 258 | – | 258 | <1% | 504 | – | 504 | <1% | 762 | <1% | 0 | <1% | 762 | <1% |
| Domestic | 0 | – | 0 | <1% | 1,983 | – | 1,983 | <1% | 1,983 | <1% | 0 | <1% | 1,983 | <1% |
| Industrial | 7,505 | – | 7,505 | <1% | 4,481 | – | 4,481 | <1% | 11,986 | <1% | 0 | <1% | 11,986 | <1% |
| Irrigation | 1,658 | – | 1,658 | <1% | 1,225,189 | – | 1,225,189 | 96% | 1,226,847 | 96% | 0 | <1% | 1,226,847 | 96% |
| Livestock | 2,229 | – | 2,229 | <1% | 11,537 | – | 11,537 | <1% | 13,767 | 1% | 0 | <1% | 13,767 | 1% |
| Mining | 56 | – | 56 | <1% | 168 | – | 168 | <1% | 224 | <1% | 0 | <1% | 224 | <1% |
| Public Water Supply | 8,524 | – | 8,524 | <1% | 13,543 | – | 13,543 | 1% | 22,067 | 2% | 0 | <1% | 22,067 | 2% |
| Thermoelectric Power | 0 | – | 0 | <1% | 5,041 | – | 5,041 | <1% | 5,041 | <1% | 0 | <1% | 5,041 | <1% |
| **Total** | **20,230** | **–** | **20,230** | **2%** | **1,262,446** | **–** | **1,262,446** | **98%** | **1,282,677** | **100%** | **0** | **<1%** | **1,282,677** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water withdrawal data are in AF/year unless otherwise indicated.

* Saline water is defined as water containing dissolved solids of 1,000 mg/L or more. Saline water withdrawals are not reported for domestic, irrigation, or livestock water withdrawal (Dieter et al. 2018).

–: no data available

Current levels of oil and gas production in Kansas are low relative to other states. In 2023, Kansas produced approximately 136.9 million cubic feet of marketed natural gas, accounting for 0.3% of U.S. production. As of March 2025, the state also produced around 69,000 barrels of crude oil per day, representing 0.5% of national oil output (U.S. Energy Information Administration 2025). From 2014 to 2024, FracFocus reports 464 total wells (Table 3-3) where the total annual water use associated with the hydraulic fracturing of reported oil and gas wells throughout Kansas generally decreased from 2014 to 2024. The year 2014 represented the greatest reported total hydraulic fracturing water use at 1,185.5 AF (see Table 3-3). Most of the wells and associated water use are reported as non-federal and non-tribal; reported hydraulic fracturing water use for these wells totaled 1,632.4 AF from 2014 to 2024. During the same time period, 3 federal wells were reported to FracFocus and the total hydraulic fracturing water use for federal wells was 3 AF.

The average 3-year water use (2022 to 2024) was 1.2 AF for hydraulic fracturing water purposes (see Table 3-3) (FracFocus 2025). An average water use of 1.2 AF per well for hydraulic fracturing is lower compared to Oklahoma and Texas (39.7 AF and 55.6 AF, respectively). The two most likely reasons for this difference are: 1) the prevalence of vertical wells in Kansas (vertical wells generally require significantly less water than horizontal wells), and 2) the underlying geologic formations in Kansas generally require less water for hydraulic fracturing than formations in other states (BLM 2016). FracFocus reports on water use directly associated with hydraulic fracturing jobs only, which represents the majority of water use per well across the planning area (see Table 3-3). The amount of water used in fracturing operations varies significantly depending on the well configuration (vertical or horizontal), the number of fractured stages, and the specific characteristics of the formation. In vertical wells with a single fractured stage, water use associated with hydraulic fracturing can be less than 50,000 gallons of water per fracture job, or approximately 0.15 AF. In contrast, a multi-stage fracture job in a horizontal well can require several million to tens of millions of gallons of water (FracFocus 2025). Although direct water usage associated with hydraulic fracturing jobs represents the majority of water usage for well development, well development requires other direct and indirect types of water use which are not associated with the hydraulic fracturing process (i.e., non-hydraulic fracturing water usage).

FracFocus does not report on non-hydraulic fracturing water use, which is largely associated with drilling activities. Non-hydraulic fracturing water use represents a small fraction of the total water use per well; however, this amasses to a substantial sum of additional water use across the planning area. Estimates for non-hydraulic fracturing water use are detailed in *Estimates of Water Use Associated with Continuous Oil and Gas Development in the Permian Basin, Texas and New Mexico, 2010–19* (Valder et al. 2021). Valder et al. (2021) characterizes non-hydraulic fracturing water uses as either direct or indirect water uses, which are defined as follows:

- **Direct non-hydraulic fracturing water usage**: This includes water used directly in a wellbore for activities such as drilling, cementing, and maintaining the well during production.
- **Indirect non-hydraulic fracturing water usage**: This encompasses water used at or near the well site, including water for dust abatement, equipment cleaning, materials washing, worker sanitation, and site preparation.

Valder et al. (2021) provides the following estimates for direct and indirect non-hydraulic fracturing water use:

- Direct – cementing (0.043 AF per well)
- Direct – drilling (0.439 AF per well)
- Indirect (0.341 AF per well)

Total non-hydraulic fracturing water use is approximately 0.82 AF per well. The value of 0.82 AF per well is an estimate based on the best available data on water use for non-hydraulic fracturing operations. It is intended to serve as a reasonable approximation for estimating water use per well. Using the total well count from 2014 to 2024 from FracFocus, coupled with the estimate of 0.82 AF per well from the USGS, it is estimated that non-hydraulic fracturing water use in the State of Kansas totaled 380.48 AF for 464 wells between 2014 and 2024 (see Table 3-3); however, this total likely only represents post-2015 well development.

Total hydraulic fracturing water use, and non-hydraulic fracturing water use for 2014 through 2024 is estimated to be 1,994.38 AF with the year 2014 recording the highest single-year water use associated with hydraulic fracturing, 1,342.94 AF (see Table 3-3). The reported total is an estimation and does not consider variables such as differences in water use between vertical and horizontal wells and local geology.

### 3.2.2 Produced Water

In 2021, Kansas reported a total produced water volume of approximately 1,016,408,380 barrels, as estimated from the state's produced water management practices data. The KCC, which oversees oil and gas activities, does not directly track produced water volumes but does distinguish between conventional and unconventional development. The state had 72,161 hydrocarbon wells that produced 27,908,720 barrels of crude oil and 167,849.25 million cubic feet of natural gas in 2021. The majority of produced water—760,157,395 barrels, or 74.79%—was disposed of via injection by operators, primarily for enhanced recovery projects. The remaining 256,249,232 barrels (25.21%) were injected for disposal. No beneficial reuse of produced water was reported for the year (GWPC 2021a).

Trends in produced water volumes in Kansas show moderate fluctuations over the past decade. Produced water volumes increased by 14% between 2012 (1,061,019,000 barrels) and 2017 (1,205,091,949 barrels). However, between 2017 and 2021, produced water volumes decreased by approximately 19%, dropping to 1,016,408,380 barrels. During this period, the number of producing wells also declined by 4.4% (a reduction of 3,318 wells). Despite these changes, Kansas ranked eighth among U.S. states in total produced water volume in 2021, reflecting its ongoing role in national oil and gas production and water management practices (GWPC 2021a).

**Table 3-3. Water Use by Oil and Gas Wells for Hydraulic Fracturing and Non-Hydraulic Fracturing in Kansas from 2014 through 2024**

| Year | Federal HF Water Use (AF) | Non-Federal/Non-Tribal HF Water Use* (AF) | Total HF Water Use (AF) | Federal HF Water Use (%) | Federal HF Cumulative Water Use (AF) | Total HF Cumulative Water Use (AF) | Average HF Water Use per Well* (AF) | Total No. of Federal Wells | Total No. of Wells | Total Non-HF Water Use (AF) | Total water Use (HF plus non-HF) (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 | – | 1,185.5 | 1,185.5 | – | – | 1,185.5 | 6.2 | – | 192 | 157.44 | 1,342.94 |
| 2015 | 2.6 | 290.5 | 293.1 | <1% | 2.6 | 1,478.6 | 5.1 | 1 | 57 | 46.74 | 339.84 |
| 2016 | –- | 38.3 | 38.3 | – | – | 1,516.9 | 4.8 | – | 8 | 6.56 | 44.86 |
| 2017 | –- | 17.5 | 17.5 | – | – | 1,534.4 | 1.0 | – | 18 | 14.76 | 32.26 |
| 2018 | 0.4 | 30.2 | 30.6 | <1% | 3 | 1,565.0 | 1.1 | 2 | 29 | 23.78 | 54.38 |
| 2019 | – | 12.0 | 12.0 | – | – | 1,577.0 | 0.2 | – | 52 | 42.64 | 54.64 |
| 2020 | – | 1.3 | 1.3 | – | – | 1,578.3 | 0.1 | – | 13 | 10.66 | 11.96 |
| 2021 | – | 3.8 | 3.8 | – | – | 1,582.1 | 0.1 | – | 38 | 31.16 | 34.96 |
| 2022 | – | 25.4 | 25.4 | – | – | 1,607.5 | 0.7 | – | 38 | 31.16 | 56.56 |
| 2023 | – | 7.0 | 7.0 | – | – | 1,614.5 | 0.8 | – | 9 | 7.38 | 14.38 |
| 2024 | – | 20.9 | 20.9 | – | – | 1,635.4 | 2.1 | – | 10 | 8.20 | 7.60 |
| **Total** | **3.0** | **1,632.4** | **1,635.4** | **<1%** | **3** | **1,635.4** | **1.2†** | **3** | **464** | **380.48** | **1,994.38** |

Source: FracFocus (2025). Data only for those wells that reported water use to FracFocus are presented.

Note: Produced water is naturally occurring water that exists in a formation that is being targeted for mineral extraction and is produced as a byproduct.

* Includes both federal and non-federal wells.

† 3-year average (2022–2025)

–: no data available

HF = hydraulic fracturing; Non-HF = non-hydraulic fracturing

## 3.3 STATE WATER QUALITY

### 3.3.1 Surface Water

In the state of Kansas, the KDHE administers CWA Sections 303(d), 305(b), and 314 which pertain to surface water quality assessment and reporting. The KDHE defines designated beneficial uses for surface water and establishes standards to assess whether those uses are being met. Every 2 years, KDHE publishes a report on all waterbodies in the state. Data are assessed using criteria established in Kansas water quality standards (Kansas Administrative Regulation 28-16-28e). If a parameter does not meet the water quality standards in a waterbody, the waterbody is considered impaired, the associated beneficial use is classified as "not supporting," and the waterbody is placed on the 303(d) list. The report also contains information on surface water quality and water pollution control programs in the state of Kansas. The most recent approved report was published in 2024 (KDHE 2024a). Only the KDHE has the authority to determine use attainment based on water chemistry data; the BLM does not have this jurisdiction. Designated beneficial uses in Kansas are defined as aquatic life, domestic water supply, food procurement, groundwater recharge, industrial water supply, irrigation, livestock watering, and recreation (KDHE 2024a). In Kansas streams, the primary causes of waterbody impairments are suboptimal aquatic macroinvertebrate metrics (aquatic life), elevated mercury in fish tissue, and exceedances of bacteria and metals in water—each indicating designated use nonsupport (KDHE 2024a). Additionally, the most widespread class of stressors responsible for designated beneficial use Kansas stream impairments were from agriculture and anthropogenic influences whereas urban stressors were less prevalent (KDHE 2024a).

### 3.3.2 Groundwater

The majority of the west half of the state of Kansas is underlain by the High Plains aquifer, which also occupies six additional states (South Dakota, Wyoming, Nebraska, Colorado, New Mexico, Oklahoma, and Texas). The High Plains aquifer, commonly referred to as the Ogallala Aquifer is a primary source of groundwater for various uses in the state (Kansas Geological Survey [KGS] 1993). The quality of the groundwater was assessed in 2015 and 2016 through a sampling of 80 public water supply wells that were distributed in multiple states and locations within the aquifer, 11 of which were in the state of Kansas (USGS 2019). Samples were analyzed for a variety of water quality constituents that originate from both natural and human sources and then compared to established benchmarks to determine the overall level of contamination (USGS 2019). Contaminant categories of "high," "moderate," and "low" were identified based on the magnitude of exceedance of established benchmarks for both human health (e.g., arsenic) and secondary non-health (e.g., TDS). Wells sampled in Kansas were generally in the moderate to high category for TDS (benchmark = 500 parts per million) and uranium (benchmark = 30 parts per billion), and in the moderate category for arsenic (benchmark = 10 parts per billion) and fluoride (benchmark = 2 parts per million) (USGS 2019).

### 3.3.3 Potential Sources of Contamination

The chemical composition of water used during the hydraulic fracturing process varies due to differences in fracturing techniques used by oil and gas companies. A typical oil/gas well uses approximately 20 to 25 unique chemicals during the hydraulic fracturing process, but in some cases, more than 60 distinct chemicals can be used.

According to FracFocus, from 2014 through 2024, water was the most commonly disclosed ingredient in hydraulic fracturing operations with 1,843 entries, representing 10.69% of all FracFocus entries and 19.76% of the total hydraulic fracturing jobs (chemical volume by percentage mass) from 2014 through 2024. Methanol (1,366 disclosures), isopropyl alcohol (531 disclosures), and propargyl alcohol (475 disclosures) represent the next most commonly reported chemicals constituents of hydraulic fracturing operations (see Table 3-4).

Additionally, 590 entries within Kansas did not include an ingredient name, CAS number, or volume used, but were still entered into the FracFocus registry as unnamed ingredients used for some purpose during the hydraulic fracturing process. For the purpose of this report, these entries that lack any details on ingredient names or volumes are referred to as “unnamed” ingredients. Unnamed ingredients represented 3.42% of all FracFocus entries from 2014 through 2024; however, given that they do not have reported volumes, it is unknown what percentage of the total hydraulic fracturing jobs (volume by percent mass) they represent. Unnamed ingredients are distinct from those reported as “proprietary,” which may lack details on specific chemical constituents, but still include information on suppliers, trade names, chemical properties (e.g., additives or mass), and reported volumes used for hydraulic fracturing. No proprietary ingredients were entered into FracFocus for Kansas wells from 2014 through 2024. For a detailed explanation of how FracFocus data are analyzed and summarized, please refer to Appendix A.

**Table 3-4. Most Frequently Disclosed Ingredients Reported to FracFocus within Kansas from 2014 through 2024**

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Disclosures‡ (%) |
|---|---|---|---|---|
| Water | 7732-18-5 | 1,843 | 19.76 | 10.69 |
| Methanol | 67-56-1 | 1,366 | 0.01 | 7.92 |
| Unnamed | Unknown | 590 | Unknown | 3.42 |
| Isopropyl Alcohol | 67-63-0 | 531 | 0.03 | 3.08 |
| Propargyl Alcohol | 107-19-7 | 475 | 0.00 | 2.76 |
| Ethylene Glycol Butylether | 111-76-2 | 387 | 0.03 | 2.25 |
| Diethanlaminophosphonic Acid Ester (Ammonium Salt) | Variable | 367 | 0.00 | 2.13 |
| Cocamide Diethanolamine Salt | 68603-42-9 | 363 | 0.02 | 2.11 |
| Diethanolamine | 111-42-2 | 362 | 0.00 | 2.10 |
| Fatty Acid Diethanolamide | 68603-42-9 | 359 | 0.00 | 2.08 |
| Poly[Osyethylene(Dimethyliminio)Ethylene (Dimethyliminio)Ethylene Dichloride) | 31512-74-0 | 339 | 0.00 | 1.97 |
| Crystalline Silica (Quartz) | 14808-60-7 | 332 | 12.17 | 1.93 |
| Alcohols, C14-15, Ethoxylated | 68951-67-7 | 331 | 0.00 | 1.92 |
| Diethylene Glycol | 111-46-6 | 316 | 0.00 | 1.83 |
| Potassium Metaborate | 13709-94-9 | 310 | 0.02 | 1.80 |
| Potassium Hydroxide | 1310-58-3 | 303 | 0.00 | 1.76 |
| Ethylene Glycol | 107-21-1 | 298 | 0.01 | 1.73 |
| Acetic Acid | 64-19-7 | 272 | 0.01 | 1.58 |
| Alcohols, C9-C11, Ethoxylated | 68439-46-3 | 260 | 0.00 | 1.51 |
| 2-Butoxy-1-Ethanol | 111-76-2 | 258 | 0.00 | 1.50 |
| Alcohols, C12-C13, Ethoxylated | 68439-50-9 | 257 | 0.00 | 1.49 |
| Hydrochloric Acid | 7647-01-0 | 255 | 0.18 | 1.48 |
| Tributyl Tetradecyl Phosphonium Chloride | 81741-28-8 | 226 | 0.00 | 1.31 |

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Disclosures‡ (%) |
|---|---|---|---|---|
| Ammonium Persulfate | 7727-54-0 | 217 | 0.01 | 1.26 |
| Nitrogen, $N_2$ | 7727-37-9 | 198 | 20.07 | 1.15 |

Source: FracFocus (2025)

Note: Ingredient names and CAS numbers are not standardized in FracFocus, leading to widespread differences in CAS numbers, number of disclosures, and ingredient names. For this reason, the values and ingredients presented in this table are for general information only.

Table includes only the top 25 most frequently disclosed ingredients, along with their percentages relative to the total list of ingredients; because all ingredients are not listed, percentages will not sum to 100%.

N/A = Not applicable

* FracFocus lists certain chemicals as proprietary, and no additional information is available regarding ingredient contents.

† The amount of the ingredient in the total hydraulic fracturing volume by percent mass (definition from FracFocus [2025] data dictionary).

‡ Percentage represents the number of documented chemical disclosures out of the total number of disclosures.

Oil and gas spills have the potential to impact surface water directly through inadvertent discharges into a waterbody or indirectly by surface runoff, soil contamination, and ensuing transport during rainfall, or migration into groundwater and subsequent discharge from a spring into surface water. According to Kansas Administration Regulations 82-3-603, major releases must be reported to KCC upon initial discovery of the release. Major releases are not defined by quantity; however, spills include unintended escape of saltwater, oil, or refuse from oil, gas, injection, service, or gas storage wells, or associated infrastructure like tanks, pipelines, dikes, or pits. This includes activities related to the exploration, drilling, storage, treatment, or gathering of oil or gas, and the operation or abandonment of wells (Cornell Law School 2024). Minor spills such as drips and leaks do not require reporting according to the KCC; however, operators are required to clean up all spills, including those exempt from reporting (e.g., drips and leaks) within 24 hours of initial discovery (KCC 2024). All major and minor release reports (spills) are archived in the KCC spills database.

Spill data for Kansas were retrieved from the KCC (KCC 2025a). Spill reporting across Kansas was quantified; however, spill quantities are clustered around specific, discrete volumes (e.g., 200 gallons), suggesting that many reported spill volumes do not accurately reflect the actual spill amounts. This clustering could result from administrative errors, the convenience of reporting specific discrete quantities, or potential incentives to report certain volumes (e.g., overreporting). As a result, the quantity of each spill category reported in Tables 3-5 and 3-6 should be interpreted with caution and may not represent actual spill volumes associated with each spill type. Additionally, although KCC data differentiates between spills that impacted waters and those that did not, it does not specify whether the waters impact are surface water or groundwater features. More information on data processing is included in Appendix A.

In total, 11,247 spills were reported to the KCC between 2014 and 2024, with 192 incidents reporting impacts to waters (Table 3-5), and 11,055 incidents reporting no impacts to waters (Table 3-6).

From 2014 to 2024, 58,048.6 barrels of oil were spilled with no reported impact to surface waters; approximately 48% of the total sum of oil spilled was recovered, equating to 28,132.3 barrels. During the same time period, 918.8 barrels of oil were spilled with reported impacts to water resources; approximately 54% of the total sum of spills was recovered, equating to 496.6 barrels of oil recovered (see Table 3-5, Table 3-6, and Figure 3-2).

From 2014 to 2024, 10,466,396 gallons of saltwater were spilled with no reported impacts to surface water resources. Of the total volume of spilled saltwater, 5,727,134 gallons (55%) was recovered. Out of the 1,454,439 gallons of spilled saltwater that were reported to impact waters, 1,273,692 gallons (88%) were recovered. Finally, 5,989.5 barrels of unknown substances were spilled with no recorded impact to surface waters, with 5,767.3 barrels recovered (96% recovered) (see Table 3-5, Table 3-6, and Figure 3-2).

**Table 3-5. Summary of Spills that Impacted Waters in the State of Kansas from 2014 through 2024**

| Year | Oil Spills | | | | Saltwater Spills | | | | Total Reported Spills |
|---|---|---|---|---|---|---|---|---|---|
| | Spill Quantity (barrels) | Quantity Recovered (barrels) | Percent Recovery | Reported Spills | Spill Quantity (gallons) | Quantity Recovered (gallons) | Percent Recovery | Reported Spills | |
| 2014 | 134.0 | 96.5 | 72% | 14 | 159,810 | 134,526 | 84% | 13 | 27 |
| 2015 | 29.3 | 25.8 | 88% | 7 | 42,462 | 17,850 | 42% | 9 | 16 |
| 2016 | 54.0 | 15.0 | 28% | 9 | 138,390 | 129,150 | 93% | 10 | 19 |
| 2017 | 177.5 | 49.0 | 28% | 11 | 203,280 | 196,854 | 97% | 10 | 21 |
| 2018 | 61.1 | 0.5 | 0.80% | 7 | 723,198 | 714,000 | 99% | 10 | 17 |
| 2019 | 32.3 | 22.5 | 70% | 12 | 88,788 | 12,600 | 14% | 14 | 26 |
| 2020 | 153.0 | 52.0 | 34% | 8 | 5,040 | 3,570 | 71% | 6 | 14 |
| 2021 | 63.3 | 62.0 | 98% | 11 | 38,556 | 28,560 | 74% | 10 | 21 |
| 2022 | 166.3 | 142.8 | 86% | 9 | 40,026 | 28,140 | 55% | 12 | 21 |
| 2023 | 22.0 | 16.5 | 75% | 2 | 8,400 | 8,400 | 100% | 2 | 4 |
| 2024 | 26.0 | 14.0 | 54% | 3 | 6,489 | 42 | 1% | 3 | 6 |
| **Total** | **918.8** | **496.6** | **54%** | **93** | **1,454,439** | **1,273,692** | **88%** | **99** | **192** |

Source: KCC (2025c)

**Table 3-6. Summary of Spills that did not Impact Waters in the State of Kansas from 2014 through 2024**

| Year | Oil Spills | | | | Saltwater Spills | | | | Other Spills | | | | Total Reported Spills |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spill Quantity (barrels) | Quantity Recovered (barrels) | Percent Recovery | Reported Spills | Spill Quantity (gallons) | Quantity Recovered (gallons) | Percent Recovery | Reported Spills | Spill Quantity (barrels) | Quantity Recovered (barrels) | Percent Recovery | Reported Spills | |
| 2014 | 6,486.0 | 3,375.4 | 52% | 536 | 1,440,948 | 852,113 | 59% | 729 | 5,831 | 5,670 | 97% | 11 | 1,276 |
| 2015 | 5,606.0 | 2,781.1 | 50% | 511 | 1,389,973 | 805,340 | 58% | 691 | – | – | – | – | 1,202 |
| 2016 | 5,544.7 | 2,328.4 | 42% | 510 | 1,108,671 | 585,055 | 53% | 669 | 36 | 5 | 14% | 8 | 1,187 |
| 2017 | 4,862.4 | 2,342.9 | 48% | 457 | 1,008,698 | 543,518 | 54% | 666 | – | – | – | – | 1,123 |
| 2018 | 7,730.2 | 2,380.6 | 31% | 517 | 1,113,210 | 568,155 | 51% | 731 | 47 | 40 | 85% | 5 | 1,253 |
| 2019 | 7,514.8 | 3,385.5 | 45% | 579 | 1,123,203 | 585,003 | 52% | 797 | 0.5 | 0.5 | 100% | 2 | 1,378 |
| 2020 | 4,829.4 | 2,407.3 | 50% | 354 | 937,467 | 471,623 | 50% | 515 | 52 | 47 | 90% | 5 | 874 |
| 2021 | 5,351.2 | 3,291.9 | 61% | 417 | 817,121 | 506,039 | 62% | 578 | 10 | 4 | 40% | 3 | 998 |
| 2022 | 4,582.8 | 3,007.4 | 66% | 316 | 722,881 | 409,597 | 57% | 498 | 11 | 0.75 | 6.8% | 3 | 817 |
| 2023 | 3,903.7 | 2,010.2 | 51% | 284 | 573,297 | 267,315 | 47% | 430 | – | – | – | – | 714 |
| 2024 | 1,637.4 | 821.6 | 50% | 103 | 230,927 | 133,376 | 58% | 130 | 2 | – | – | – | 233 |
| **Total** | **58,048.6** | **28,132.3** | 48% | **4,584** | **10,466,396** | **5,727,134** | 55% | **6,434** | **5,989.5** | **5,767.3** | 96% | **37** | **11,055** |

Source: KCC (2025c)

–: no data available

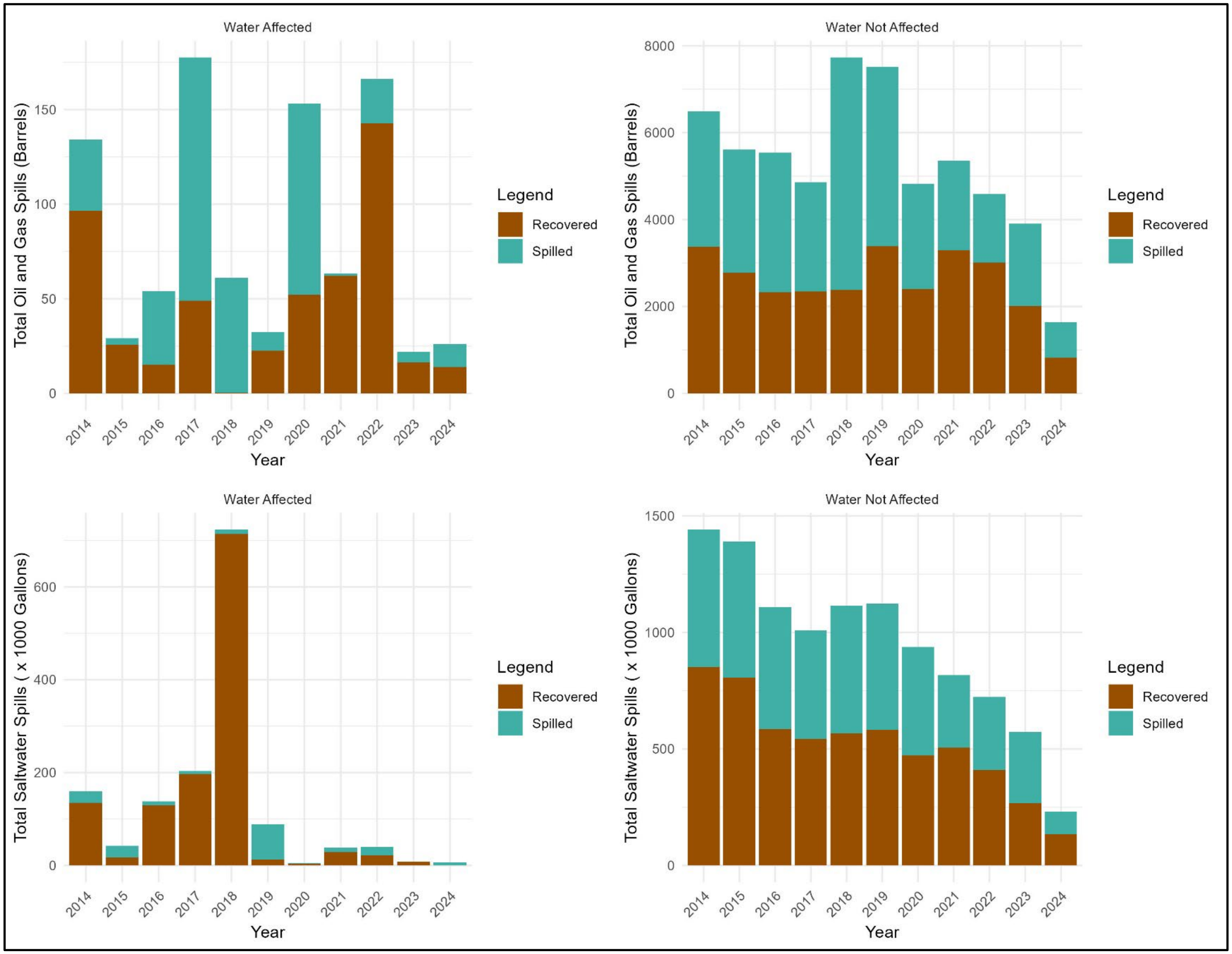


**Figure 3-2. Summary of oil and gas spills and saltwater spills by year in the state of Kansas, colored by the percent of total spill quantity recovered (KCC 2025a).**

# 4 TEXAS

This chapter provides an analysis and summary of available water use and water quality data for the state of Texas and its major oil and gas plays: 1) Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Play; and 2) East Texas and Gulf Coast Texas, Permian Basin, and Shelf oil and gas Play. The chapter is organized into several sections that address key aspects of water use, planning, and quality across the state and within specific oil and gas plays:

- **Section 4.1:** Presents an overview of the state's water planning process and related documentation.
- **Section 4.2:** Provides estimates for all categories of consumptive water use (e.g., public water supply, irrigation, thermoelectric power, etc.) and hydraulic fracturing water use for the state.
- **Section 4.3:** Discusses issues related to surface water and groundwater quality, including data on spills and the chemical constituents used in hydraulic fracturing.
- **Sections 4.4.1** and **4.5.1:** Gives insight into the hydrogeologic setting of each designated region.
- **Sections 4.4.2** and **4.5.2:** Cover surface water and groundwater quality issues for the oil and gas plays.
- **Sections 4.4.3** and **4.5.3:** Provide estimates for consumptive water use and hydraulic fracturing specific to the two regional oil and gas plays.

## 4.1 STATE OF TEXAS WATER PLANNING AND PERMITTING

The State of Texas's approach to water resources management is guided by the State Water Plan developed and managed by the Texas Water Development Board (TWDB). The State Water Plan is updated every 5 years with the most recent version published in 2022. The State Water Plan is based on 16 regional water plans and addresses the needs of several water user groups in the state that include municipal, irrigation, manufacturing, livestock, mining, and steam-electric power while also serving as a guide for policy recommendations and identifying sites of unique value (TWDB 2024a). The plan covers nine primary topics (TWDB 2024b):

1) Policy recommendations
2) Drought and drought response
3) Future population and water demand
4) Water availability and existing supplies
5) Water supply needs
6) Water management strategies and projects
7) Conservation
8) Financing
9) Implementation and funding of the past state water plan

Within the defined water usage categories of the State Water Plan, water use associated with oil and gas exploration, development, and extraction is included in the mining category. Water use for the processing of oil and gas is included in the manufacturing water use category. Based on the oil and gas industry outlook, mining demand is predicted to increase through 2030 and decline in decades to follow (TWDB

2024a). Water use in the State of Texas is dominated by irrigation and followed by municipal purposes, while mining and manufacturing account for only a small percentage of overall water use.

In Texas, water resource planning and permitting involve coordination between multiple state agencies. The Texas Commission on Environmental Quality (TCEQ) is responsible for regulating surface water and groundwater quality and availability. Additionally, TCEQ oversees wastewater and stormwater management and surface water permitting (TCEQ 2025b). Oil and gas exploration, production, and transportation are regulated by the Texas Railroad Commission (RRC) Oil and Gas Division. Permits for drilling, well construction, injection, and surface management of oil and gas waste are all managed by the RRC Oil and Gas Division (RRC 2024). While TCEQ focuses on environmental protections and public health related to water quality, the RRC ensure safe energy resource development with oversight of activities that could impact groundwater or surface water through oil and gas operations.

## 4.2 STATE WATER QUANTITY

### 4.2.1 Surface Water and Groundwater Use

In 2015, the combined fresh and saline water withdrawals for all water use categories across the state of Texas totaled 35,469,083 AF (Table 4-1; Figure 4-1) (Dieter et al. 2018). The majority of water withdrawals in the state of Texas came from thermoelectric power totaling 23,292,575 AF or 66% of the total water withdrawals in 2015. Irrigation and public water supply represented the second and third greatest withdrawals within the state of Texas totaling 6,148,786 AF (17%) and 3,231,981 (9%)AF, respectively. Industrial, mining, and livestock constituted relatively minor proportions of the cumulative water withdrawal, ranging from 1% to 4% (308,600 AF to 1,272,537 AF). Finally, aquaculture and domestic uses constituted the lowest water withdrawal in the state of Texas, at less than 1% (25,987 AF and 153,112 AF, respectively). Surface water resource withdrawals totaled 27,365,110 AF constituting 77% of the total water withdrawals and groundwater withdrawals totaled 8,103,973 AF, accounting for the remaining 23%. Irrigation represented the greatest source of groundwater withdrawal at 5,014,351 AF (62%) of total groundwater withdrawals. Thermoelectric power sourced approximately 23,208,161 AF (84%) of water from surface water resources, which represented the largest source of surface water withdrawals in 2015 (see Table 4-1 and Figure 4-1).

It is important to consider the impacts of groundwater well pumping on surface water availability, especially since Texas uses surface water for over half of its water withdrawal needs (Dieter et al. 2018). Groundwater pumping impacts the storage capacity of an aquifer. This reduction affects groundwater discharge zones, where groundwater naturally flows out of the aquifer, often connecting to surface water bodies like rivers, lakes, and streams. Altering aquifer storage capacity through groundwater pumping can change the local hydraulic gradient—the slope of the water table surface that determines groundwater flow direction and speed. Significant changes in this gradient can reduce groundwater discharge into surface water systems, thereby decreasing surface water availability (Barlow and Leake 2012).

Annual water use in the state of Texas for both hydraulic and non-hydraulic fracturing totaled 2,966,448.44 AF from 2014 to 2024 (Table 4-2). Out of the total, 2,902,626.20 AF were used in hydraulic fracturing while 63,822.24 AF were used in non-hydraulic fracturing. Most of the usage associated with hydraulic fracturing is associated with non-federal and non-tribal entities. In 2024, 375,117.56 AF was used in both non-hydraulic and hydraulic fracturing. There was also a slight decrease in non-hydraulic and hydraulic fracturing as well as the number of wells associated with these practices. Since 2014, 77,832 wells have been in use for fracturing with an average of 55.60 AF hydraulic fracturing water use per well.

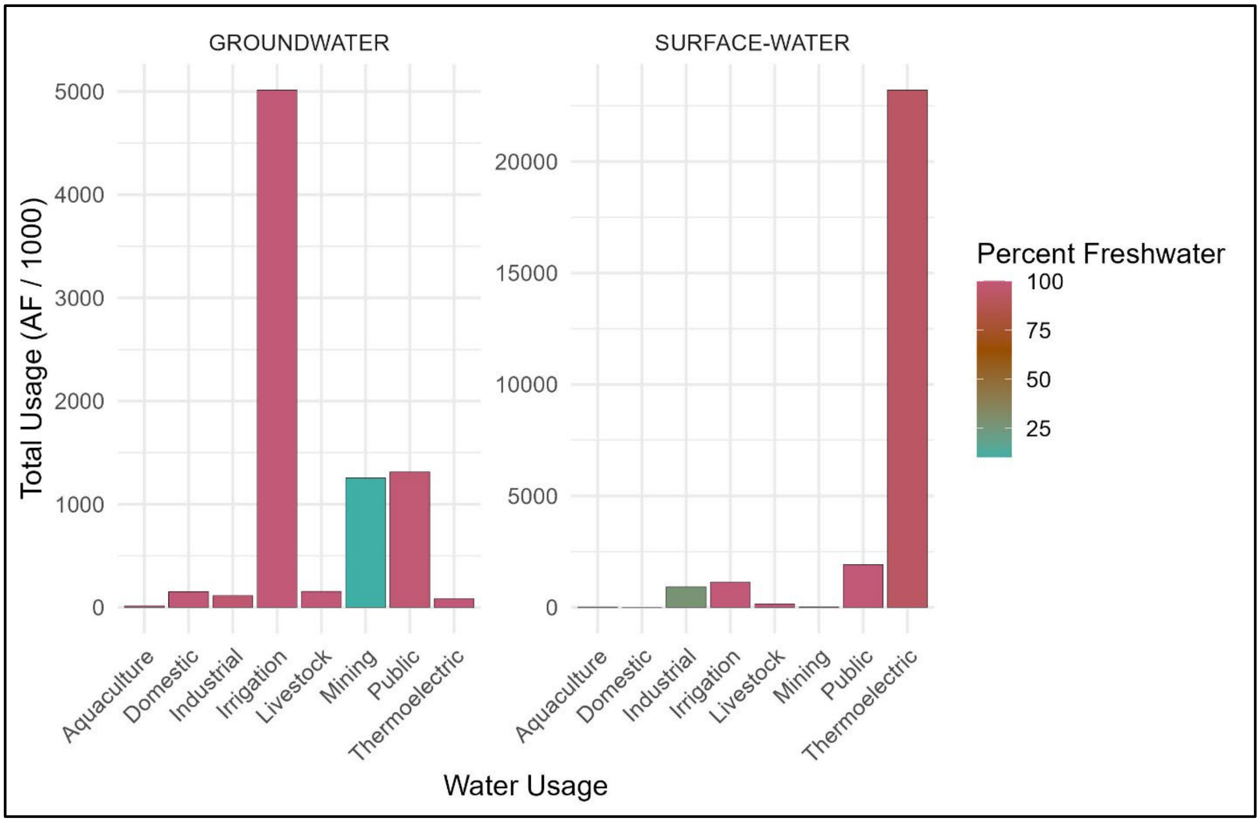


**Figure 4-1. Water withdrawal by category for the state of Texas in 2015, colored by the percentage of freshwater withdrawal out of the total water withdrawal (freshwater plus saline water withdrawal) (Dieter et al. 2018).**

**Table 4-1. State of Texas Water Withdrawal by Category in 2015**

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Withdrawal (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Total Withdrawal (%) | Saline* | Total Withdrawal (%) | | |
| Aquaculture | 12,019 | 963 | 12,982 | <1% | 13,005 | 0 | 13,005 | <1% | 25,024 | <1% | 963 | <1% | 25,987 | <1% |
| Domestic | 0 | – | 0 | 0% | 153,112 | – | 153,112 | <1% | 153,112 | <1% | – | 0% | 153,112 | <1% |
| Industrial | 250,061 | 669,957 | 920,018 | 3% | 111,813 | 3,674 | 115,487 | <1% | 361,874 | 1% | 673,631 | 2% | 1,035,505 | 3% |
| Irrigation | 1,134,435 | – | 1,134,435 | 3% | 5,014,351 | – | 5,014,351 | 14% | 6,148,786 | 17% | – | 0% | 6,148,786 | 17% |
| Livestock | 153,796 | – | 153,796 | <1% | 154,804 | – | 154,804 | <1% | 308,600 | 1% | – | 0% | 308,600 | 1% |
| Mining | 17,799 | 11 | 17,810 | <1% | 129,421 | 1,125,306 | 1,254,727 | 4% | 147,220 | <1% | 1,125,317 | 3% | 1,272,537 | 4% |
| Public Water Supply | 1,915,544 | 2,364 | 1,917,908 | 5% | 1,291,995 | 22,078 | 1,314,073 | 4% | 3,207,539 | 9% | 24,442 | <1% | 3,231,981 | 9% |
| Thermoelectric Power | 21,512,221 | 1,695,940 | 23,208,161 | 65% | 84,414 | 0 | 84,414 | <1% | 21,596,635 | 61% | 1,695,940 | 5% | 23,292,575 | 66% |
| **Total** | **24,995,875** | **2,369,235** | **27,365,110** | **77%** | **6,952,915** | **1,151,058** | **8,103,973** | **23%** | **31,948,790** | **90%** | **3,520,293** | **10%** | **35,469,083** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water withdrawal data are in AF/year unless otherwise indicated.

* Saline water is defined as water containing dissolved solids of 1,000 mg/L or more. Saline water withdrawals are not reported for domestic, irrigation, or livestock water withdrawal (Dieter et al. 2018).

–: no data available

**Table 4-2. Water Use by Oil and Gas Wells for Hydraulic Fracturing and Non-Hydraulic Fracturing in Texas from 2014 through 2024**

| Year | Federal HF Water Use (AF) | Tribal HF Water Use (AF) | Non-Federal/ Non-Tribal HF Water Use* (AF) | Total HF Water Use (AF) | Federal HF Water Use (%) | Federal HF Cumulative Water Use (AF) | Total HF Cumulative Water Use (AF) | Average HF Water Use per Well* (AF) | Total No. of Federal Wells | Total No. of Wells | Total Non-HF Water Use (AF) | Total Water Use (HF plus non-HF) (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 | 4,072.9 | – | 164,750.1 | 168,823.0 | 2% | 4,072.9 | 168,823.0 | 12.3 | 431 | 13,727 | 11,256.14 | 180,079.14 |
| 2015 | 1,581.5 | – | 133,852.5 | 135,434.0 | 1% | 5,654.4 | 304,257.0 | 18.1 | 107 | 7,502 | 6,151.64 | 141,585.64 |
| 2016 | 1,443.2 | 9.3 | 123,380.6 | 124,833.1 | 1% | 7,097.6 | 429,090.1 | 27.3 | 58 | 4,576 | 3,752.32 | 128,585.42 |
| 2017 | 4,774.3 | – | 223,962.1 | 228,736.4 | 2% | 11,871.9 | 657,826.5 | 35.4 | 117 | 6,463 | 5,299.66 | 234,036.06 |
| 2018 | 3,646.5 | – | 312,847.1 | 316,493.6 | 1% | 15,518.4 | 974,320.1 | 40.3 | 104 | 7,863 | 6,447.66 | 322,941.26 |
| 2019 | 3,105.8 | 29.3 | 343,237.7 | 346,372.8 | 1% | 18,624.2 | 1,320,692.9 | 45.0 | 97 | 7,704 | 6,317.28 | 352,690.08 |
| 2020 | 2,621.7 | 76.3 | 193,141.3 | 195,839.3 | 1% | 21,245.9 | 1,516,532.2 | 49.1 | 72 | 3,988 | 3,270.16 | 199,109.46 |
| 2021 | 6,507.8 | 28.2 | 271,222.6 | 277,758.6 | 2% | 27,753.7 | 1,794,290.8 | 46.7 | 128 | 5,946 | 4,875.72 | 282,634.32 |
| 2022 | 9,748.7 | 188.2 | 345,693.1 | 355,630.0 | 3% | 37,502.4 | 2,149,920.8 | 49.1 | 192 | 7,237 | 5,934.34 | 361,564.34 |
| 2023 | 11,149.0 | – | 371,394.1 | 382,543.1 | 3% | 48,651.4 | 2,532,463.9 | 56.4 | 214 | 6,783 | 5,562.06 | 388,105.16 |
| 2024 | 12,412.3 | 97.2 | 357,652.8 | 370,162.3 | 3% | 61,063.7 | 2,902,626.2 | 61.3 | 191 | 6,043 | 4,955.26 | 375,117.56 |
| **Total** | **61,063.7** | **428.5** | **2,841,134.0** | **2,902,626.2** | **2%** | **61,063.7** | **2,902,626.2** | **55.6†** | **1,711** | **77,832** | **63,822.24** | **2,966,448.44** |

Source: FracFocus (2025). Data only for those wells that reported water use to FracFocus are presented; well data may be incomplete due to state reporting requirements and may not reflect total active wells and exact water use.

Note: Produced water is naturally occurring water that exists in a formation that is being targeted for mineral extraction and is produced as a byproduct.

* Includes both federal and non-federal wells.

† 3-year average (2021–2024)

–: no data available
HF = hydraulic fracturing; Non-HF = non-hydraulic fracturing

FracFocus reports on water use directly associated with hydraulic fracturing jobs only, which represents the majority of water use per well across the planning area (see Table 4-2). The amount of water used in fracturing operations varies significantly depending on the well configuration (vertical or horizontal), the number of fractured stages, and the specific characteristics of the formation. In vertical wells with a single fractured stage, water use associated with hydraulic fracturing can be less than 50,000 gallons of water per fracture job, or approximately 0.15 AF. In contrast, a multi-stage fracture job in a horizontal well can require several million to tens of millions of gallons of water (FracFocus 2025). Although direct water usage associated with hydraulic fracturing jobs represents the majority of water usage for well development, well development requires other direct and indirect types of water use that are not associated with the hydraulic fracturing process (i.e., non-hydraulic fracturing water usage).

FracFocus does not report on non-hydraulic fracturing water use, which is largely associated with drilling activities. Non-hydraulic fracturing water use represents a small fraction of the total water use per well; however, this amasses to a substantial sum of additional water use across the planning area. Estimates for non-hydraulic fracturing water use are detailed in *Estimates of Water Use Associated with Continuous Oil and Gas Development in the Permian Basin, Texas and New Mexico, 2010–19* (Valder et al. 2021). Valder et al. (2021) characterizes non-hydraulic fracturing water uses as either direct or indirect water uses, which are defined as follows:

- **Direct non-hydraulic fracturing water usage**: This includes water used directly in a wellbore for activities such as drilling, cementing, and maintaining the well during production.
- **Indirect non-hydraulic fracturing water usage**: This encompasses water used at or near the well site, including water for dust abatement, equipment cleaning, materials washing, worker sanitation, and site preparation.

Valder et al. (2021) provides the following estimates for direct and indirect non-hydraulic fracturing water use:

- Direct – cementing (0.043AF per well)
- Direct – drilling (0.439 AF per well)
- Indirect (0.341 AF per well)

Total non-hydraulic fracturing water use is approximately 0.82 AF per well. The value of 0.82 AF per well is an estimate developed using the best available data on non-hydraulic fracturing water use and serves to provide an estimate by which an approximation can be derived. It is estimated that non-hydraulic fracturing water use in the State of Texas totaled 63,822.24 AF for 77,832 wells between the years 2014 and 2024 (see Table 4-2). The reported total is an estimation and does not consider variables such as differences in water use between vertical and horizontal wells and local geology; additionally, this total assumes that FracFocus data is accurate and represents the total number of wells across Texas.

### 4.2.2 Produced Water

In 2021, Texas reported an estimated total produced water volume of 8,107,645,550 barrels, based on data collected by the RRC through produced water management practices. The state, which leads the nation in both oil and natural gas production, had 203,207 hydrocarbon wells that produced 1,459,827,134 barrels of crude oil, 10,741,016 million cubic feet of natural gas, and 264,574,972 barrels of condensate.
The predominant produced water management practice in Texas was injection for disposal by operators, accounting for 3,541,581,140 barrels, or 43.68% of the state's total produced water volume.
The remainder was managed through injection for enhanced oil recovery (32.14%) and disposal at commercial facilities (24.18%). No beneficial reuse of produced water was reported in 2021 (GWPC 2021a).

Looking at trends over the past decade, Texas experienced a significant increase in produced water volumes from 2012 to 2017, rising by 33% from 7,435,659,000 barrels to 9,895,084,619 barrels. However, between 2017 and 2021, produced water volumes decreased by approximately 18%, dropping to 8,107,645,550 barrels. This reduction in injection volume—about 1,787,439,000 barrels—may reflect the growing reuse and recycling industry, especially in the Permian Basin. During this period, the number of hydrocarbon-producing wells also declined by 4,594 wells (5.6%). It is worth noting that well and production counts are based on the "unconventional fracture treated" field designation, which may not capture all unconventional wells due to the timing of classification adoption. Despite these nuances, Texas ranked first nationally in total produced water volume, underscoring its central role in U.S. oil, gas, and water management activities (GWPC 2021a).

## 4.3 STATE WATER QUALITY

### 4.3.1 Surface Water

In the state of Texas, the TCEQ administers CWA Sections 303(d), 305(b), and 314 related to surface water quality assessment and reporting. The TCEQ defines surface water quality beneficial uses and water quality standards to evaluate if these uses are being attained. Water quality standards include beneficial uses for surface waters of the state and associated water quality criteria to protect those uses. The TCEQ prepares an "Integrated Report of Surface Water Quality for Clean Water Act Section 305(b) and 303(d)" ("Integrated Report") every 2 years that identifies waterbodies not attaining their beneficial uses and lists them as "impaired." The Integrated Report also contains information on surface water quality and water pollution control programs in the state of Texas. The most recent Integrated Report was published in 2024 (TCEQ 2024a). Only TCEQ has the authority to determine use attainment based on water chemistry data; the BLM does not have this jurisdiction.

Beneficial uses in Texas are identified as recreation, domestic water supply, aquatic life, navigation, agricultural water supply, industrial water supply, and wetland water quality functions (TCEQ 2024b). According to the 2024 Integrated Report, 1,370 waterbodies are listed as impaired across several different uses that include recreation, aquatic life, and fish consumption (TCEQ 2024a). The primary pollutants causing water quality impairments are bacteria, dissolved oxygen, dioxin/polychlorinated biphenyls, dissolved solids, and excessive algal growth (TCEQ 2024a).

The 2024 Integrated Report also identifies potential sources of water quality impairments and concerns by compiling information from multiple sources, including surface water quality monitoring data, field observations, land use analyses, Clean Rivers Program assessments, and nonpoint source assessment reports (TCEQ 2024a). These potential sources, which include petroleum and natural gas activities, are considered preliminary until more comprehensive studies are conducted. Each impairment is geographically defined by an assessment unit with a unique identifier and is assigned a management strategy, which may include total maximum daily load development, water quality standards evaluation, or additional monitoring. The report categorizes parameters not meeting water quality standards and assigns a level of support, indicating the degree of impairment or concern. Possible sources of impairment are listed as point sources, nonpoint sources, or unknown, and are intended to guide, but not limit, future water quality management actions (TCEQ 2024c).

### 4.3.2 Groundwater

The Groundwater Division of the TWDB oversees all aspects of groundwater studies in the state for nine major and 22 minor aquifers (TWDB 2024c). As a primary source of water, groundwater provided approximately 55% of the 14.7 million AF of water used in the state in 2020 (TWDB 2024c). There are approximately 98 groundwater conservation districts in Texas, and most groundwater (about 75% of the state supply) is withdrawn solely from the Ogallala Aquifer. The TWDB conducts an extensive groundwater monitoring program across the state with an inventory of approximately 140,000 wells.

The TCEQ developed a comprehensive groundwater assessment in June 2024 that summarizes groundwater protection policies, ambient monitoring data, and groundwater contamination (TCEQ 2024d). Water quality constituents with a maximum contaminant level (MCL) or secondary standard were assessed by the number of wells that exceeded the MCL or standard (Table 4-3). The highest number of wells that exceeded an MCL or standard were for dissolved nitrate-nitrogen, fluoride, dissolved solids, and sulfate (see Table 4-3) (TCEQ 2024b). Major sources of documented or potential groundwater contamination identified by the report include above and underground storage tanks, surface impoundments, landfills, septic systems, agricultural activities, abandoned wells, oil and gas activities, and natural occurrence (TCEQ 2024d). Of the 2,943 confirmed groundwater contamination cases in Texas in 2022, 2,387 are under the jurisdiction of TCEQ programs and 556 are under the RRC, Oil and Gas Division (TCEQ 2024d). The 2024 TCEQ groundwater assessment report includes further details into these contaminated site cases such as impacted major and minor aquifers, site activity status, and examples of contaminants (TCEQ 2024d).

**Table 4-3. Groundwater Quality Summary by Assessed Wells**

| Parameters With an MCL | Primary MCL or Secondary Standard* | Total Number of Wells | Number of Wells That Exceed the MCL or Secondary Standard* | Percentage of Wells That Exceed the MCL or Secondary Standard* |
|---|---|---|---|---|
| Dissolved Nitrate-Nitrogen | 10 mg/L | 2,099 | 431 | 21% |
| Fluoride | 2 mg/L | 2,113 | 424 | 20% |
| Dissolved Solids | 1,000 mg/L | 2,093 | 385 | 18% |
| Sulfate | 300 mg/L | 2,149 | 340 | 16% |
| Iron | 0.3 mg/L | 2,096 | 254 | 12% |
| Chloride | 300 mg/L | 2,149 | 228 | 11% |
| Manganese | 50 µg/L | 2,078 | 185 | 9% |
| Dissolved Arsenic | 10 µg/L | 2,055 | 88 | 4% |
| Dissolved Fluoride | 4 mg/L | 2,113 | 88 | 4% |
| Dissolved Selenium | 50 µg/L | 2,055 | 42 | 2% |
| Zinc | 5 mg/L | 2,054 | 1 | < 1% |
| Dissolved Barium | 2 mg/L | 2,062 | 1 | < 1% |
| Dissolved Cadmium | 5 µg/L | 2,034 | 1 | < 1% |
| Dissolved Mercury | 2 µg/L | 2,046 | 1 | < 1% |
| Dissolved Chromium | 100 µg/L | 2,054 | 0 | 0% |
| Copper | 1 mg/L | 2,055 | 0 | 0% |

µg/L = micrograms per liter

*Secondary standard is a concentration above which water in a public system may only be used with written approval from the TCEQ (TCEQ 2024a).

## 4.3.3 Potential Sources of Contamination

The chemical composition of water used during the hydraulic fracturing process varies due to differences in fracturing techniques used by oil and gas companies. A typical oil/gas well uses approximately 20 to 25 unique chemicals during the hydraulic fracturing process, but in some cases, more than 60 distinct chemicals can be used.

According to FracFocus, from 2014 through 2024, most entries (299,123) within Texas did not include an ingredient name, CAS number, or volume used, but were still entered into the FracFocus registry as unnamed ingredients used for some purpose during the hydraulic fracturing process. For the purpose of this report, these entries that lack any details on ingredient names or volumes are referred to as “unnamed” ingredients. Unnamed ingredients represented 9.97% of all FracFocus entries from 2014 through 2024; however, given that they do not have reported volumes, it is unknown what percentage of the total hydraulic fracturing jobs (volume by percent mass) they represent. Unnamed ingredients are distinct from those reported as “proprietary,” which may lack details on specific chemical constituents, but still include information on suppliers, trade names, chemical properties (e.g., additives or mass), and reported volumes used for hydraulic fracturing. Proprietary disclosures have been grouped into a single ingredient category in Table 4-4.

Not including unnamed ingredients, water is the most commonly disclosed ingredient in hydraulic fracturing operations with 281,396 entries, representing 9.38% of all FracFocus entries and 21.93% of the total hydraulic fracturing jobs (chemical volume by percentage mass) from 2014 through 2024. Methanol (95,806 disclosures), hydrochloric acid (68,683 disclosures), and crystalline silica (67,410 disclosures) represent the next most commonly reported chemicals constituents of hydraulic fracturing operations (see Table 4-4). In total, 2,998,991 unique chemical constituent disclosures in Texas were entered in the FracFocus database (see Table 4-4) (FracFocus 2025). However, because ingredient names and CAS numbers are not standardized in FracFocus, many “unique” chemical recordings may represent the same chemicals recorded differently. For a detailed explanation of how FracFocus data are analyzed and summarized, please refer to Appendix A.

Oil and gas development spills have the potential to impact surface water directly through inadvertent discharges into a waterbody or indirectly by surface runoff, soil contamination, and ensuing transport during rainfall, or migration into groundwater and subsequent discharge from a spring into surface water. The jurisdiction over different spill types in Texas is divided among several state and federal agencies, each with specific responsibilities based on the nature and location of the spill. The TCEQ oversees spills that involve hazardous materials, chemicals, and other pollutants that affect state waters and land, including but not limited to oil-related spills (TCEQ 2022). The Texas General Land Office handles oil spills in Texas coastal waters, including bays, estuaries, and the Gulf of Mexico (Texas General Land Office 2025). The RRC is the primary agency for reporting and handling oil and gas spills, particularly those related to exploration, production, and transportation within the oil and gas sector (RRC 2024).

According to the Texas Administrative Code Title 30, Section 327.3, the release of oil, petroleum products, used oil, hazardous substances, industrial solid waste, or other materials into the environment must be reported to the TCEQ within 24 hours of the discovery. Rule § 327.4 specifies exact threshold quantities that trigger reporting to the TCEQ; for example, any quantity of water spilled into waters of the state that are sufficient to create a sheen, or any spill onto land of 210 gallons (5 barrels) or more (Texas Secretary of the State 1996). All major and minor release reports (spills) are archived in the TCEQ spills database, which can be downloaded online (TCEQ 2025a).

Spill data for Texas were retrieved from the TCEQ (2025a). Spill data for Texas include a variety of metadata, such as the type of spill (e.g., waste, water, air release), the spill classification (e.g., oil, water, hazardous, other), and the specific material released (e.g., produced water, diesel). At least one of these metadata categories are included for each spill entry; however, not all entries include sufficient detail to identify the material released. Using these metadata, a hierarchical classification scheme was devised to group spills into the following groups: gaseous spills, hazardous, oil, waste, and produced water. Additional details on frequently reported materials spilled are included herein; however, the list is not used to group spill types due to quantity of reported spill materials across the state. Additionally, the TCEQ includes the name of receiving waterbody, which was used to create a ternary grouping scheme with the following levels: Waters Impacted, Waters Not Impacted, and Unknown Impact to Waters. The TCEQ spill data does not include data on the quantity of each spill that was recovered.

**Table 4-4. Most Frequently Disclosed Ingredients Reported to FracFocus within the State of Texas from 2014 through 2024**

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Disclosures‡ (%) |
|---|---|---|---|---|
| Unnamed | Unknown | 299,123 | Unknown | 9.97 |
| Water | 7732-18-5 | 281,396 | 21.93 | 9.38 |
| Methanol | 67-56-1 | 95,806 | 0.03 | 3.19 |
| Hydrochloric Acid | 7647-01-0 | 68,683 | 0.19 | 2.29 |
| Crystalline Silica (Quartz) | 14808-60-7 | 67,410 | 8.67 | 2.25 |
| Sodium Hydroxide | 1310-73-2 | 43,144 | 0.01 | 1.44 |
| Sodium Chloride | 7647-14-5 | 40,993 | 0.04 | 1.37 |
| Ethylene Glycol | 107-21-1 | 39,558 | 0.02 | 1.32 |
| Acetic Acid | 64-19-7 | 38,399 | 0.00 | 1.28 |
| Proprietary | Proprietary | 34,920 | 0.02 | 1.16 |
| Guar Gum | 9000-30-0 | 29,996 | 0.16 | 1.00 |
| Ethanol | 64-17-5 | 28,912 | 0.01 | 0.96 |
| Glutaraldehyde | 111-30-8 | 28,761 | 0.03 | 0.96 |
| Ammonium Chloride | 12125-02-9 | 28,044 | 0.00 | 0.94 |
| Citric Acid | 77-92-9 | 27,964 | 0.01 | 0.93 |
| Ammonium Persulfate | 7727-54-0 | 25,410 | 0.02 | 0.85 |
| Isopropanol | 67-63-0 | 24,236 | 0.01 | 0.81 |
| Propargyl Alcohol | 107-19-7 | 24,144 | 0.00 | 0.81 |
| Hydrotreated Light Petroleum Distillate | 64742-47-8 | 18,247 | 0.03 | 0.61 |
| Didecyl Dimethyl Ammonium Chloride | 7173-51-5 | 17,022 | 0.01 | 0.57 |
| Potassium Hydroxide | 1310-58-3 | 16,673 | 0.01 | 0.56 |
| Surfactant | varies | 16,170 | 0.02 | 0.54 |
| Sodium Hypochlorite | 7681-52-9 | 15,345 | 0.00 | 0.51 |
| Aluminum Oxide | 1344-28-1 | 15,015 | 0.49 | 0.50 |
| Silica | 7631-86-9 | 14,503 | 7.91 | 0.48 |

Source: FracFocus (2025)

Note: Ingredient names and CAS numbers are not standardized in FracFocus, leading to widespread differences and discrepancies in CAS numbers, number of disclosures, and ingredient names. For this reason, the values and ingredients presented in this table are for general information only. Table includes only the top 25 most frequently disclosed ingredients, along with their percentages relative to the total list of ingredients; because all ingredients are not listed, percentages will not sum to 100%.

N/A = Not applicable

* FracFocus lists certain chemicals as proprietary, and no additional information is available regarding ingredient contents.

† The amount of the ingredient in the total hydraulic fracturing volume by percent mass (definition from FracFocus [2025] data dictionary).

‡ Percentage represents the number of documented chemical disclosures out of the total number of disclosures.

In 2024, the TCEQ received 139 reported oil spills, totaling 2,702 barrels. Of the total quantity of oil spilled, 586 barrels were reported to impact water resources, 409 barrels were reported to not impact water resources, and the impact on water resources was unknown for 1,707 barrels. Additionally, the following cumulative total spills were reported to the TCEQ in 2024: 140 pounds of gaseous material (classified as air), 5,015 barrels and an additional 1,583 pounds of waste, 918 barrels and an additional 76,146 pounds of hazardous material, and 2,561 barrels of water (see Tables 4-5 and 4-6 for additional details on reported spills, units, and cumulative totals, as reported to the TCEQ).

Within the state of Texas, the most frequently reported spill type is diesel fuel (in barrels), with 863 reported incidents between the years 2014 and 2024. Other frequently reported spill materials during the same time period include sewage (207 barrels), benzene (174 pounds), and gasoline (147 barrels) (Table 4-7).

**Table 4-5. Summary of Spill Counts Reported across the State of Texas from 2014 through 2024**

| Year | Waters Impacted | | | | | | Waters Not Impacted | | | | | | Unknown Impact to Waters | | | | | | Total Spills |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | |
| 2014 | 2 | 33 | 73 | 41 | 11 | 160 | ND | 34 | 56 | 10 | 2 | 102 | 14 | 45 | 75 | 57 | 26 | 217 | 479 |
| 2015 | 3 | 29 | 83 | 35 | 22 | 172 | 2 | 30 | 53 | 13 | 1 | 99 | 16 | 106 | 130 | 74 | 30 | 356 | 627 |
| 2016 | 3 | 28 | 62 | 18 | 41 | 152 | ND | 16 | 27 | 7 | 2 | 52 | 31 | 228 | 207 | 62 | 35 | 563 | 767 |
| 2017 | – | 32 | 60 | 21 | 36 | 149 | – | 12 | 24 | 7 | 1 | 44 | 60 | 240 | 226 | 77 | 19 | 622 | 815 |
| 2018 | 2 | 25 | 70 | 33 | 43 | 173 | ND | 15 | 29 | 9 | ND | 53 | 103 | 192 | 209 | 86 | 23 | 613 | 839 |
| 2019 | 1 | 22 | 72 | 23 | 21 | 139 | 1 | 13 | 54 | 6 | 1 | 75 | 51 | 90 | 160 | 67 | 20 | 388 | 602 |
| 2020 | 4 | 16 | 67 | 21 | 23 | 131 | 1 | 7 | 44 | 5 | ND | 57 | 105 | 63 | 102 | 37 | 32 | 339 | 527 |
| 2021 | 1 | 13 | 69 | 19 | 22 | 124 | ND | 4 | 21 | 2 | ND | 27 | 163 | 70 | 111 | 81 | 78 | 503 | 654 |
| 2022 | 1 | 6 | 35 | 18 | 13 | 73 | ND | 2 | 5 | 3 | 1 | 11 | 95 | 33 | 71 | 93 | 66 | 358 | 442 |
| 2023 | 3 | 8 | 32 | 15 | 9 | 67 | ND | 2 | 5 | 11 | ND | 18 | 24 | 19 | 76 | 87 | 51 | 257 | 342 |
| 2024 | 3 | 6 | 45 | 34 | 12 | 100 | ND | 2 | 6 | 5 | ND | 13 | 3 | 22 | 88 | 51 | 21 | 185 | 298 |
| **Total** | **23** | **218** | **668** | **278** | **253** | **1,440** | **4** | **137** | **324** | **78** | **8** | **551** | **665** | **1,108** | **1,455** | **772** | **401** | **4,401** | **6,392** |

Source: TCEQ (2025a)

–: no data available

ND = No Data

**Table 4-6. Summary of 2024 Spills Reported Across the State of Texas, Including Those That Impacted Waters, Did Not Impact Waters, and Had Unknown Impacts on Waters**

| Spill Type | Waters Impacted | | | | Waters Not Impacted | | | | Unknown Impact to Waters | | | | Total Barrels spilled | Total Pounds spilled | Total Spills |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barrels Spilled | Pounds Spilled | Total Spill Count Including Known Units | Total Spill Count Including Unknown Units | Barrels Spilled | Pounds Spilled | Total Spill Count Including Known Units | Total Spill Count Including Unknown Units | Barrels Spilled | Pounds Spilled | Total Spill Count Including Known Units | Total Spill Count Including Unknown Units | | | |
| Air | – | – | – | 3 | – | – | – | – | – | 140 | 2 | 1 | – | 140 | 6 |
| Waste | 3,589 | 332 | 8 | 26 | 40 | – | 4 | 1 | 1,386 | 1,251 | 29 | 22 | 5,015 | 1,583 | 90 |
| Hazardous | 18 | 53,000 | 6 | – | 3 | 22,000 | 2 | – | 897 | 1,146 | 21 | 1 | 918 | 76,146 | 30 |
| Water | 2,401 | – | 8 | 4 | – | – | – | – | 160 | – | 16 | 5 | 2,561 | – | 33 |
| Oil | 586 | 10 | 42 | 3 | 409 | – | 5 | 1 | 1,707 | 10 | 85 | 3 | 2,702 | 10 | 139 |
| **Total** | **6,594** | **53,342** | **64** | **36** | **452** | **22,000** | **11** | **2** | **4,150** | **2,547** | **153** | **32** | **11,196** | **77,879** | **298** |

Source: TCEQ (2025)

Note: "–" = No numeric data, representing entries with known units and no numeric spill entry. For the purposes of this report, it is assumed that these entries represent unknown spill quantities.

ND = No data due to no reporting

Although many spill entries with unknown units include numeric entries, these values are not reported herein to avoid reporting across different units. Regardless, the spill is reported here as a spill with a non-zero quantity spilled.

–: no data available

**Table 4-7. Summary of the Most Reported Spill Materials to the State of Texas from 2014 to 2024, Categorized by Unit of Spill**

| Material | Unit | Spills Reported | Total Reported Quantity Spilled |
|---|---|---|---|
| Diesel fuel | bbl | 863 | 10,312 |
| Sewage | bbl | 207 | 130,592 |
| Other | bbl | 144 | 205,477 |
| Gasoline | bbl | 147 | 40,030 |
| Diesel/gasoline/water mixture | bbl | 117 | 5,302 |
| Hydraulic Oil | bbl | 123 | 435 |
| Crude Oil | bbl | 115 | 7,950 |
| Wastewater discharge, municipal | bbl | 82 | 30,790 |
| Gasoline, automotive or aviation | bbl | 87 | 1,215 |
| Diesel Oil #2/ Guar Gum | bbl | 78 | 571 |
| Oil | bbl | 78 | 1,347 |
| Benzene | lbs | 174 | 14,204 |
| Sulfur Dioxide | lbs | 145 | 399,952 |
| Vinyl Chloride | lbs | 84 | 277 |
| Ethylene dichloride | lbs | 53 | 44,121 |
| Ethylene oxide | lbs | 40 | 24,255 |
| Hydrogen Sulfide | lbs | 36 | 7,494 |
| 1,3-Butadiene | lbs | 104 | 7,005 |
| Vinyl Chloride Monomer | lbs | 33 | 273 |
| N/A | Unknown | 448 | – |
| Other | Unknown | 110 | – |
| Diesel fuel | Unknown | 46 | 164 |
| Unknown | Unknown | 39 | – |
| Gasoline | Unknown | 35 | – |
| Unknown Substance | Unknown | 32 | – |
| Vinyl Chloride | Unknown | 26 | – |
| Wastewater discharge, industrial | Unknown | 25 | – |
| Unknown or other oil | Unknown | 22 | – |
| Oil | Unknown | 21 | – |
| Smoke | Unknown | 21 | – |

bbl = barrels; lbs = pounds; N/A = Not applicable

Source: TCEQ (2025a)

–: no data available


**Figure 4-2. Total reported spills across Texas from 2014 to 2024, categorized by spill type and water impact.**

## 4.4 CENTRAL AND NORTH TEXAS AND TEXAS-OKLAHOMA PANHANDLES, HUGOTON EMBAYMENT PLAY

This section details several significant oil and gas plays in central and northern Texas, including productive portions of the Barnett Shale, Granite Wash, and other prolific hydrocarbon-bearing formations that span Denton, Grayson, Hemphill, Hutchinson, Tarrant, and Wise counties. This section specifically presents water use and water quantity data for these targeted oil and gas counties within the Central and North Texas-Oklahoma Panhandles, as well as the Hugoton Embayment Play.

### 4.4.1 Hydrogeologic Setting

The regions of Central and North Texas, along with the Texas-Oklahoma Panhandle, host a significant amount of oil and gas resources. Among these are the Granite Wash Formation, situated in the eastern Texas Panhandle and Western Oklahoma, and the Barnett Shale, which is found in North Central Texas. Additionally, the largest oil and gas resource throughout this region, the Hugoton Embayment Play, extends across parts of Kansas, Oklahoma, and Texas. The Pennsylvanian Granite Wash Formation is a tight, sand-dominated unit. Horizontal drilling advancements have been successfully implemented in the Granite Wash Formation and has enhanced its production (RRC 2025a). The Barnett Shale consists of thick sequences of organic-rich shale and spans about 5,000 square miles. Additionally, the Barnett Shale is considered one of the largest natural gas fields in the continental United States (RRC 2025b). The Hugoton Embayment, another significant source of natural gas, is a carbonate reservoir characterized by high porosity, which facilitates the accumulation of natural gas from adjacent gas-producing shale formations (KGS 2025a).

Within the Central and North Texas and Texas-Oklahoma Panhandle, Hugoton Embayment Play are four principal aquifers: the Blaine aquifer, the Seymour aquifer, the Edwards-Trinity aquifer system, and the High Plains aquifer, which is the most extensive in this region (USGS 2003). Additionally, there are several minor aquifers that are not considered significant water resources throughout the Central and North Texas and Texas-Oklahoma Panhandle, Hugoton Embayment Play.

### 4.4.2 Water Quality

The chemical composition of water used during the hydraulic fracturing process varies due to differences in fracturing techniques used by oil and gas companies. A typical oil/gas well uses approximately 20 to 25 unique chemicals during the hydraulic fracturing process, but in some cases, more than 60 distinct chemicals can be used.

According to FracFocus, from 2014 through 2024, water was the most commonly disclosed ingredient in hydraulic fracturing operations with 189 entries, representing 9.8% of all FracFocus entries and 34.3% of the total hydraulic fracturing jobs (chemical volume by percentage mass) within the Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Play. Methanol (73 disclosures) and ethanol (70 disclosures) represent the next most commonly reported chemicals constituents of hydraulic fracturing operations (see Table 4-8).

Additionally, 144 entries within the Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Play did not include an ingredient name, CAS number, or volume used, but were still entered into the FracFocus registry as unnamed ingredients used for some purpose during the hydraulic fracturing process. For the purpose of this report, these entries that lack any details on ingredient names or volumes are referred to as “unnamed” ingredients. Unnamed ingredients represented 7.45% of all FracFocus entries from 2014 through 2024; however, given that they do not have reported volumes, it is unknown what percentage of the total hydraulic fracturing jobs (volume by percent mass) they represent. Unnamed ingredients are distinct from those reported as "proprietary," which may lack details on specific chemical constituents, but still include information on suppliers, trade names, chemical properties (e.g., additives or mass), and reported volumes used for hydraulic fracturing. Proprietary disclosures have been grouped into a single ingredient category in Table 4-8.

In total, 1,934 unique chemical constituent disclosures in the Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Play were entered in the FracFocus database (see Table 4-8) (FracFocus 2025). However, because ingredient names and CAS numbers are not standardized in FracFocus, many "unique" chemical recordings may represent the same chemicals recorded differently. For a detailed explanation of how FracFocus data are analyzed and summarized, please refer to Appendix A.

Spill data for Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Play were retrieved from the TCEQ (2025b). Spill data for Texas includes a variety of metadata, such as the type of spill (e.g., waste, water, air), the spill classification (e.g., oil, water, hazardous, other), and the specific material released (e.g., produced water, diesel). At least one of these metadata categories are included for each spill entry; however, not all entries include sufficient detail to identify the material released. Using these metadata, spills were grouped by spill material as gaseous, hazardous waste, or produced water. Additional details on frequently reported spilled materials are included herein; however, spills are not grouped by spill type (i.e., the cause of the spill) due to the diversity of materials reported statewide. Additionally, the TCEQ includes the name of the receiving waterbody, which was used to create a ternary grouping scheme with the following levels: Waters Impacted, Waters Not Impacted, and Unknown Impact to Waters. The TCEQ spill data does not include data on the quantity of each spill that was recovered.

Spills in Central and North Texas and Texas-Oklahoma Panhandle, Hugoton Embayment Play totaled 341 from 2014 to 2024 (Table 4-9). Oil is the most commonly spilled material and has accounted for 225 spills since 2014. In 2024, 37 spills occurred, with 13 spills reported to have affected either surface water or groundwater resources and 24 reported as uncertain water impact. Notably, there were 0 reported spills of both water and air (gaseous material) in 2024. In 2024, 25 of the 37 reported spills were oil spills and nine of them had a groundwater or surface water impact.

**Table 4-8. Most Frequently Disclosed Ingredients Reported to FracFocus for Targeted Counties within Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Play from 2014 through 2024**

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Entries‡ (%) |
|---|---|---|---|---|
| Water | 7732-18-5 | 189 | 34.27 | 9.77 |
| Unnamed | Unknown | 144 | Unknown | 7.45 |
| Methanol | 67-56-1 | 73 | 0.00 | 3.77 |
| Ethanol | 64-17-5 | 70 | 0.00 | 3.62 |
| Crystalline Silica (Quartz) | 14808-60-7 | 63 | 8.39 | 3.26 |
| Ammonium Persulfate | 7727-54-0 | 42 | 0.03 | 2.17 |
| Sodium Chloride | 7647-14-5 | 41 | 0.01 | 2.12 |
| Petroleum Distillates | varies | 41 | 0.02 | 2.12 |
| Proprietary | Proprietary | 40 | 0.03 | 2.07 |
| Didecyl Dimethyl Ammonium Chloride | 7173-51-5 | 36 | 0.00 | 1.86 |

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Entries‡ (%) |
|---|---|---|---|---|
| Acetic Acid | 64-19-7 | 35 | 0.00 | 1.81 |
| Hydrochloric Acid | 7647-01-0 | 28 | 0.12 | 1.45 |
| Propargyl Alcohol | 107-19-7 | 28 | 0.00 | 1.45 |
| Olefins | varies | 27 | 0.00 | 1.40 |
| Citric Acid | 77-92-9 | 24 | 0.00 | 1.24 |
| Ammonium Chloride | 12125-02-9 | 22 | 0.00 | 1.14 |
| Glutaraldehyde | 111-30-8 | 22 | 0.00 | 1.14 |
| Ethylene Glycol | 107-21-1 | 20 | 0.01 | 1.03 |
| Oxyalkylated Phenolic Resin | varies | 17 | 0.00 | 0.88 |
| Naphthalene | 91-20-3 | 14 | 0.00 | 0.72 |
| Acetic Anhydride | 108-24-7 | 13 | 0.01 | 0.67 |
| Alcohols, C12-16, Ethoxylated | 68439-45-2 | 13 | 0.01 | 0.67 |
| Alcohols, C12-C18 Ethoxylated | 68213-23-0 | 13 | 0.00 | 0.67 |
| 2-Propenoic Acid, Polymer with 2-Propenamide | 25085-02-3 | 12 | 0.02 | 0.62 |
| Alkyl Dimethyl Benzyl Ammonium Chloride | 8001-54-5 | 12 | 0.00 | 0.62 |

Source: FracFocus (2025)

Note: Ingredient names and CAS numbers are not standardized in FracFocus, leading to widespread differences and discrepancies in CAS numbers, number of disclosures, and ingredient names. For this reason, the values and ingredients presented in this table are for general information only. The data summarized in this table represents the targeted counties, listed in Section 1.2, within the boundary of the Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Plays. Table includes only the top 25 most frequently disclosed ingredients, along with their percentages relative to the total list of ingredients; because all ingredients are not listed, percentages will not sum to 100%.

N/A = Not applicable.

* FracFocus lists certain chemicals as proprietary, and no additional information is available regarding ingredient contents.

† The amount of the ingredient in the total hydraulic fracturing volume by percent mass (definition from FracFocus [2025] data dictionary).

‡ Percentage represents the number of documented chemical disclosures out of the total number of disclosures.

## Table 4-9. Summary of Spill Counts Reported for Targeted Counties in the Central and North Texas Stratigraphy and Texas-Oklahoma Panhandles, Hugoton Embayment Plays from 2014 through 2024

| Year | Waters Impacted | | | | | | Waters Not Impacted | | | | | | Unknown Impact to Waters | | | | | | Total Spills |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | |
| 2014 | – | – | 2 | – | – | 2 | – | – | 1 | – | – | 1 | 1 | 9 | 7 | 5 | – | 22 | 25 |
| 2015 | – | 2 | 9 | 2 | – | 13 | – | – | 5 | 1 | – | 6 | – | 8 | 10 | 7 | 3 | 28 | 47 |
| 2016 | – | – | 1 | 1 | – | 2 | – | – | 5 | 2 | – | 7 | – | 5 | 9 | 5 | – | 19 | 28 |
| 2017 | – | 1 | 6 | 1 | 1 | 9 | – | 1 | 2 | 1 | – | 4 | – | 2 | 13 | 3 | 1 | 19 | 32 |
| 2018 | – | 1 | 11 | – | 4 | 16 | – | – | 4 | – | – | 4 | – | – | 21 | 3 | – | 24 | 44 |
| 2019 | – | 2 | 12 | 1 | 2 | 17 | – | 1 | 13 | 3 | – | 17 | 1 | – | 6 | 1 | – | 8 | 42 |

| Year | Waters Impacted | | | | | | Waters Not Impacted | | | | | | Unknown Impact to Waters | | | | | | Total Spills |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | |
| 2020 | – | – | 12 | – | 3 | 15 | – | 1 | 12 | 1 | – | 14 | – | 1 | 4 | – | – | 5 | 34 |
| 2021 | – | – | 3 | – | 2 | 5 | – | – | 6 | – | – | 6 | – | 1 | 2 | 1 | – | 4 | 15 |
| 2022 | – | – | 3 | – | 2 | 5 | – | 1 | – | – | – | 1 | – | – | 6 | 2 | – | 8 | 14 |
| 2023 | – | 1 | 5 | – | 2 | 8 | – | – | – | – | – | 0 | 1 | 1 | 10 | 3 | – | 15 | 23 |
| 2024 | – | 2 | 9 | 2 | – | 13 | – | – | – | – | – | 0 | – | 6 | 16 | 2 | – | 24 | 37 |
| **Total** | **0** | **9** | **73** | **7** | **16** | **105** | **0** | **4** | **48** | **8** | **0** | **60** | **3** | **33** | **104** | **32** | **4** | **176** | **341** |

Source: TCEQ (2025a)

Note: TCEQ spill reporting does not include sufficient detail to report on quantities of each spill and recovery efforts. Reported incidents are based on the number of unique incident IDs during each calendar year. Each reported incident may include an oil spill, a water spill, or both. The data summarized in this table represents the targeted counties, listed in Section 1.2, within the boundary of the Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Plays.

–: no data available

### 4.4.3 Water Quantity

In 2015, the combined fresh and saline water withdrawals for all water use categories across the Central, North Texas and Texas-Oklahoma Panhandle totaled 261,093 AF (Table 4-10, Figure 4-3) (Dieter et al. 2018). Thermoelectric power accounted for the largest withdrawal (48%) of both total and surface water withdrawals, or 124,627 AF. The second highest consumer category was irrigation which accounted for 25% (65,204 AF) of the total withdrawals and was the top user of groundwater. Public water usage accounted for 17% of the total water withdrawn, or 44,716 AF. Out of the 14,170 AF used for mining (5% of total withdrawals), 10,731 AF was saline making the mining category the primary user of saline water. Industrial and livestock withdrawals accounted for 2% each of total water usage and was followed by domestic and aquaculture water use, at 1% and less than 1%, respectively.

Total water usage by oil and gas wells in Central, North Texas and Texas-Oklahoma Panhandle for hydraulic fracturing has steadily increased from 2014 to present with a peak of 27,254.70 AF in 2024 (Table 4-11). In contrast, water use for non-hydraulic fracturing has steadily decreased from 2014 with a lowest recorded value of 42.64 AF in 2024. Overall, total water usage considering oil and gas wells for both hydraulic fracturing and non-hydraulic fracturing is descending with a value of 1,407.54 AF for 2024 which is 732 AF less than 2023. In addition, the total number of reported wells decreased from 100 in 2023 to 52 in 2024.

Total hydraulic fracturing water use and non-hydraulic fracturing water use between the years 2014 and 2024 is estimated to be 28,806 AF (see Table 4-11). The reported total is an estimation and does not consider variables such as differences in water use between vertical and horizontal wells and local geology; additionally, this total assumes that FracFocus data is accurate and represents the total number of wells across the Central, North Texas, and Texas-Oklahoma Panhandle Play.

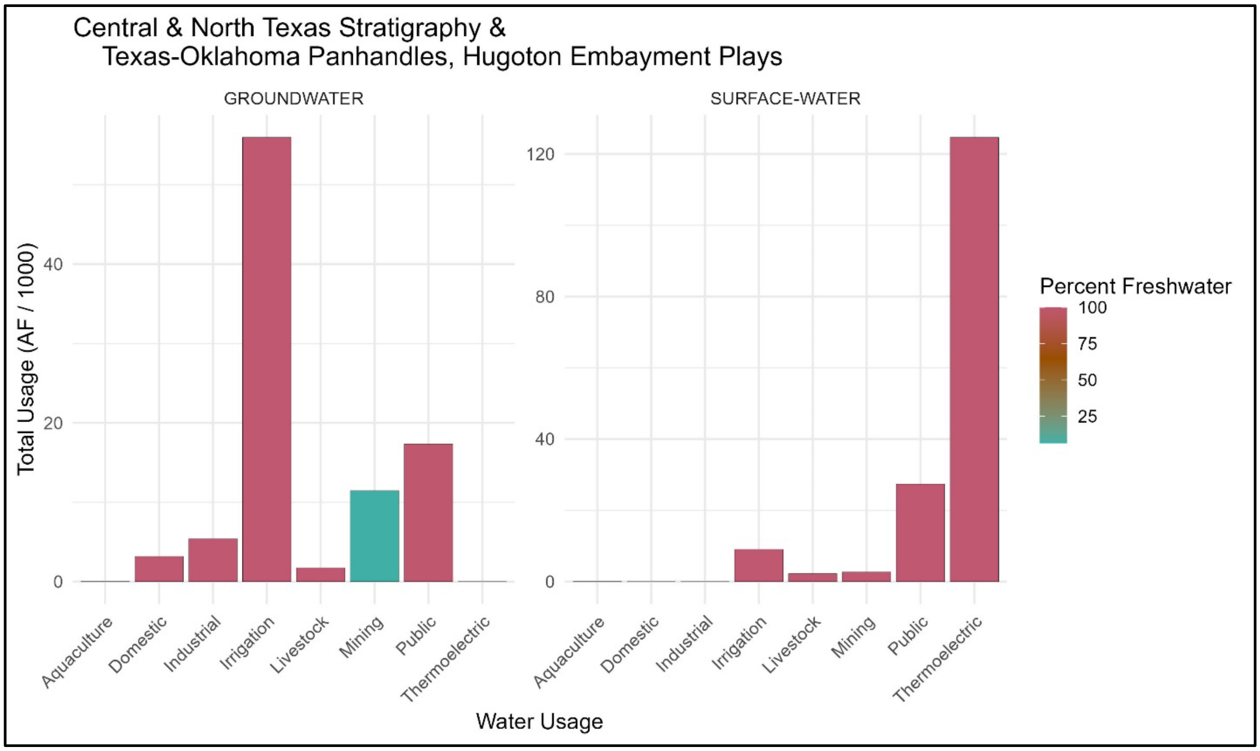


**Figure 4-3. Water withdrawal by category for Targeted Counties in the Central and North Texas Stratigraphy and Texas-Oklahoma Panhandles, Hugoton Embayment Plays in 2015, colored by the percentage of freshwater withdrawal out of the total water withdrawal (freshwater plus saline water withdrawal) (Dieter et al. 2018).**

**Table 4-10. Central and North Texas Stratigraphy and Texas-Oklahoma Panhandle, Hugoton Embayment Play: Water Withdrawal by Category in 2015 for Targeted Counties**

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Withdrawal (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Total Withdrawal (%) | Saline* | Total Withdrawal (%) | | |
| Aquaculture | 11 | – | 11 | <1% | 11 | – | 11 | <1% | 22 | <1% | 0 | <1% | 22 | <1% |
| Domestic | 0 | – | 0 | <1% | 3,170 | – | 3,170 | 1% | 3,170 | 1% | 0 | <1% | 3,170 | 1% |
| Industrial | 0 | – | 0 | <1% | 5,399 | – | 5,399 | 2% | 5,399 | 2% | 0 | <1% | 5,399 | 2% |
| Irrigation | 9,062 | – | 9,062 | 3% | 55,962 | – | 55,962 | 21% | 65,024 | 25% | 0 | <1% | 65,024 | 25% |
| Livestock | 2,229 | – | 2,229 | <1% | 1,736 | – | 1,736 | <1% | 3,965 | 2% | 0 | <1% | 3,965 | 2% |
| Mining | 2,711 | – | 2,711 | 1% | 728 | 10,731 | 11,459 | 4% | 3,439 | 1% | 10,731 | 4% | 14,170 | 5% |
| Public Water Supply | 27,376 | – | 27,376 | 10% | 17,183 | 157 | 17,340 | 7% | 44,559 | 17% | 157 | <1% | 44,716 | 17% |
| Thermoelectric Power | 124,627 | – | 124,627 | 48% | 0 | – | 0 | <1% | 124,627 | 48% | 0 | <1% | 124,627 | 48% |
| **Total** | **166,016** | **–** | **166,016** | **64%** | **84,189** | **–** | **95,077** | **36%** | **250,205** | **96%** | **10,888** | **4%** | **261,093** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water withdrawal data are in AF/year unless otherwise indicated.

* Saline water is defined as water containing dissolved solids of 1,000 mg/L or more. Saline water withdrawals are not reported for domestic, irrigation, or livestock water withdrawal (Dieter et al. 2018).

–: no data available

**Table 4-11. Water Use by Oil and Gas Wells for Hydraulic Fracturing and Non-Hydraulic Fracturing for Targeted Counties in the Central and North Texas and Texas-Oklahoma Panhandle, Hugoton Embayment Play from 2014 through 2024**

| Year | Federal HF Water Use (AF) | Tribal HF Water Use (AF) | Non-Federal/ Non-Tribal HF Water Use* (AF) | Total HF Water Use (AF) | Federal HF Water Use (%) | Federal HF Cumulative Water Use (AF) | Total HF Cumulative Water Use (AF) | Average HF Water Use per Well* (AF) | Total No. of Federal Wells | Total No. of Wells | Total Non-HF Water Use (AF) | Total Water Use (HF plus non-HF) (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 | 36.9 | – | 6,340 | 6,376.5 | 1% | 36.9 | 6,376.5 | 12.5 | 5 | 512 | 419.84 | 6,796.34 |
| 2015 | 66.1 | – | 4,627 | 4,693.2 | 1% | 103.00 | 11,069.7 | 12.1 | 4 | 389 | 318.98 | 5,012.18 |
| 2016 | 59.9 | – | 904 | 964.2 | 6% | 162.90 | 12,033.9 | 11.5 | 3 | 84 | 68.88 | 1,033.08 |
| 2017 | – | – | 1,714 | 1,713.9 | – | 162.90 | 13,747.8 | 19.0 | – | 90 | 73.80 | 1,787.70 |
| 2018 | 75.1 | – | 2,409 | 2,483.7 | 3% | 238.00 | 16,231.5 | 20.0 | 4 | 124 | 101.68 | 2,585.38 |
| 2019 | – | – | 1,086 | 1,086.0 | – | 238.00 | 17,317.5 | 14.9 | – | 73 | 59.86 | 1,145.86 |
| 2020 | – | – | 263 | 262.9 | – | 238.00 | 17,580.4 | 5.2 | – | 51 | 41.82 | 304.72 |
| 2021 | – | – | 2,250 | 2,250.2 | – | 238.00 | 19,830.6 | 11.4 | – | 198 | 162.36 | 2,412.56 |
| 2022 | – | – | 4,001 | 4,001.4 | – | 238.00 | 23,832.0 | 18.3 | – | 219 | 179.58 | 4,180.98 |
| 2023 | – | – | 2,058 | 2,057.8 | – | 238.00 | 25,889.8 | 20.6 | – | 100 | 82.00 | 2,139.80 |
| 2024 | – | – | 1,365 | 1,364.9 | – | 238.00 | 27,254.7 | 26.2 | – | 52 | 42.64 | 1,407.54 |
| **Total** | **238.0** | **–** | **27,017** | **27,254.7** | **1%** | **238.00** | **27,254.7** | **21.7†** | **16** | **1,892** | **1,551.44** | **28,806.14** |

Source: FracFocus (2025). Data only for those wells that reported water use to FracFocus are presented; well data may be incomplete due to state reporting requirements and may not reflect total active wells and exact water use.

Note: Produced water is naturally occurring water that exists in a formation that is being targeted for mineral extraction and is produced as a byproduct. The data summarized in this table represents the targeted counties, listed in Section 1.2, within the boundary of the Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Plays.

* Includes both federal and non-federal wells.

† 3-year average (2021–2024)

–: no data available
HF = hydraulic fracturing; Non-HF = non-hydraulic fracturing

# 4.5 EAST TEXAS AND GULF COAST TEXAS, PERMIAN BASIN AND SHELF PLAY

This section provides an overview of several major oil and gas plays in the East Texas and Gulf Coast Texas, and Permian Basin and Shelf regions, which encompass a wide range of prolific hydrocarbon-producing formations. These plays span numerous counties, including Andrews, Burleson, Calhoun, Cherokee, Comal, Culberson, Delta, Gaines, Galveston, Guadalupe, Houston, Jackson, Jasper, Karnes, Kenedy, Lee, Live Oak, Loving, McMullen, Montgomery, Sabine, San Augustine, San Jacinto, Shelby, Trinity, Walker, Washington, Winkler, and Zapata Counties.

## 4.5.1 Hydrogeologic Setting

The East Texas and Gulf Coast Texas, and Permian Basin and Shelf oil and gas plays consists of two distinct stratigraphic regions; however, they were grouped as one region due to similarities in water use between each region. The Permian Basin, a sedimentary rock formation spanning from west Texas into New Mexico, has been a producing oil and natural gas field since the early 1900s. The Permian Basin is the largest oil-producing region in the United States, accounting for over 39% of total United States oil production (U.S. Energy Information Administration 2020).

The East Texas and Gulf Coast Texas sediments are characterized by multi-layered flow system composed of Tertiary and Quaternary clastic sediments. Sediments form two main aquifer systems that span 128,000 square miles onshore and offshore and range from only a few feet to 12,000 feet in thickness. The older Texas coastal uplands system includes four aquifers and two confining units within the Wilcox and Claiborne Groups, bounded below by the Midway confining unit or the top of the geopressured zone, and above by the Vicksburg-Jackson confining unit. The younger coastal lowlands system consists of five permeable zones and two confining units, ranging in age from the Oligocene to the Holocene. Hydrogeologic units from both systems are exposed in bands that trend parallel to the coastline, dipping and thickening gulfward (Ryder 1988).

## 4.5.2 Water Quality

The chemical composition of water used during the hydraulic fracturing process varies due to differences in fracturing techniques used by oil and gas companies. A typical oil/gas well uses approximately 20 to 25 unique chemicals during the hydraulic fracturing process, but in some cases, more than 60 distinct chemicals can be used.

From 2014 through 2024, most entries (2,288) within the East Texas and Gulf Coast Texas, and Permian Basin and Shelf Play were unnamed (i.e., did not include an ingredient name, CAS number, or volume used, but were still entered into the FracFocus registry as unnamed ingredients used for some purpose during the hydraulic fracturing process). Unnamed ingredients represented 13.23% of all FracFocus entries within the East Texas and Gulf Coast Texas, and Permian Basin and Shelf Play; however, given that they do not have reported volumes, it is unknown what percentage of the total hydraulic fracturing jobs (volume by percent mass) they represent. Unnamed ingredients are distinct from those reported as "proprietary," which may lack details on specific chemical constituents, but still include information on suppliers, trade names, chemical properties (e.g., additives or mass), and reported volumes used for hydraulic fracturing. Proprietary disclosures have been grouped into a single ingredient category in Table 4-12.

Not including unnamed ingredients, water is the most commonly disclosed ingredient in hydraulic fracturing operations within the East Texas and Gulf Coast Texas, and Permian Basin and Shelf Play with 1,587 entries, representing 9.18% of all FracFocus entries and 30.9% of the total hydraulic fracturing jobs (chemical volume by percentage mass) from 2014 through 2024. Crystalline silica (533 disclosures) and methanol (528 disclosures) represent the next most commonly reported chemicals constituents of hydraulic fracturing operations (see Table 4-12) (FracFocus 2025). For a detailed explanation of how FracFocus data are analyzed and summarized, please refer to Appendix A.

In total, 17,289 unique chemical constituent disclosures in the East Texas and Gulf Coast Texas, and Permian Basin and Shelf Play were entered in the FracFocus database (see Table 4-12) (FracFocus 2025). However, because ingredient names and CAS numbers are not standardized in FracFocus, many "unique" chemical recordings may represent the same chemicals recorded differently. For a detailed explanation of how FracFocus data are analyzed and summarized, please refer to Appendix A

Spill data for the East Texas and Gulf Coast Texas, and Permian Basin and Shelf Play were retrieved from the TCEQ (2024b). Spill data for Texas includes a variety of metadata, such as the type of spill (e.g., waste, water, air), the spill classification (e.g., oil, water, hazardous, other), and the specific material released (e.g., produced water, diesel). At least one of these metadata categories are included for each spill entry; however, not all entries include sufficient detail to identify the material released. Using these metadata, spills were grouped by spill material as gaseous, hazardous waste, or produced water. Additional details on frequently reported spilled materials are included herein; however, spills are not grouped by spill type (i.e., the cause of the spill) due to the diversity of materials reported statewide. Additionally, the TCEQ includes the name of the receiving waterbody, which was used to create a ternary grouping scheme with the following levels: Waters Impacted, Waters Not Impacted, and Unknown Impact to Waters. The TCEQ spill data does not include data on the quantity of each spill that was recovered.

Spills in Central and North Texas and Texas-Oklahoma Panhandle, Hugoton Embayment Play totaled 468 from 2014 to 2024 (Table 4-13). The number of spills in 2024 was about half the number of spills in 2023, which were reported as 12 and 20, respectively. Out of the 12 reported spills, five impacted either surface water or groundwater and seven were reported as uncertain in water impact. Since 2014, the most commonly spilled material is oil with 50 spills affecting water, 10 that had no effect on water resources, and 96 spills with uncertain water impact. The highest number of spills in any given year was in 2018, with 72 spills.

**Table 4-12. Most Frequently Disclosed Ingredients Reported to FracFocus within Targeted Counties in the East Texas and Gulf Coast Texas and Permian Basin and Shelf Plays from 2014 through 2024**

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Disclosures‡ (%) |
|---|---|---|---|---|
| Unnamed | Unknown | 2,288 | Unknown | 13.23 |
| Water | 7732-18-5 | 1,587 | 30.90 | 9.18 |
| Crystalline Silica (Quartz) | 14808-60-7 | 533 | 10.33 | 3.08 |
| Methanol | 67-56-1 | 528 | 0.01 | 3.05 |
| Hydrochloric Acid | 7647-01-0 | 432 | 0.10 | 2.50 |
| Glutaraldehyde | 111-30-8 | 247 | 0.03 | 1.43 |
| Ethanol | 64-17-5 | 241 | 0.00 | 1.39 |
| Acetic Acid | 64-19-7 | 204 | 0.01 | 1.18 |
| Ethylene Glycol | 107-21-1 | 187 | 0.01 | 1.08 |

| Ingredient Name* | CAS Registry Number | Number of Disclosures | Percentage of Hydraulic Fracturing Jobs† (%) | Percentage of Total Number of FracFocus Disclosures‡ (%) |
|---|---|---|---|---|
| Ammonium Chloride | 12125-02-9 | 182 | 0.00 | 1.05 |
| Guar Gum | 9000-30-0 | 178 | 0.14 | 1.03 |
| Didecyl Dimethyl Ammonium Chloride | 7173-51-5 | 174 | 0.02 | 1.01 |
| Sodium Chloride | 7647-14-5 | 168 | 0.12 | 0.97 |
| Hydrotreated Light Petroleum Distillate | 64742-47-8 | 150 | 0.05 | 0.87 |
| Sodium Hydroxide | 1310-73-2 | 148 | 0.02 | 0.86 |
| Ammonium Persulfate | 7727-54-0 | 138 | 0.09 | 0.80 |
| Proprietary | Proprietary | 136 | 0.02 | 0.79 |
| Propargyl Alcohol | 107-19-7 | 130 | 0.00 | 0.75 |
| Citric Acid | 77-92-9 | 119 | 0.00 | 0.69 |
| Alcohols, C12-16, Ethoxylated | 68439-45-2 | 96 | 0.00 | 0.56 |
| Ethoxylated Alcohol | varies | 93 | 0.00 | 0.54 |
| Potassium Hydroxide | 1310-58-3 | 93 | 0.01 | 0.54 |
| Isopropanol | 67-63-0 | 88 | 0.04 | 0.51 |
| Aluminum Oxide | 1344-28-1 | 83 | 0.04 | 0.48 |
| Surfactant | Variable | 77 | 0.04 | 0.45 |

Source: FracFocus (2025)

Note: Ingredient names and CAS numbers are not standardized in FracFocus, leading to widespread differences and discrepancies in CAS numbers, number of disclosures, and ingredient names. For this reason, the values and ingredients presented in this table are for general information only. The data summarized in this table represents the targeted counties, listed in Section 1.2, within the boundary of the East Texas and Gulf Coast Texas Stratigraphy and Permian Basin Shelf Plays. Table includes only the top 25 most frequently disclosed ingredients, along with their percentages relative to the total list of ingredients; because all ingredients are not listed, percentages will not sum to 100%.

* FracFocus lists certain chemicals as proprietary, and no additional information is available regarding ingredient contents.

† The amount of the ingredient in the total hydraulic fracturing volume by percent mass (definition from FracFocus [2025] data dictionary).

‡ Percentage represents the number of documented chemical disclosures out of the total number of disclosures.

## Table 4-13. Summary of Spill Counts Reported for Targeted Counties in the East Texas and Gulf Coast Texas and Permian Basin and Shelf Plays from 2014 through 2024

| Year | Waters Impacted | | | | | | Waters Not Impacted | | | | | | Unknown Impact to Waters | | | | | | Total Spills |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | |
| 2014 | 1 | 6 | 8 | 2 | 1 | 18 | – | 2 | 3 | 1 | – | 6 | 3 | 2 | 2 | 2 | – | 9 | 33 |
| 2015 | – | 1 | 8 | 2 | – | 11 | – | 2 | 4 | – | – | 6 | – | 9 | 10 | 2 | 2 | 23 | 40 |
| 2016 | – | 1 | 2 | – | 5 | 8 | – | – | – | – | – | 0 | 3 | 29 | 21 | 3 | 2 | 58 | 66 |
| 2017 | – | 1 | 2 | 1 | 3 | 7 | – | – | – | 1 | – | 1 | 4 | 10 | 12 | 5 | 19 | 50 | 58 |
| 2018 | 1 | 1 | 7 | 2 | 4 | 15 | – | 2 | 1 | – | – | 3 | 3 | 9 | 14 | 6 | 22 | 54 | 72 |
| 2019 | – | 1 | 5 | 1 | 1 | 8 | – | 1 | 2 | – | – | 3 | 4 | 10 | 15 | 4 | 4 | 37 | 48 |
| 2020 | – | 1 | 3 | 1 | 1 | 6 | – | – | – | – | – | 0 | 6 | 7 | 5 | 2 | 6 | 26 | 32 |

| Year | Waters Impacted | | | | | | Waters Not Impacted | | | | | | Unknown Impact to Waters | | | | | | Total Spills |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | Air | Hazardous | Oil | Waste | Produced Water | Total | |
| 2021 | – | 3 | 6 | 1 | 2 | 12 | – | – | – | – | – | 0 | 20 | 2 | 6 | 5 | 3 | 36 | 48 |
| 2022 | – | 1 | 8 | 2 | 2 | 13 | – | – | – | – | – | 0 | 8 | 2 | 4 | 11 | 1 | 26 | 39 |
| 2023 | 2 | 1 | – | 1 | – | 4 | – | – | – | 2 | – | 2 | 2 | – | 5 | 7 | – | 14 | 20 |
| 2024 | 1 | 1 | 1 | 2 | – | 5 | – | – | – | – | – | 0 | 1 | – | 2 | 3 | 1 | 7 | 12 |
| **Total** | **5** | **18** | **50** | **15** | **19** | **107** | **0** | **7** | **10** | **4** | **0** | **21** | **54** | **80** | **96** | **50** | **60** | **340** | **468** |

Source: TCEQ (2025a)

Note: TCEQ spill reporting does not include sufficient detail to report on quantities of each spill and recovery efforts. Reported incidents are based on the number of unique incident IDs during each calendar year. Each reported incident may include an oil spill, a water spill, or both. The data summarized in this table represents the targeted counties, listed in Section 1.2, within the boundary of the East Texas Gulf Coast Texas Stratigraphy and Permian Basin Shelf Plays.

–: no data available

### 4.5.3 Water Quantity

In 2015, the combined fresh and saline water withdrawals for all water use categories in the East Texas and Gulf Coast Texas, Permian Basin, and Shelf Play totaled 1,994,111 AF (Table 4-14, Figure 4-4) (Dieter et al. 2018). The largest category of water withdrawal was thermoelectric power at 840,980 AF (42%) followed by irrigation at 587,739 AF (29%). Thermoelectric power and irrigation were also the primary users of surface water and groundwater, respectively. Mining was the only notable user of saline water, at about 14% or 277,661 AF of the total withdrawals. Public water supply accounted for 8% (155,610 AF) of total water supply and industrial uses used approximately 4% (73,089 AF). Use associated with livestock, domestic, and aquaculture used relatively minimal amounts of 2%, <1%, and <1%, respectively.

According to data from Table 4-15, covering the East Texas and Gulf Coast Texas, Permian Basin, and Shelf Play regions, total water consumption for hydraulic fracturing associated with oil and gas wells from 2014 to 2024 is estimated at 562,794.6 AF. In 2024, water use for hydraulic fracturing declined by 5,042.4 AF compared to 2023, totaling 70,151.50 AF. Similarly, water use for non-hydraulic fracturing activities decreased from 1,143.9 AF in 2023 to 1,047.96 AF in 2024.

As in the previous year, there were no reported instances of tribal water use for hydraulic fracturing in 2024. The majority of water used continues to be attributed to non-federal sources. Since 2014, 16,975 wells have been reported, of which 385 are classified as federal wells.

The reported totals are estimations and do not consider variables such as differences in water use between vertical and horizontal wells and local geology; additionally, this total assumes that FracFocus data is accurate and represents the total number of wells across the East Texas and Gulf Coast Texas, Permian Basin, and Shelf Play.

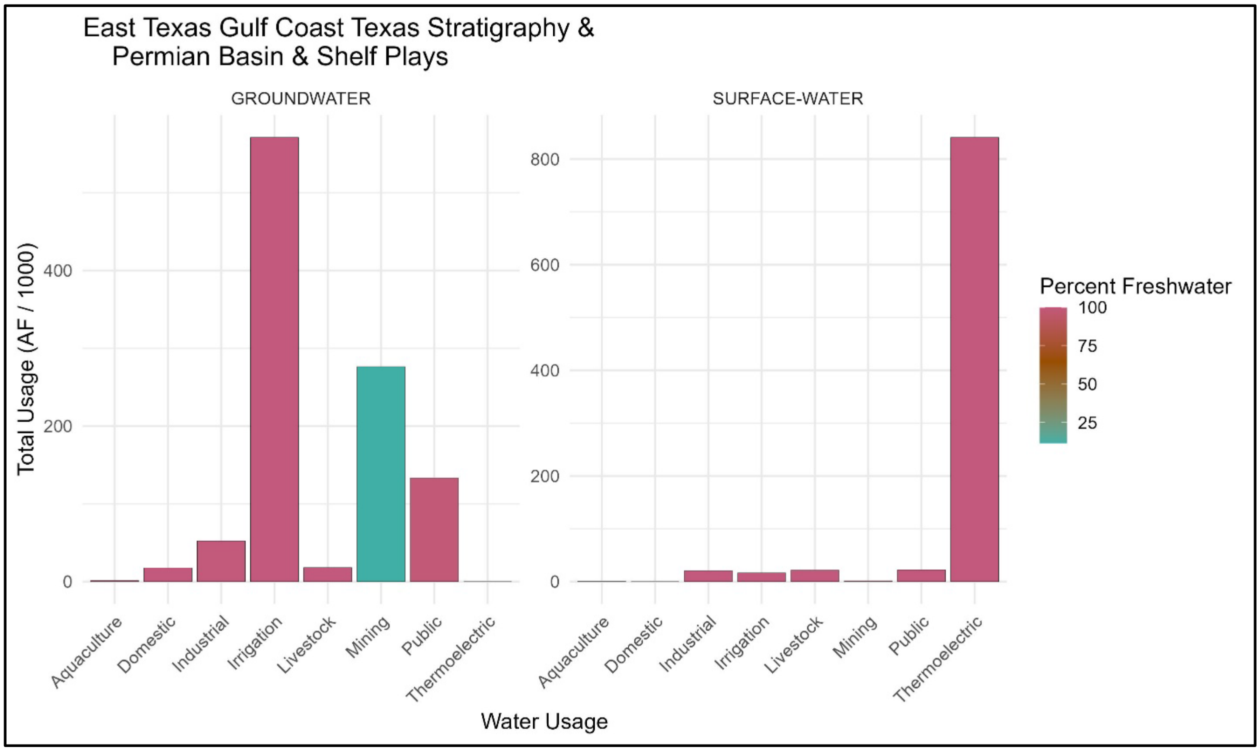


**Figure 4-4. Water withdrawal by category for targeted counties in the East Texas and Gulf Coast Texas, and Permian Basin and Shelf Plays in 2015, colored by the percentage of freshwater withdrawal out of the total water withdrawal (freshwater plus saline water withdrawal) (Dieter et al. 2018).**

**Table 4-14. East Texas and Gulf Coast Texas, Permian Basin, and Shelf Play: Water Withdrawal by Category in 2015 for Targeted Counties**

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Withdrawal (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Saline* | Total | Total Withdrawal (%) | Fresh | Total Withdrawal (%) | Saline* | Total Withdrawal (%) | | |
| Aquaculture | 314 | – | 314 | <1% | 1,389 | – | 1,389 | <1% | 1,703 | <1% | 0 | <1% | 1,703 | <1% |
| Domestic | 0 | – | 0 | <1% | 17,553 | – | 17,553 | <1% | 17,553 | <1% | 0 | <1% | 17,553 | <1% |
| Industrial | 20,689 | – | 20,689 | 1% | 52,299 | 101 | 52,400 | 3% | 72,988 | 4% | 101 | <1% | 73,089 | 4% |
| Irrigation | 16,567 | – | 16,567 | <1% | 571,172 | – | 571,172 | 29% | 587,739 | 29% | 0 | <1% | 587,739 | 29% |
| Livestock | 21,776 | – | 21,776 | 1% | 18,001 | – | 18,001 | <1% | 39,776 | 2% | 0 | <1% | 39,776 | 2% |
| Mining | 1,299 | – | 1,299 | <1% | 31,946 | 244,415 | 276,362 | 14% | 33,246 | 2% | 244,415 | 12% | 277,661 | 14% |
| Public Water Supply | 22,268 | – | 22,268 | 1% | 131,482 | 1,859 | 133,342 | 7% | 153,751 | 8% | 1,859 | <1% | 155,610 | 8% |
| Thermoelectric Power | 840,980 | – | 840,980 | 42% | 0 | – | 0 | <1% | 840,980 | 42% | 0 | <1% | 840,980 | 42% |
| **Total** | **923,893** | **–** | **923,893** | **46%** | **823,842** | **246,375** | **1,070,219** | **54%** | **1,747,736** | **88%** | **246,375** | **12%** | **1,994,111** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water withdrawal data are in AF/year unless otherwise indicated.

* Saline water is defined as water containing dissolved solids of 1,000 mg/L or more. Saline water withdrawals are not reported for domestic, irrigation, or livestock water withdrawal (Dieter et al. 2018).

–: no data available

**Table 4-15. Water Use by Oil and Gas Wells for Hydraulic Fracturing and Non-Hydraulic Fracturing for targeted counties in the East Texas and Gulf Coast Texas, Permian Basin, and Shelf Plays from 2014 through 2024**

| Year | Federal HF Water Use (AF) | Tribal HF Water Use (AF) | Non-Federal/ Non-Tribal HF Water Use* (AF) | Total HF Water Use (AF) | Federal HF Water Use (%) | Federal HF Cumulative Water Use (AF) | Total HF Cumulative Water Use (AF) | Average HF Water Use per Well* (AF) | Total No. of Federal Wells | Total No. of Wells | Total Non-HF Water Use (AF) | Total Water Use (HF plus non-HF) (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2014 | 698.1 | – | 32,486 | 33,184.2 | 2% | 698.1 | 33,184.2 | 11.8 | 80 | 2,806 | 2,300.92 | 35,485.12 |
| 2015 | 325.6 | – | 28.487 | 28,812.5 | 1% | 1,023.7 | 61,996.7 | 17.0 | 13 | 1,694 | 1,389.08 | 30,201.58 |
| 2016 | 191.0 | 9.3 | 24,084 | 25,284.6 | 1% | 1,214.7 | 87,281.3 | 22.9 | 8 | 1,105 | 906.10 | 26,190.70 |
| 2017 | 2,407.5 | – | 43,931 | 46,338.2 | 5% | 3,662.2 | 133,619.5 | 30.3 | 50 | 1,529 | 1,253.78 | 47,591.98 |
| 2018 | 1,676.2 | – | 63,085 | 64,761.5 | 3% | 5,298.4 | 198,381.0 | 35.7 | 37 | 1,815 | 1,488.30 | 66,249.80 |
| 2019 | 824.5 | 29.3 | 65,382 | 66,235.4 | 1% | 6,122.9 | 264,616.4 | 37.1 | 25 | 1,785 | 1,463.70 | 67,699.10 |
| 2020 | 249.3 | 24.3 | 38,845 | 39,118.2 | 1% | 6,372.2 | 303,734.6 | 41.0 | 12 | 955 | 783.10 | 39,901.30 |
| 2021 | 2,283.1 | – | 49,726 | 52,009.0 | 4% | 8,655.3 | 355,743.6 | 42.3 | 46 | 1,229 | 1,007.78 | 53,016.78 |
| 2022 | 3,152.0 | 150.0 | 58,404 | 61,705.6 | 5% | 11,807.3 | 417,449.2 | 44.6 | 56 | 1,384 | 1,134.88 | 62.840.48 |
| 2023 | 2,336.6 | – | 72,857 | 75,193.9 | 3% | 14,143.9 | 492,643.1 | 53.9 | 40 | 1,395 | 1,143.90 | 76,337.80 |
| 2024 | 1,369.2 | – | 68,782 | 70,151.5 | 2% | 15,513.1 | 562,794.6 | 54.9 | 18 | 1,278 | 1,047.96 | 71,199.46 |
| **Total** | **15,513.1** | **212.9** | **547,069** | **562,794.6** | **3%** | **15,513.1** | **562,794.6** | **51.1†** | **385** | **16,975** | **13,919.50** | **576,714.10** |

Source: FracFocus (2025). Data only for those wells that reported water use to FracFocus are presented; well data may be incomplete due to state reporting requirements and may not reflect total active wells and exact water use.

Note:. Produced water is naturally occurring water that exists in a formation that is being targeted for mineral extraction and is produced as a byproduct. The data summarized in this table represents the targeted counties, listed in Section 1.2, within the boundary of the East Texas, and Gulf Coast Texas, Permian Basin, and Shelf Plays.

* Includes both federal and non-federal wells.

† 3-year average (2021–2024)

–: no data available
HF = hydraulic fracturing; Non-HF = non-hydraulic fracturing

# 5 OKLAHOMA FIELD OFFICE

## 5.1 POTENTIAL SOURCES OF WATER USE FOR THE OFO

The OFO oil and gas plays across Kansas, Texas, and Oklahoma predominantly use a combination of groundwater and surface water for oil and gas activities (BLM 2016). Kansas and Oklahoma rely predominantly on surface water for hydraulic fracturing, while the more arid regions, especially southwest Texas, rely on groundwater sources (BLM 2016). Until recently, most groundwater used for hydraulic fracturing came from freshwater sources; however, saline, produced, and flowback water are now being used for many hydraulic fracturing jobs (BLM 2016). Groundwater underlying oil and gas lease areas represents a significant source of water for oil and gas development in the OFO planning area. Figure 5-1 shows the total water use reported to FracFocus over the course of three years across the OFO planning area and its associated oil and gas plays, and with targeted lease sales counties in bold. Table 5-1 presents each county in the OFO where oil and gas leasing and development has occurred over the last 10 years (2014–2024), with each county's associated principal aquifer. Water use by category (derived from Dieter et al. 2018) for targeted oil and gas APD counties across each state within the OFO can be found in Appendix B of this report.

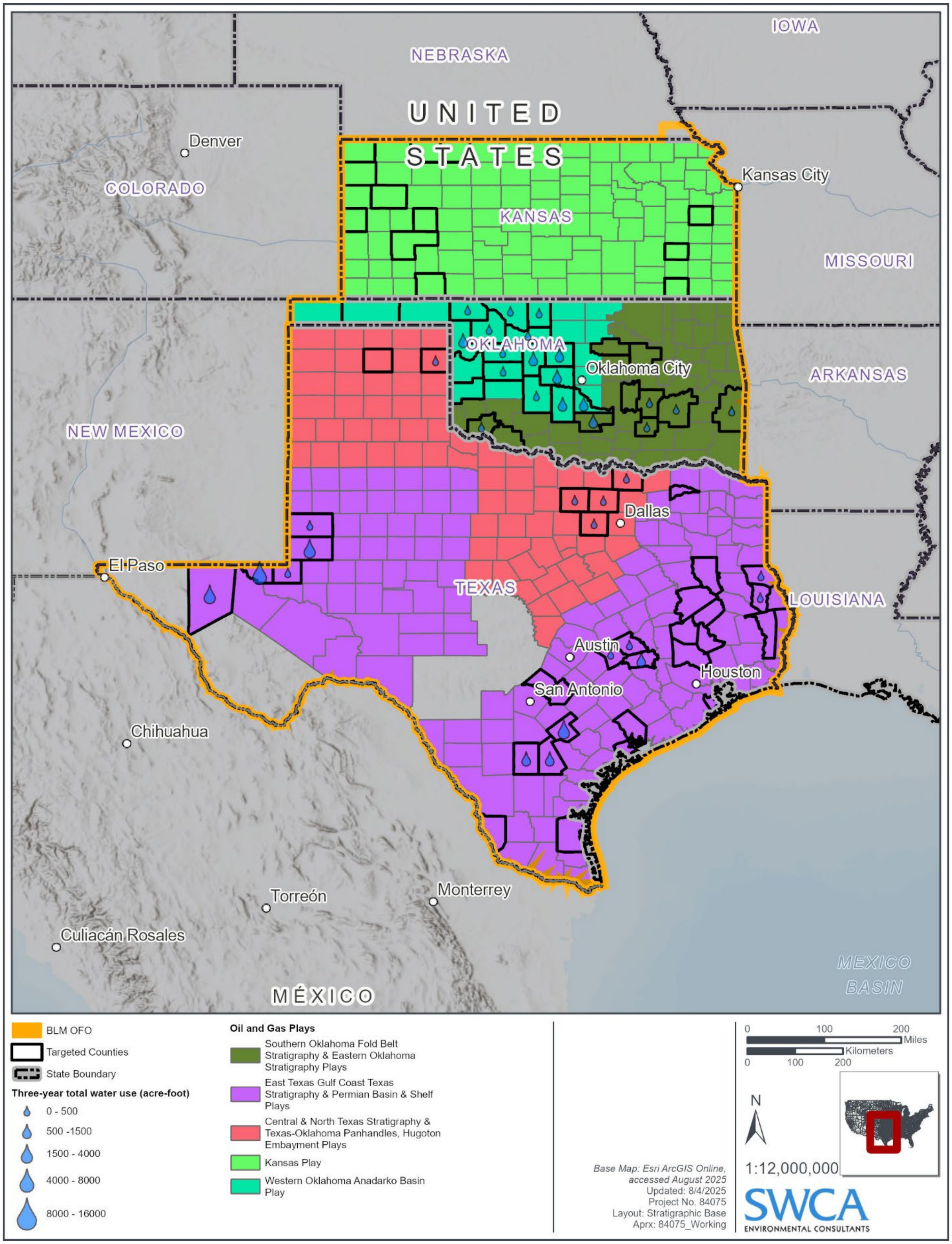


**Figure 5-1. Total 3-year water use (2022–2024) reported to FracFocus across the OFO planning area and its associated oil and gas plays, with targeted lease sale counties in bold.**

Note: Some counties do not have 3-year total water use data because the data are not available.

**Table 5-1. Principal Aquifers by State and County in the OFO**

| State | County | Principal Aquifer |
|---|---|---|
| Kansas | Cheyenne | High Plains aquifer |
| | | Other rocks |
| | Decatur | High Plains aquifer |
| | Finney | High Plains aquifer |
| | | Other rocks |
| | Franklin | Other rocks |
| | Greeley | High Plains aquifer |
| | Lane | High Plains aquifer |
| | | Other rocks |
| | Logan | High Plains aquifer |
| | | Other rocks |
| | Meade | High Plains aquifer |
| | | Other rocks |
| | Montgomery | Other rocks |
| | Norton | High Plains aquifer |
| | | Other rocks |
| | Sherman | High Plains aquifer |
| | Woodson | Other rocks |
| Oklahoma | Alfalfa | Other rocks |
| | Beaver | High Plains aquifer |
| | | Other rocks |
| | Beckham | Blaine aquifer |
| | | High Plains aquifer |
| | | Other rocks |
| | Blaine | Other rocks |
| | | Rush Springs aquifer |
| | Caddo | Other rocks |
| | | Rush Springs aquifer |
| | Canadian | Other rocks |
| | | Rush Springs aquifer |
| | Cimarron | High Plains aquifer |
| | | Other rocks |
| | Coal | Arbuckle-Simpson aquifer |
| | | Other rocks |
| | Creek | Ada-Vamoosa aquifer |
| | | Other rocks |
| | Custer | Other rocks |
| | | Rush Springs aquifer |

| State | County | Principal Aquifer |
|---|---|---|
| Oklahoma | Dewey | High Plains aquifer |
| | | Other rocks |
| | | Rush Springs aquifer |
| | Ellis | High Plains aquifer |
| | | Other rocks |
| | Garvin | Arbuckle-Simpson aquifer |
| | | Other rocks |
| | Grady | Other rocks |
| | | Rush Springs aquifer |
| | Harper | High Plains aquifer |
| | | Other rocks |
| | Hughes | Other rocks |
| | Jackson | Blaine aquifer |
| | | Other rocks |
| | | Seymour aquifer |
| | Kingfisher | Other rocks |
| | Le Flore | Other rocks |
| | Major | Other rocks |
| | McClain | Other rocks |
| | Payne | Ada-Vamoosa aquifer |
| | | Central Oklahoma aquifer |
| | | Other rocks |
| | Pittsburg | Other rocks |
| | Roger Mills | High Plains aquifer |
| | | Other rocks |
| | Seminole | Ada-Vamoosa aquifer |
| | | Other rocks |
| | Tillman | Other rocks |
| | Woods | Other rocks |
| | Woodward | High Plains aquifer |
| | | Other rocks |
| Texas | Andrews | High Plains aquifer |
| | | Pecos River Basin alluvial aquifer |
| | Burleson | Coastal lowlands aquifer system |
| | | Other rocks |
| | | Texas coastal uplands aquifer system |
| | Calhoun | Coastal lowlands aquifer system |
| | Cherokee | Texas coastal uplands aquifer system |
| | Comal | Edwards-Trinity aquifer system |
| | | Other rocks |

| State | County | Principal Aquifer |
|---|---|---|
| Texas | Culberson | Edwards-Trinity aquifer system |
| | | Other rocks |
| | | Rio Grande aquifer system |
| | Delta | Other rocks |
| | Denton | Edwards-Trinity aquifer system |
| | | Other rocks |
| | Gaines | High Plains aquifer |
| | Galveston | Coastal lowlands aquifer system |
| | Grayson | Edwards-Trinity aquifer system |
| | | Other rocks |
| | Guadalupe | Other rocks |
| | | Texas coastal uplands aquifer system |
| | Hemphill | High Plains aquifer |
| | Houston | Other rocks |
| | | Texas coastal uplands aquifer system |
| | Hutchinson | High Plains aquifer |
| | | Other rocks |
| | Jackson | Coastal lowlands aquifer system |
| | Jasper | Coastal lowlands aquifer system |
| | | Other rocks |
| | Karnes | Coastal lowlands aquifer system |
| | | Other rocks |
| | | Texas coastal uplands aquifer system |
| | Kenedy | Coastal lowlands aquifer system |
| | Lee | Other rocks |
| | | Texas coastal uplands aquifer system |
| | LiveOak | Coastal lowlands aquifer system |
| | | Other rocks |
| | Loving | Other rocks |
| | | Pecos River Basin alluvial aquifer |
| | McMullen | Coastal lowlands aquifer system |
| | | Other rocks |
| | | Texas coastal uplands aquifer system |
| | Montgomery | Coastal lowlands aquifer system |
| | Sabine | Coastal lowlands aquifer system |
| | | Mississippi embayment aquifer system |
| | | Other rocks |
| | | Texas coastal uplands aquifer system |
| | San Augustine | Other rocks |
| | | Texas coastal uplands aquifer system |

| State | County | Principal Aquifer |
|---|---|---|
| Texas | San Jacinto | Coastal lowlands aquifer system |
| | | Other rocks |
| | Shelby | Mississippi embayment aquifer system |
| | | Texas coastal uplands aquifer system |
| | Tarrant | Edwards-Trinity aquifer system |
| | | Other rocks |
| | Trinity | Coastal lowlands aquifer system |
| | | Other rocks |
| | | Texas coastal uplands aquifer system |
| | Walker | Coastal lowlands aquifer system |
| | | Other rocks |
| | | Texas coastal uplands aquifer system |
| | Washington | Coastal lowlands aquifer system |
| | | Other rocks |
| | Winkler | Edwards-Trinity aquifer system |
| | | High Plains aquifer |
| | | Other rocks |
| | | Pecos River Basin alluvial aquifer |
| | Wise | Edwards-Trinity aquifer system |
| | | Other rocks |
| | Zapata | Coastal lowlands aquifer system |

Note: Targeted counties were selected through review of BLM OFO oil and gas lease sales over the last 10 years (2014–2024) and BLM OFO APDs over the last 10 years (2014–2024).

Note: "Other rocks " is a groundwater reservoir that is smaller in size, less permeable, or less well-connected than major aquifers, and which might be more limited in its capacity or recharge rate.

Source: USGS (2003).

There are 15 principal aquifers present within the OFO's jurisdictional boundary. Most water used for oil and gas development is primarily sourced from five principal aquifers, which are described in the following sections (High Plains, Rio Grande, Texas coastal uplands, coastal lowlands, and Pecos River Basin) (Figure 5-2). Aquifer boundaries across OFO are defined by the USGS Principal Aquifer dataset (USGS 2003).

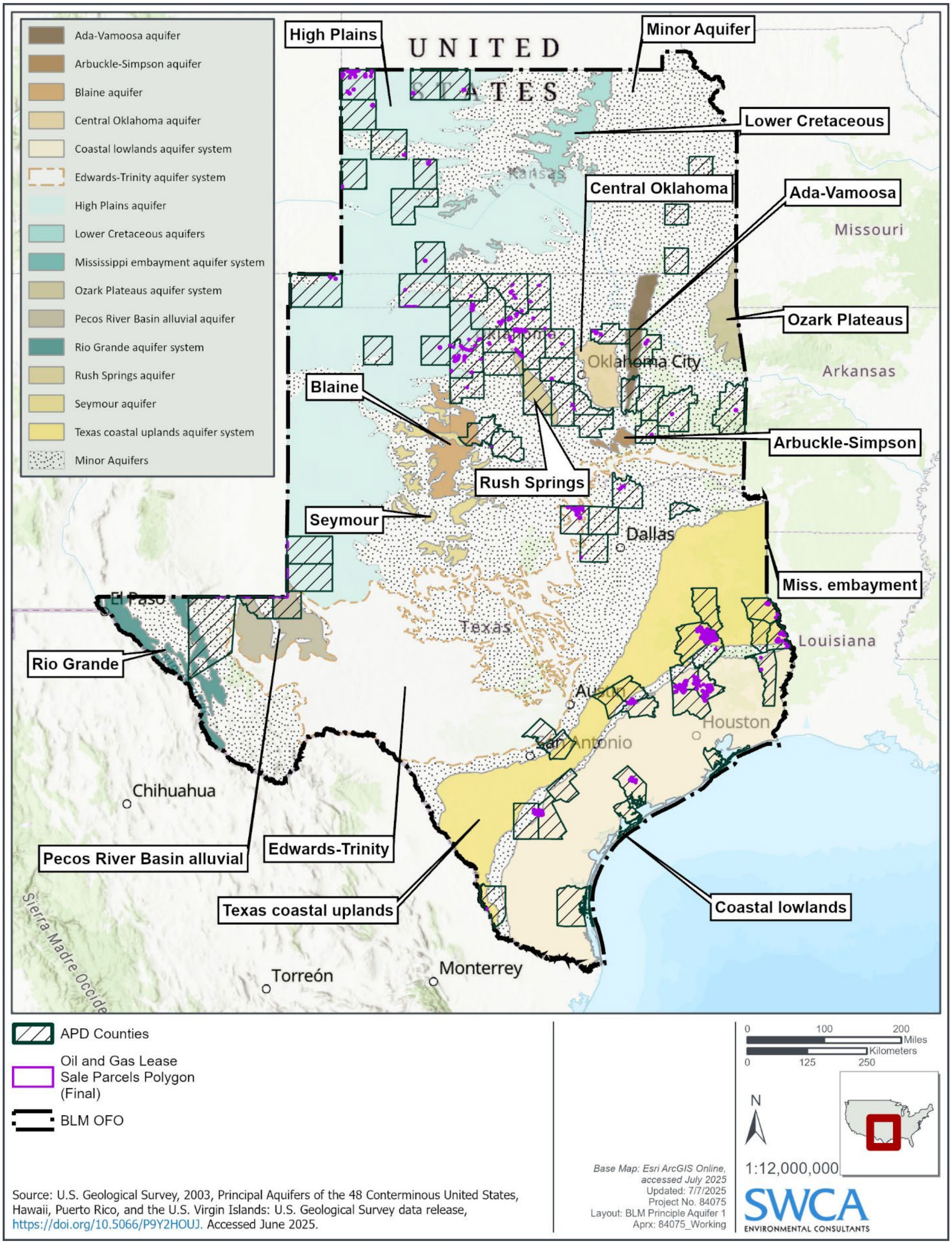


**Figure 5-2. Oil and gas leases and associated principal aquifers in the OFO.**

### 5.1.1 High Plains Aquifer

The High Plains Aquifer spans from northern Texas to southern South Dakota, covering an area of approximately 175,000 square miles across eight states (McGuire and Strauch 2024). The High Plains Aquifer underlies a primary agricultural region in the United States. Water production for irrigation began in the late 1800s; however, groundwater withdrawals increased throughout the early twentieth century to an estimated 19 million AF in 1974 (McGuire and Strauch 2024).

Recent analyses during predevelopment and post-development (1950 and 2019, respectively) indicate that the recoverable water in storage is approximately 2.91 billion AF, representing a decline of 286.4 million AF (or about 10%) since the 1950s (McGuire and Strauch 2024). From 2017 to 2019, water level changes by well varied from a rise of 34 feet to a decline of 27 feet. Overall, the area-weighted, average water-level change in the High Plains aquifer displayed a decline of 16.5 feet (McGuire and Strauch 2024). See Table 5-2 for OFO-specific, area-weighted, average water level changes by state. Geographically, the High Plains aquifer water level declines are most severe in the southwest corner of Kansas, and the Texas panhandle. While less prevalent than areas of decline, some locations within the High Plains aquifer region are experiencing water level rises up to 50 feet. These areas of increase are primarily concentrated in Nebraska with sporadic, localized zones in other states, including Kansas, Oklahoma, and Texas.
The saturated thickness of the High Plains aquifer varies from 0 ft to about 1,200 ft (McGuire et al. 2012). In 2000, the High Plains aquifer water levels ranged from 0 feet below ground surface to over 300 feet (USGS 2025).

Groundwater withdrawals currently exceed recharge rates across large portions of the aquifer. In 2015, water withdrawals from the High Plains aquifer were estimated to be around 13 million AF with irrigation accounting for 95% of use (McGuire and Strauch 2024). The High Plains aquifer is primarily recharged via precipitation with additional contributions from irrigation return and seepage from streams, canals, and reservoirs (McGuire and Strauch 2024). Additional data on groundwater level changes and aquifer storage trends are provided in *Water-Level and Recoverable Water in Storage Changes, High Plains Aquifer, Predevelopment to 2019 and 2017 to 2019* (McGuire and Strauch 2024).

**Table 5-2. High Plains Aquifer Water Level Changes in Kansas, Oklahoma, and Texas from 1950 to 2019**

| State | Area-Weighted, Average Water-Level Change from Predevelopment to 2019 (1950 to 2019) |
|---|---|
| Kansas | -27.3 |
| Oklahoma | -14.2 |
| Texas | -44.1 |

Source: McGuire and Strauch (2024)

### 5.1.2 Rio Grande Aquifer

The Rio Grande Aquifer spans an area of 29,000 square miles and underlies portions of Colorado, New Mexico, and southwest Texas, representing a major source of public domestic and irrigational water supply. The aquifer ranks eighteenth in the nation for public water supply, providing approximately 736.1 AF per day, with an additional 2,661.5 AF per day used for irrigation and 55.2 AF per day for domestic water use. In total, the Rio Grande Aquifer supplies 1.125 billion gallons of water per day, or about 3,450 AF per day (USGS 2017). Recharge occurs primarily through precipitation, infiltration of runoff in mountainous regions, irrigation return, and groundwater inflows from proximal basins. (USGS

1995). Irrigation withdrawals along the Rio Grande Aquifer region have contributed substantially to discharge and have influenced groundwater flow directions in some regions (USGS 2017).

The Rio Grande aquifer system in westernmost Texas represents the eastern segment of the Southwest alluvial basins aquifer system, which spans parts of the southwestern United States and Mexico. Within Texas, this system comprises six principal alluvial basins: Mesilla, Hueco, Salt, Eagle, Red Light, and Presidio. The basin deposits serve as the main water source for El Paso, an area with limited annual precipitation. Despite the substantial water storage capacity of the basin deposits, groundwater withdrawals consistently exceed natural recharge rates, resulting in long-term aquifer depletion (USGS 1999a).

### 5.1.3 Texas Coastal Uplands Aquifer System

The Texas Coastal Uplands Aquifer System, consisting of the subcrop and outcrop of the Carrizo Wilcox Aquifer system, underlies approximately 48,000 square miles of the Coastal Plain Physiographic Province. This principal aquifer trends northeast-southwest across the southeastern part of Texas and provides large quantities of freshwater for agriculture, industry, and public needs. The Texas Coastal Uplands Aquifer System is a principal aquifer that is composed of four smaller aquifers and two hydrologically unique confining units (Ryder 1988). These are, from shallowest to deepest, the upper Claiborne Aquifer; the middle Claiborne confining unit; the middle Claiborne Aquifer; the lower Claiborne confining unit; the lower Claiborne-upper Wilcox Aquifer; and the middle Wilcox Aquifer (Ryder 1988). The entire Texas Coastal Uplands Aquifer System is underlain by the highly impermeable Midway confining layer (Ryder 1988). Horizontal hydraulic conductivity values are variable across the Texas Coastal Uplands Aquifer System and range between approximately 1 and 102 feet per day (Ryder 1988).

Recharge to the Texas Coastal Uplands Aquifer System occurs primarily through direct precipitation and downward percolation to the aquifer system. The Texas Coastal Uplands Aquifer System averages between 21 and 50 inches of precipitation per year; however, it has an approximate recharge rate of 0.52 inch/year (Ryder 1988). The Texas Coastal Uplands Aquifer System has a thickness that ranges between approximately 0 and 3,000 feet (Ryder 1988). The aquifer is primarily characterized by high permeability unconsolidated materials that consist mainly of sand, gravel, and clay (Ryder 1988). Water levels in the Texas Coastal Uplands aquifer system range from 6.1 feet to 130.6 feet below the ground surface, averaging 28.9 feet (Reutter and Dunn 2000).

### 5.1.4 Coastal Lowlands Aquifer System

The Coastal Lowlands Aquifer System, also known as the Gulf Coast Aquifer, is composed of seven distinct hydrologic units. The Coastal Lowlands Aquifer System, from oldest formation to youngest, contains the lower Miocene-upper Oligocene permeable zone; lower Miocene-upper Oligocene confining unit; middle Miocene permeable zone; middle Miocene confining unit; lower Pliocene-upper Miocene permeable zone; lower Pleistocene-upper Pliocene permeable zone; and Holocene-upper Pleistocene permeable zone (Ryder 1988). In the Coastal Lowlands Aquifer System, water containing permeability zones are confined by near-impermeable layers (Ryder 1988). Aquifer thickness is variable across the Coastal Lowlands Aquifer System but typically ranges from 0 to 4,000 feet (Ryder 1988). Water-bearing aquifer material primarily consists of high-porosity sands intermixed with semi-permeable clay lenses (Ryder 1988). Horizontal hydraulic conductivity values typically range from 60 to 170 feet per day across the Coastal Lowlands Aquifer System (Ryder 1988). Higher hydraulic conductivity values are typically found in the younger shallower aquifers and generally decrease in the older aquifers (Ryder 1988).

Recharge to the Coastal Lowlands Aquifer System occurs primarily through direct precipitation and percolation to the water table (Ryder 1988). Some cross-aquifer flows occur between the overlying and underlying aquifers; however, recharge from cross-aquifer flow is negligible (Ryder 1988).

### 5.1.5 Pecos River Basin Alluvial Aquifer

The Pecos River Basin Alluvial Aquifer, more recently called the Pecos Valley Aquifer, underlies approximately 8,650 square miles across west Texas and New Mexico and provides a substantial source of freshwater for irrigation, public supply, and industrial purposes (Meyer et al. 2012). The Pecos Valley Aquifer is separated by two distinct hydrologic units, the north-south-trending Pecos and Monument Draws. The Pecos and Monument Draws are filled with approximately 1,700 feet of tertiary and quaternary alluvial sediments (Meyer et al. 2012). The Pecos Valley Aquifer is primarily composed of alluvial material that consists of unconsolidated silt, sand, gravel, and clay (Meyer et al. 2012). The Pecos Valley Aquifer contains approximately 15 million AF of freshwater and approximately 85 million AF of brackish water (1,000 to 10,000 mg/L of TDS) (Meyer et al. 2012). Recharge to the Pecos Valley Aquifer generally occurs from direct precipitation, seepage from intermittent streams, irrigation returns, and subsurface input from adjacent formations (USGS 1999a). Due to the presence of high-porosity alluvial aquifer materials, the Pecos River Basin Alluvial Aquifer has a relatively high mean hydraulic conductivity of 8.6 feet per day (Meyer et al. 2012). Transmissivity values range widely (approximately 0 to 14,000 square feet/day) due to changes in aquifer thickness (Meyer et al. 2012).

## 5.2 FUTURE WATER USE ASSOCIATED WITH REASONABLY FORESEEABLE OIL AND GAS DEVELOPMENT

The 2016 *Reasonable Foreseeable Development Scenario for the Oklahoma Field Office* (BLM 2016) provides future projections associated with oil and gas development. The 2016 RFD provides a 20-year development scenario to predict oil and gas development across the entire OFO. The 2016 RFD forecasts future well construction and oil and gas production across the OFO by extrapolating projection data from the U.S. Energy Information Administration, production data from IHS-Energy, and well completion data from the BLM's Automated Fluid Minerals Management Support System (BLM 2016). The 2016 RFD estimates that there could be between 775 and 3,054 new federal and trust wells within the OFO planning area by 2040 (BLM 2016). In an effort to project water use associated with oil and gas into the future, three well construction projections (conservative, modest, aggressive) are presented using the range of well construction estimates from the 2016 RFD: conservative (775 new wells), moderate (1,527 new wells), and aggressive (3,054 new wells) (Figure 5-3).

The BLM estimates that approximately 50% of oil and gas wells constructed after year 2018 will be horizontal fracture wells; however, the 2016 RFD does not estimate water use associated with hydraulic fracturing into future years (BLM 2016). Wells that used hydraulic fracturing are assumed to use 25% more water when compared to other fracturing processes (BLM 2016). The BLM estimates that between 5% and 40% of water used during the fracturing process is returned via hydraulic flowback; however, flowback is generally flushed out during well testing or in the early stages of production, making it difficult to quantify (BLM 2016). For all projected scenarios, flowback will not be considered, and both fracturing and refracturing hydraulic wells will assume 0% recoverable water.

To calculate cumulative water use for each well construction projection, the average per-well water use estimates for the states of Oklahoma, Kansas, and Texas (see Chapters 2, 3, and 4, respectively) were averaged to create a per-well water use estimate for the OFO planning area. The OFO per-well water use estimate was multiplied by each well construction forecast to find the cumulative water use for each well construction scenario (Table 5-3a; see Figure 5-3). The average water use per well for the OFO planning area is estimated at 32.2 AF.

### Table 5-3a. RFD Federal Well Projections and Associated Water Use

| RFD Scenario (2040 new well development [annual well development])* | Cumulative Water Use (AF) (2012–2040)† | Annual Water Use (AF) (2012–2040) |
|---|---|---|
| Conservative (775 wells [27 wells per year]) | 24,955 | 869 |
| Moderate (1,527 wells [53 wells per year]) | 49,169 | 1,707 |
| Aggressive (3,054 wells [105 wells per year]) | 98,339 | 3,381 |

*RFD well development projections (see Chart 50 of the 2016 RFD [BLM 2016]) begin in the year 2012 and end in the year 2040.

†Water use estimates are calculated using an average water use per well of 32.2 AF across the OFO planning area.

The OFO contains federal, non-federal, and tribal wells (as reported in FracFocus), but the 2016 RFD provides projections only for federal wells and wells held in trust for Tribes. These historically make up a small percentage of all wells drilled in the OFO, so current well construction across the OFO is significantly higher than estimates in the 2016 RFD. Table 5-3b shows the total number of wells reported to FracFocus (regardless of well ownership) and compares the federal wells reported to FracFocus with the 2016 RFD federal and trust well projections.

Between the years 2014 and 2024, 92,604 wells were constructed across the OFO according to FracFocus, with 1,939 being federal wells. In contrast, annual well projections from the 2016 RFD (105 wells per year under the most aggressive scenario) result in an estimated 1,155 wells over this same time frame, which is 40% less than the actual number of federal wells reported to FracFocus (see Table 5-3b).

The cumulative water use reported by FracFocus from 2014 to 2024 was 3,278,527.7, with 67,133.9 AF accounted for by federal wells. In contrast, the water use estimate for the most aggressive RFD scenario (105 wells per year) would be 37,191 AF over the same time frame (3,381 AF annually, over 11 years), which is 45% less than the actual federal water use reported to FracFocus (see Table 5-3b). Table 5-4 estimates RFD water use based on the OFO average per-well water consumption according to FracFocus (32.2 AF per well).

### Table 5-3b. RFD and FracFocus Federal Well Construction Across the OFO

| Year | Total Well Construction Across the OFO | Federal Well Construction Across the OFO | RFD Federal and Trust Well Projection (Aggressive) |
|---|---|---|---|
| 2014 | 16,967 | 484 | 105 |
| 2015 | 9,235 | 166 | 105 |
| 2016 | 5,722 | 71 | 105 |
| 2017 | 8,015 | 134 | 105 |
| 2018 | 9,792 | 140 | 105 |
| 2019 | 9,301 | 124 | 105 |
| 2020 | 4,493 | 79 | 105 |
| 2021 | 6,615 | 128 | 105 |
| 2022 | 8,236 | 194 | 105 |
| 2023 | 7,578 | 224 | 105 |
| 2024 | 6,650 | 195 | 105 |
| **Total** | **92,604** | **1,939** | **1,155** |
| **Yearly Average** | **8,418** | **176** | **105** |

Note: Well construction totals for Oklahoma, Texas, and Kansas were summed to get yearly well construction across the OFO (FracFocus 2025). Total and federal well construction numbers come from FracFocus (2025), and RFD projections come from BLM (2016).

### Table 5-4. RFD and FracFocus Cumulative Water Use

| Year | FracFocus Cumulative Water Use (AF) | FracFocus Federal Water Use (AF) | RFD Federal and Trust Water Use Projection (Aggressive) (AF) |
|---|---|---|---|
| 2014 | 200,383.0 | 4,622.9 | 3,381.0 |
| 2015 | 361,558.8 | 7,610.7 | 6,762.0 |
| 2016 | 515,690.5 | 9,257.9 | 10,143.0 |
| 2017 | 794,017.2 | 14,407.3 | 13,524.0 |
| 2018 | 1,171,978.6 | 18,853.2 | 16,905.0 |
| 2019 | 1,571,152.2 | 23,401.2 | 20,286.0 |
| 2020 | 1,782,714.7 | 26,441.0 | 23,667.0 |
| 2021 | 2,079,716.8 | 32,948.8 | 27,048.0 |
| 2022 | 2,467,343.7 | 42,754.4 | 30,429.0 |
| 2023 | 2,880,072.2 | 54,435.3 | 33,810.0 |
| 2024 | 3,278,527.7 | 67,133.9 | 37,191.0 |

Note: Because no average AF was present in the 2016 RFD, the average AF for the OFO (32.2 AF) was taken from FracFocus and multiplied by the RFD well construction projections (105 wells per year under the aggressive scenario) to get cumulative water use per year.

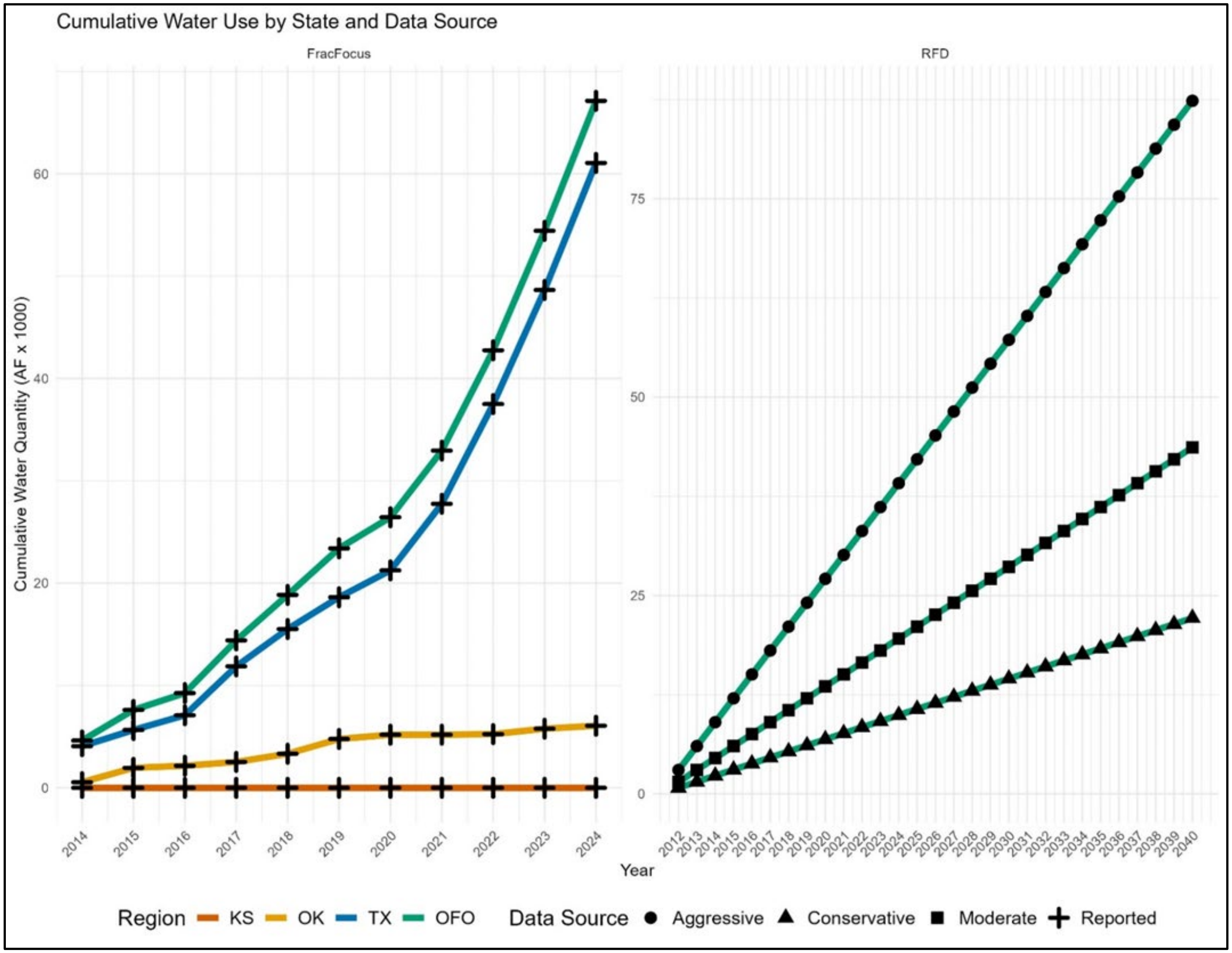


**Figure 5-3. Projected and reported cumulative water use for federal wells across the OFO by state. Reported data is based on FracFocus federal well data (FracFocus 2025) for the OFO and its constituent states; projected water use is based on federal well estimates from the RFD for the OFO.**

# 5.3 DROUGHT AND WATER AVAILABILITY IN THE OFO

To standardize drought reporting across federally managed lands, the BLM used ClimateEngine.org to calculate and categorize predicted drought impacts across various jurisdictions. ClimateEngine.org integrates multiple drought indices and weights them differently to produce both long- and short-term drought blend summaries. “Blends” are a compilation of multi-temporal drought indices that represent different drought timescales to assess both short- and long-term processes and associated impacts across regions (ClimateEngine.org 2025). Both the long- and short-term drought blend assessments provide analysis at the same temporal levels (current, 3-month, and 1-year); however, the data indices used are weighted differently to produce a different drought blend (long- and short-term). ClimateEngine.org evaluates the following indices and spatial data to determine drought severity at the landscape level:

- Palmer-Z Index; a short-term indicator of monthly moisture anomalies, often used for early drought detection (Integrated Drought Management Programme 2025a; Palmer 1965).
- Palmer Drought Severity Index; measures drought severity by estimating relative dryness using a water-balance model that incorporates precipitation and temperature (Dai and National Center for Atmospheric Research Staff 2023).
- Standardized Precipitation Index; a versatile drought index focused solely on precipitation that can be used over various time scales (Keyantash and National Center for Atmospheric Research Staff 2025).
- Palmer Hydrological Drought Index; modified from the Standard Precipitation Index and calculates when a drought will end based on precipitation needed (Integrated Drought Management Programme 2025b; Palmer 1965)
- National Oceanic and Atmospheric Administration Land Surface Model; provides high-resolution soil moisture data from long-term modeling of atmospheric and precipitation inputs, and satellite vegetation data (NOAA 2025).

The short-term drought blend provides insights into drought impacts over a brief period (days to months), which is useful for assessing effects on agriculture and soil moisture. In contrast, the long-term drought blend assesses impacts related to precipitation over extended periods (months to years) and is more effective for evaluating groundwater levels and overall water availability at a landscape level.
The long-term drought blend will be used in evaluating drought severity across the OFO. The drought blend figures presented below combine the current, 3-month, and 1-year drought summaries to produce each blend figure.

## 5.3.1 Drought Blend Summaries for the OFO

On June 8, 2024, 26.4% of the total jurisdictional area of the OFO experienced drought, including 6.9% of the area experiencing severe to extreme drought conditions (Table 5-5). One year later on May 30, 2025, the same total area (26.4) again experienced drought conditions, but with a 1.5% increase in area to severe, extreme, and exceptional drought conditions (see D2-D4 column in Table 5-5). Currently, 0.5% of the OFO is experiencing exceptional drought conditions. A full summary of drought conditions at various periods is presented in Table 5-5 and Figure 5-4.

**Table 5-5. Drought Blend Summary Results (as percent area) Across the OFO**

| Term | Time Period | No Drought | D0-D4 (abnormally dry to exceptional drought) | D1-D4 (moderate to exceptional drought) | D2-D4 (severe to exceptional drought) | D3-D4 (extreme to exceptional drought) | D4 (exceptional drought) |
|---|---|---|---|---|---|---|---|
| Long-Term | Current (05/30/2025) | 73.6 | 26.4 | 19.6 | 8.4 | 5.5 | 0.5 |
| | 3-Month (03/01/2025) | 67.8 | 32.2 | 24.0 | 10.6 | 7.7 | 4.1 |
| | 1-Year (06/08/2024) | 73.6 | 26.4 | 18.2 | 6.9 | 2.6 | 0.0 |
| Short-Term | Current (05/30/2025) | 88.7 | 11.3 | 6.7 | 1.0 | 0.1 | 0.0 |
| | 3-Month (03/01/2025) | 38.7 | 61.3 | 48.2 | 14.4 | 2.5 | 0.0 |
| | 1-Year (06/08/2024) | 74.5 | 25.5 | 17.7 | 7.1 | 4.3 | 0.0 |

Source: ClimateEngine.org (2025)

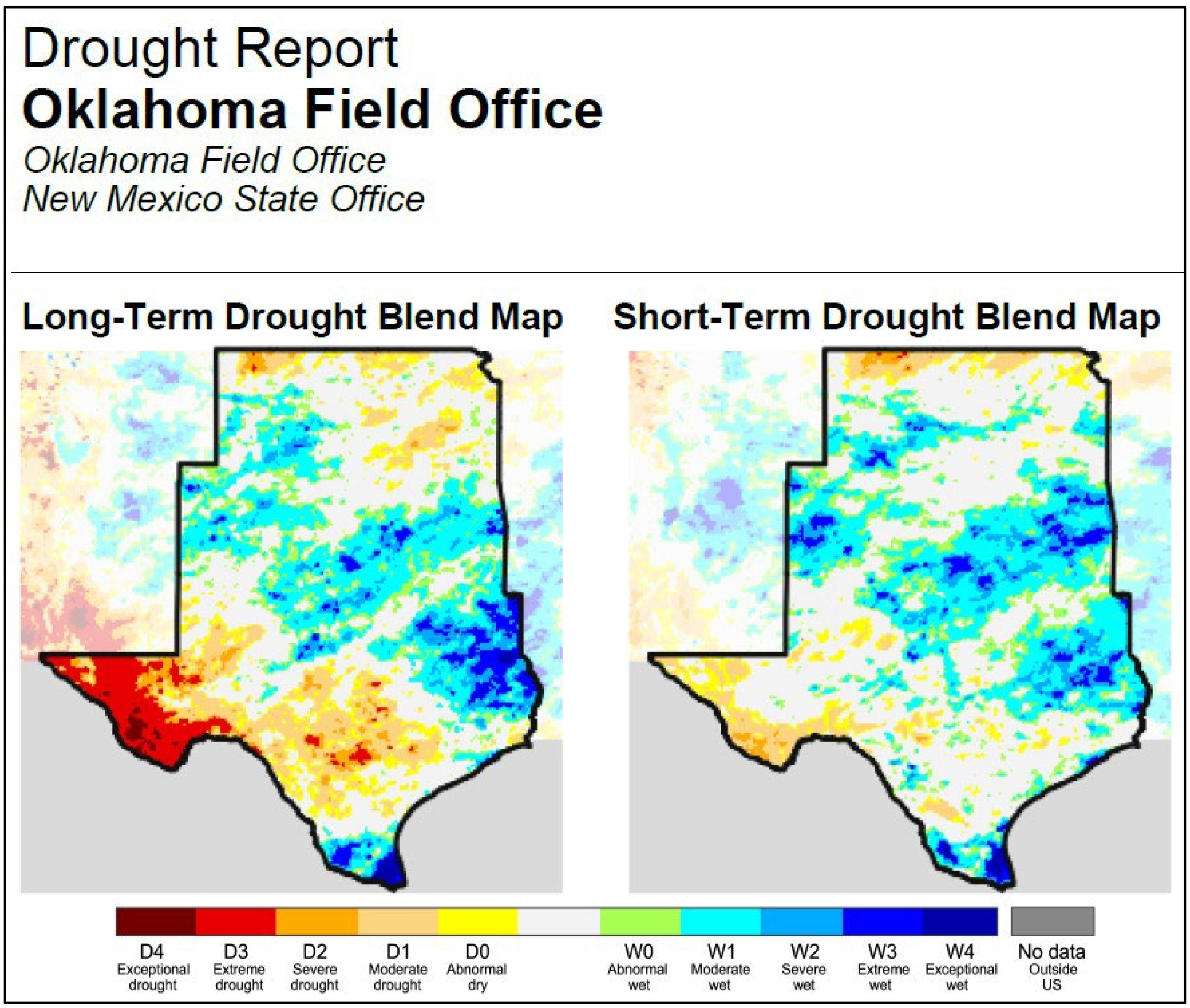


**Figure 5-4. Drought blend summaries across the OFO.**

Source: ClimateEngine.org (2025)

Long-term drought across the OFO is characterized primarily by dry conditions with short periods of extreme and exceptional drought. Before 2001, instances of extreme and exceptional drought were rare. However, since the year 2000, the intensity of drought has escalated, with significant periods of extreme and exceptional drought occurring during 2010–2015 and 2020–2025 (Figure 5-5).

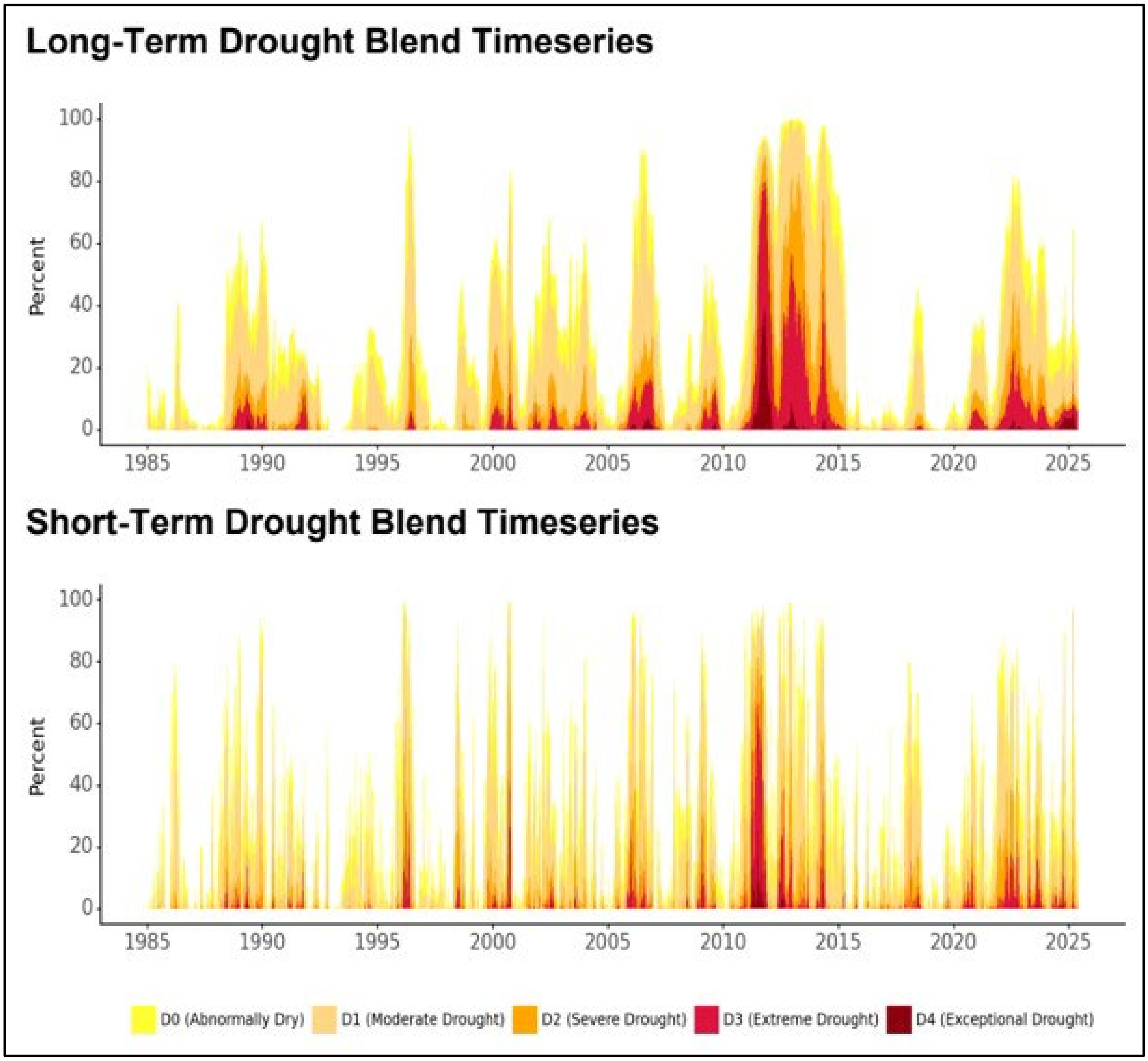


**Figure 5-5. Drought blend time series since 1985 across the OFO. Data reports through 06/11/2025.**
Source: ClimateEngine.org (2025)

## 5.3.2 U.S. Drought Monitor

According to the U.S. Drought Monitor (U.S. Drought Monitor 2025), the OFO planning area includes regions that have been subjected to a prolonged period of drought, which puts further strain on sources of water that are accessible via surface water diversion or groundwater pumping. Over the past 11 years (2014–2024), approximately 50% of the OFO planning area has been affected by varying levels of drought, ranging from abnormally dry (D0) to exceptional drought (D4). Notably, the Kansas segment of the OFO planning area experienced the highest drought impact, with 56.7% of the state affected by drought conditions (D0-D4). Table 5-6 provides a detailed breakdown of drought conditions across Oklahoma, Texas, and Kansas, including drought classifications and their associated percent area.

**Table 5-6. Mean Percent Area of Drought across Oklahoma, Kansas, and Texas from 2014 to 2024**

| State | No Drought | D0-D4 (Abnormally Dry-Exceptional Drought) | D1-D4 (Moderate Drought-Exceptional Drought) | D2-D4 (Severe Drought-Exceptional Drought) | D3-D4 (Extreme Drought-Exceptional Drought) | D4 (Exceptional Drought) |
|---|---|---|---|---|---|---|
| Kansas | 43.34% | 56.70% | 35.29% | 18.57% | 8.31% | 2.80% |
| Oklahoma | 47.35% | 52.65% | 35.64% | 22.45% | 11.03% | 2.54% |
| Texas | 46.74% | 53.26% | 35.03% | 19.46% | 8.91% | 2.38% |

Source: U.S. Drought Monitor (2025)

Figure 5-6 illustrates the change in drought severity categories from 2014 to 2024. Drought across all severity categories increased sharply from 2021 to 2023 (see Figure 5-6) with the most significant rise occurring to extreme and exceptional drought severity during this period. Although drought conditions improved in 2023 compared to the previous year, they remained elevated relative to the rest of the reporting period.

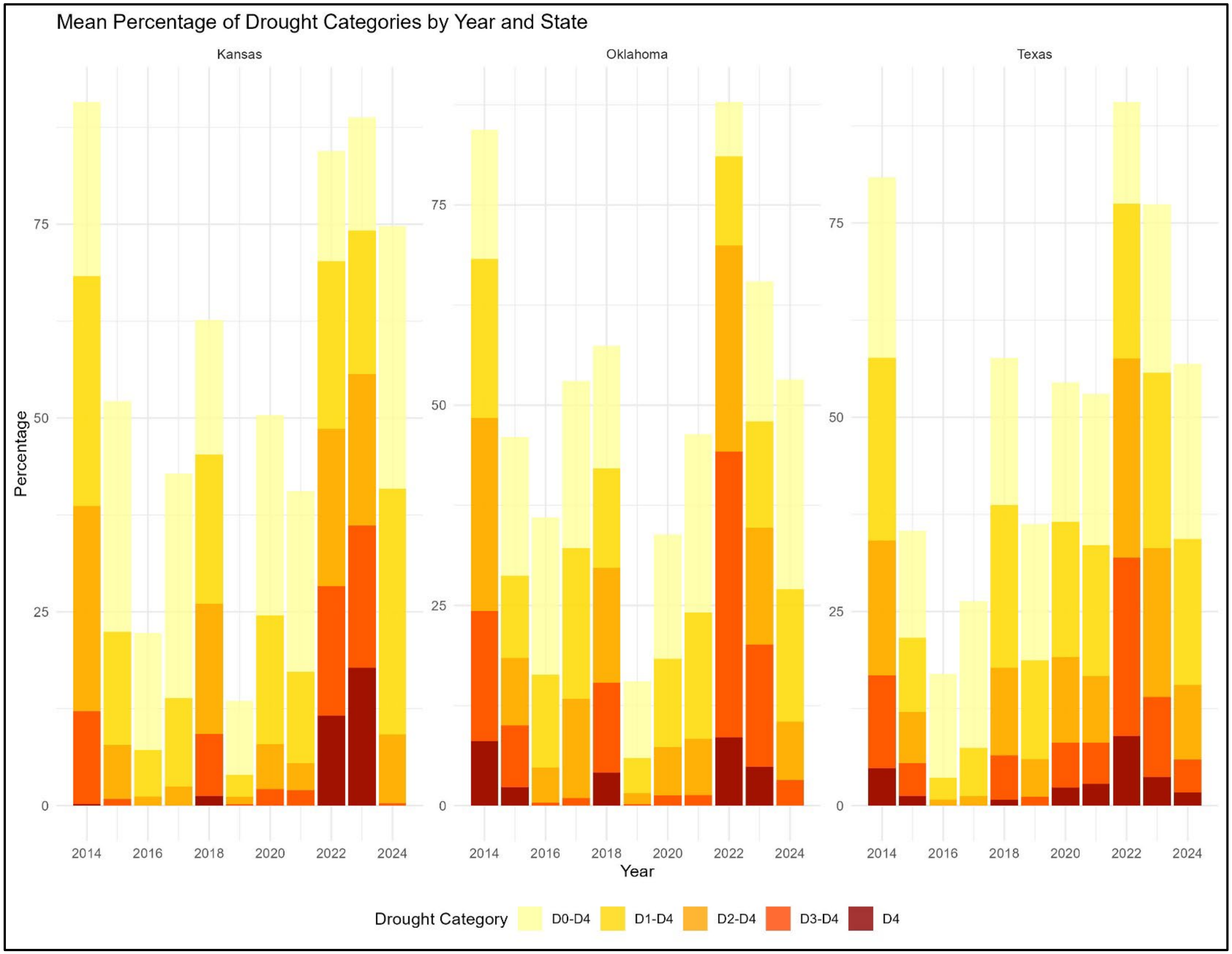


**Figure 5-6. Average percentage of each state experiencing different drought categories (D0-D4) across Kansas, Oklahoma, and Texas from 2014 to 2024.**

Source: U.S. Drought Monitor (2025)

In 2024, drought severity in the OFO planning area intensified, with 61.6% of the OFO planning area experiencing some level of drought (D0-D4). Kansas was particularly hard hit, with 74.8% of the state affected by some severity of drought. Texas had the largest percent area of exceptional drought, impacting 1.7% of the state. In comparison, Kansas and Oklahoma did not experience exceptional drought (Table 5-7).

**Table 5-7. Mean Percent Area of Drought across Oklahoma, Kansas, and Texas in 2024**

| State | No Drought | D0-D4 (Abnormally Dry-Exceptional Drought) | D1-D4 (Moderate Drought-Exceptional Drought) | D2-D4 (Severe Drought-Exceptional Drought) | D3-D4 (Extreme Drought-Exceptional Drought) | D4 (Exceptional Drought) |
|---|---|---|---|---|---|---|
| Kansas | 25.23% | 74.77% | 40.88% | 9.21% | 0.30% | 0.00% |
| Oklahoma | 46.80% | 53.21% | 27.00% | 10.45% | 3.24% | 0.00% |
| Texas | 43.08% | 56.92% | 34.35% | 15.53% | 5.92% | 1.72% |
| Average | 38.37% | 61.63% | 34.08% | 11.73% | 3.15% | 0.57% |

Source: U.S. Drought Monitor (2025).

### 5.3.3 State Resources

In Oklahoma, the OWRB authors developed the Oklahoma Drought Management Plan (OWRB 1997) and maintains a website that presents all state and federal resources regarding drought in the state (OWRB 2024). Additionally, projections of water availability are periodically updated and presented in the OCWP. The next iteration of the OCWP is currently under development to be completed in 2025. While final water availability projections are not yet published, preliminary estimates and draft forecasts have been developed and presented through stakeholder engagement meetings (see Section 2.1 for additional description of the OCWP).

In Kansas, the KWO has documented an analysis of the state's future water supply in the Vision for the Future Water Supply in Kansas (KWO 2015). The report outlines strategic goals and regional actions, and while it does not provide detailed statewide water demand or supply projections, it does include regional assessments such as estimated aquifer lifespans and depletion timelines. An update to the report is underway but it's unclear when that update will be available.

In Texas, the TWDB hosts an online *Drought Outlook* resource that compiles drought conditions for the state at various time scales (TWDB 2024d). The TWDB's most recent State Water Plan is the 2022 edition; there is no 2024 version available yet. Meanwhile, the TWDB maintains a continuously updated Drought Outlook that assesses conditions over 3-, 6-, and 9-month projection windows, incorporating regional climate factors such as El Niño/La Niña. The state water plan (see Section 4.1) identifies strategies to secure and improve future water availability that responds to changes in population, technological improvements, water supplies, and policy changes (TWDB 2024d). It presents a robust analysis of future surface water and groundwater supply by major basin. Specifically, groundwater availability is projected to decrease by 32%, from the years 2020 to 2070. This decline is primarily due to the reduced supply from the Ogallala Aquifer and the Gulf Coast Aquifer (TWDB 2024b). Additionally, the document predicts that the state of Texas would require 6.9 million AF of additional water supplies, including reduced consumption (TWDB 2024b).

## 5.4 PER- AND POLYFLUOROALKYL SUBSTANCES

PFAS is a broad term classification for a large group of human-made chemicals that are found in a wide variety of industrial processes and common household items. They are widely used in disposable food packaging, cookware, outdoor equipment, furniture, and carpet for their hydrophobic and oleophobic properties (Sunderland et al. 2018). PFAS substances are a main component of aqueous film forming foams, which are used regularly in fire suppression and prevention activities performed at airports and military bases (Sunderland et al. 2018). Aqueous film forming foam is a major source of PFAS groundwater contamination and has been recognized as a nationally significant challenge in the United States (Sunderland et al. 2018). Approximately 15,000 distinct chemicals are categorically grouped as PFAS, with the most common and widely studied PFAS, including PFOS (perfluorooctane sulfonate) and PFOA (perfluorooctanoic acid) (EPA 2024b). PFAS persistence has been linked to bioaccumulation in both the environment and human body, which may lead to adverse effects on human health (EPA 2024c).

Surveys conducted by the U.S. Centers for Disease Control and Prevention show that most people in the United States have been exposed to some PFAS. People can be exposed to PFAS through their occupations (e.g., firefighting or chemicals manufacturing and processing); drinking PFAS-contaminated water; eating PFAS-contaminated food (e.g., fish); swallowing PFAS-contaminated soils or dust; breathing PFAS-contaminated air; or interacting with products and packaging that contain PFAS. While most people’s known exposure levels are relatively low, some people have higher exposures to PFAS because of their occupations or where they live. Additionally, infants and children may be more sensitive to the harmful effects of PFAS (EPA 2024c).

Current peer-reviewed scientific studies have shown that exposure to certain levels of PFAS may lead to adverse health effects such as: reproductive effects; developmental effects or delays in children; increased risk of some cancers; reduced immune functioning; hormonal effects; and increased cholesterol levels or risk of obesity, or both. However, research is still ongoing to determine how different levels of exposure to different PFAS can effect human health (EPA 2024c).

### 5.4.1 State PFAS Planning

In April 2024, the EPA finalized drinking water regulations for six PFAS compounds in drinking water under the Safe Drinking Water Act as part of its *PFAS Strategic Roadmap* (EPA 2024d). This step, along with prior action to reduce PFAS in the past several years, has sparked an increased effort by states to better understand and document PFAS contamination within their jurisdictions. Data collection efforts of PFAS constituents are underway in states of the OFO; however, data do not appear to be publicly available. In Oklahoma, the ODEQ has developed a quality assurance program for monitoring PFAS in a variety of media, including surface water, drinking water, and groundwater (OWRB 2024). In Kansas, the KDHE has taken steps to address PFAS in drinking water through coordinated efforts with the Bureau of Environmental Remediation and the Bureau of Water. This effort includes development of a statewide inventory and prioritization of potential PFAS sources that will inform development of a public water supply monitoring program (KDHE 2024b). In Texas, the TWDB has made available a significant amount of funding to reduce PFAS through wastewater and water infrastructure updates (TWDB 2024a).

### 5.4.2 PFAS Sources in Hydraulic Fracturing

PFAS may be used during the hydraulic fracturing process due to their stability at high temperatures and pressures and may be used in well drilling (in the form of drilling fluids), well completion, and workover operations (Gaines 2022). PFAS can be used as a surfactant to enhance recovery in oil and gas wells (Gaines 2022) to decrease friction during the drilling and hydraulic fracturing processes to allow for better drilling efficiency. In addition to drilling efficiency purposes, PFAS are used as an effective method to mitigate oil spills in water. PFAS can be injected into contaminated water to promote the formation of a barrier between oil and water. This allows for an increased efficiency in skimming oil spills from water during the remediation process (Gaines 2022).

PFAS used in hydraulic fracturing are generally categorized into four groups in the FracFocus database, which are discussed below; perfluoroalkyl alkanes/cycloalkanes, fluoroalkyl alcohol substituted polyethylene glycol, nonionic fluorosurfactants, and polytetrafluoroethylene (Connor et al. 2021). However, the true occurrence of PFAS chemical usage in hydraulic fracturing is difficult to determine because PFAS chemicals reported in FracFocus include misspellings, ambiguity, alternative naming, etc. Additionally, the number of chemicals labeled as “Not Disclosed” and “Proprietary” that were reported in FracFocus may include additional PFAS chemicals.

PFAS chemicals were grouped into one of four categories as previously described (Connor et al. 2021). Using this approach, no occurrences of perfluoroalkyl alkanes/cycloalkanes reporting were uncovered across the OFO and not included in the summary table (Table 5-8). Results indicate that reported PFAS chemicals make up a minimal proportion (less than 1%) of the chemical constituents disclosed to FracFocus for hydraulic fracturing within each state of the OFO planning area from 2014 to 2024 (FracFocus 2025). However, out of 3,574,141 chemical disclosures, 363,937 chemical names were not disclosed, which likely includes additional PFAS chemicals. The uncertainty within FracFocus chemical disclosure data indicates that the actual use of PFAS chemicals across the OFO planning area could be higher. The highest number of PFAS chemical disclosures occurs in Texas (4,257), followed by Oklahoma (1,210), and Kansas (2) (see Table 5-8).

**Table 5-8. Summary of PFAS Spills Reported Spill Materials to Kansas, Oklahoma, and Texas from 2014 to 2024, Further Categorized by Unit of Spill**

| State | Fluoroalkyl Alcohol Substituted Polyethylene Glycol | Nonionic Surfactants | Polytetrafluoro ethylene | Total PFAS | Potential PFAS | Total Non-PFAS Chemical Disclosures | Total Chemical Disclosures | PFAS Percentage Out of Total Disclosure |
|---|---|---|---|---|---|---|---|---|
| Kansas | 0 | 2 | 0 | 2 | 590 | 16,641 | 17,233 | 0.01% |
| Oklahoma | 0 | 923 | 287 | 1,210 | 64,224 | 492,483 | 557,917 | 0.22% |
| Texas | 54 | 2,617 | 1,640 | 4,257 | 299,123 | 2,695,556 | 2,998,991 | 0.14% |
| ***OFO Planning Area Total*** | 54 | 3,542 | 1,927 | 5,469 | 363,937 | 3,204,680 | 3,574,141 | 0.15% |

Source: U.S. FracFocus (2025).

Note: PFAS chemicals grouping is based on Connor et al. (2021). Potential PFAS includes non-disclosed data.

## 5.5 INDUCED SEISMICITY

Induced seismicity refers to seismic events that are triggered by human activities rather than natural processes such as tectonic plate movement, fault ruptures, volcanic activity, and isostatic rebound. Although most earthquakes are caused by natural processes, some earthquakes can also be induced by a broad range of human activities, including but not limited to underground fluid injection (e.g., for wastewater and hydraulic fracturing) and oil and gas extraction (GWPC 2021b). A significant rise in seismic activity began in 2009 in the southern midcontinent region of the United States, followed by a sharp decline in 2015. This trend was attributed to fluid injection practices (GWPC 2021b). Increased pore pressure due to fluid injection, especially near stressed faults, is strongly correlated with induced seismicity (GWPC 2021b). Both induced and natural seismic events have numerous factors that influence occurrence and magnitude such as rock strength and elasticity, friction on fault surfaces, fault age and depth, temperature and pressure, permeability to allow fluid travel, and interconnectivity of fault strands. Induced seismicity usually occurs in the shallow crust and likely in the formation where the injection is occurring (GWPC 2021b).

Wastewater injection is a common practice due to the high cost of purification. However, such injection can induce potentially damaging earthquakes when many wells are used (National Earthquake Prediction Evaluation Council and USGS 2020). Seismic events caused by oil and gas extraction, geothermal energy projects, and carbon dioxide injection are much more likely to induce events large enough to be felt by humans and may cause extreme damage (GWPC 2021b). High injection rates of greater than 300,000 barrels per month are much more likely to be associated with earthquakes, and any earthquake within approximately 10 to 30 kilometers (6.2-18.6 miles) of an active injection well could be associated with that well (OCC 2018; Weingarten et al. 2015). Because very small earthquakes (micro seismic events) are guaranteed to occur as part of the fracturing process, and magnitudes up to 4 are possible, several states such as Ohio, Oklahoma, and Pennsylvania have developed procedures for hydraulic fracturing companies to limit related seismicity (GWPC 2021b). Although frequent, even relatively extreme seismic events associated with hydraulic fracturing have been well below the damage threshold for modern building codes (Petersen et al. 2018; USGS 2021).

Class II injection wells are regulated by the EPA's UIC program or by states, territories, or Tribes with EPA-approved primary enforcement authority, known as primacy (EPA 2025a). Primacy has been given to all of the states within the OFO for multiple well UIC program classes, but not for all classes. The RRC, KCC, and OCC regulate Class II (injection associated with oil and gas production) type wastewater injections for their respective states, while other state entities may regulate other UIC classes.

State agencies in each of the three states in the OFO closely monitor and track earthquake activity. In Oklahoma, from 2015–2025, there were 4,719 earthquakes greater than 2.7 magnitude, although the trend from year to year has been steadily decreasing, with 2,000 earthquakes in 2015 versus just 37 in 2023 (OCC 2024c). In Kansas, from 2015–2024, there were 5,286 earthquakes equal to or greater than 3.0 magnitude primarily located in the north-to-south centerline of the state (KGS 2025b). Finally, from 2017–2025 in Texas, 1,134 earthquakes of magnitude greater than 3 were documented in various portions of the state, although concentrated heavily in the western panhandle and south of San Antonio (Texas Bureau of Economic Geology 2024).

## 5.6 RADIOLOGICAL MATERIALS – NATURALLY OCCURRING RADIOACTIVE MATERIAL AND TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIAL

Naturally occurring radioactive materials (NORM) are radionuclides such as uranium, thorium, radium-226, radium-228, and potassium-40 that are present naturally in rocks, soil, and groundwater. When industrial activities, particularly oil and gas extraction, mining, and water treatment, mobilize or concentrate these materials, they become classified as technologically enhanced naturally occurring radioactive materials (TENORMs). TENORM has the potential to impact water quality through the contamination of surface water and groundwater with radioactive isotopes, particularly when wastewater and brine byproducts are not properly managed (EPA 2025b).

Well operation can cause radioactivity to surface in several ways, including from drilling fluid, fracking, and production water. TENORM can be produced in different forms from different types of work, including as scale, in recycled water, separation pits, shale shakers, filters, sludge, or contaminated equipment (Nicoll 2012). TENORM contamination levels of operational equipment vary among geographic regions based on formation conditions, type of production operation, and age of production well. Some of the highest equipment readings across the country were found in northern Texas, while some of the lowest were in northern Kansas (EPA 2025b).

### 5.6.1 Oklahoma

Oklahoma faces water quality concerns related to TENORM, particularly from produced water in the Anadarko and Arkoma basins. Radionuclides can dissolve into produced water during hydraulic fracturing and enhanced oil recovery processes. Improper handling or disposal of this water—such as accidental releases or insufficient treatment—can result in radioactive contamination of surface streams or groundwater (EPA 2025b).

The ODEQ regulates water quality standards and radiation management, while the OCC oversees oilfield waste disposal practices. Oklahoma prohibits the discharge of TENORM-contaminated water into surface waters without treatment. The state requires radiation testing of brine and wastewater before disposal, and injection wells used for produced water must meet specific radiological safety requirements. Monitoring programs have been instituted to track radium concentrations in water near production zones to minimize environmental health risks (EPA 2024e).

### 5.6.2 Kansas

In Kansas, TENORM impacts on water quality are primarily associated with brine and produced water from oil wells located in the central and western parts of the state. These fluids can contain naturally elevated levels of radium and uranium, which, if released or leaked, pose a risk to shallow groundwater systems and surface waters used for agriculture and public water supplies (USGS 1999b).

The KDHE provides guidance on the management of TENORM and oversees water quality standards. Although Kansas does not have highly detailed TENORM-specific regulations, it does require facilities to test and monitor water used or impacted by oilfield operations. Radiation surveys and occasional groundwater monitoring around production sites are used to ensure compliance with federal drinking water standards, particularly the EPA’s MCL for radium (5 picocuries per liter combined radium-226 and radium-228).

### 5.6.3 Texas

In Texas, TENORM contamination of water is a key environmental concern due to the scale of oil and gas production in the Permian basin and Eagle Ford Shale regions (which are included in the regional East Texas and Gulf Coast Texas, Permian Basin, and Shelf Play addressed in Section 4.5 of this report). Produced water from drilling operations can contain elevated levels of radium-226 and radium-228. If not adequately treated or disposed of, these radioactive isotopes may enter surface water bodies or seep into aquifers, posing risks to drinking water supplies and ecosystems.

The Texas Department of State Health Services and the TCEQ oversee NORM-related issues in water. Texas mandates that any water or sludge containing radium concentrations above 30 picocuries per gram be treated as regulated NORM. Operators must use licensed facilities to treat or dispose of contaminated water, and options include deep well injection and specially licensed landfills. Monitoring and testing requirements are enforced to ensure that water quality is protected from radiological pollutants. The RRC also plays a role in permitting and regulating underground injection wells for TENORM-laden produced water.

# 6 LITERATURE CITED

Ball, M.M., M.E. Henry, and S.E. Frezon. 1991. *Petroleum geology of the Anadarko Basin region, Province (115), Kansas, Oklahoma, and Texas (Open-File Report 88–450W)*. U.S. Geological Survey. Available at: https://doi.org/10.3133/ofr88450W. Accessed June 2025.

Barlow, P.M., and S.A. Leake. 2012. *Streamflow Depletion by Wells–Understanding and Managing the Effects of Groundwater Pumping on Streamflow.* Available at: https://pubs.usgs.gov/circ/1376/pdf/circ1376_barlow_report_508.pdf. Accessed August 2025.

Bureau of Land Management (BLM). 2016. *Reasonable Foreseeable Development Scenario, Kansas, Oklahoma, and Texas.* Prepared by Patrick Strong. Available upon request. Accessed August 2024.

———. 2020. BLM & BIA sign Records of Decision for Oklahoma, Kansas, and Texas Final Joint Environmental Impact Statement, BLM Resource Management Plan, and BIA Integrated Resource Management Plan. Available at: https://www.blm.gov/press-release/blm-bia-sign-records-decision-oklahoma-kansas-and-texas-final-joint-environmental?utm. Accessed July 2025.

———. 2025a. BLM Water Support Document for Oil and Gas Development in New Mexico. SWCA Environmental Consultants. In preparation.

———. 2025b. BLM Oklahoma Field Office Competitive Oil and Gas Lease Sale: *Environmental Assessment. Custer Dewey, and Roger Mills Counties, Oklahoma. Quarter 4 2025*. DOI-BLM-NM-0040-2025-0019-EA. Available at: https://eplanning.blm.gov/public_projects/2035975/200636865/20132185/251032165/EA_OFO_Q4%202025_Lease%20Sale_PublicComment_508.pdf. Accessed July 2025.

———. 2025c. New Mexico Oil and Gas Lease Sales. Available at: https://www.blm.gov/programs/energy-and-minerals/oil-and-gas/leasing/regional-lease-sales/new-mexico. Accessed July 2025.

Cardott, B. J. 2017. *Oklahoma shale resource plays. Oklahoma Geological Survey, 76(2), 21–30.* Available at: http://www.ou.edu/content/ogs/research/energy/oil-gas.html. Accessed June 2025.

Christenson, S.C., D.L. Parkhurst, and R.W. Fairchild. 1990. *Geohydrology and water quality of the Roubidoux aquifer, northeastern Oklahoma*: U.S. Geological Survey Open-File Report 90-570, prepared in cooperation with the Oklahoma Geological Survey.

ClimateEngine.org. 2025. Access Site Characterization Reports. Available at: https://reports.climateengine.org/sitecharacterization. Accessed June 2025.

Connor, J.A., I. Rhodes, C.C. Stanley, E. Gie, K.A. Graham, J.K. Anderson, A.D. Daus, and D.T. Adamson. 2021. Comment on "Fracking with Forever Chemicals" by Physicians for Social Responsibility. GSI Environmental. Available at: https://www.gsienv.com/wp-content/uploads/2021/09/Comment-on-Fracking-with-Forever-Chemicals-by-Physicians-for-Social-Responsibility-issued-July-2021-2.pdf. Accessed October 2025.

Cornell Law School. 2024. Okla. Admin. Code § 165:10-7-5 - Prohibition of pollution. Available at: https://www.law.cornell.edu/regulations/oklahoma/OAC-165-10-7-5#:~:text=(a)%20General.,Pollution%20is%20prohibited. Accessed August 2025.

Dai, Aiguo and National Center for Atmospheric Research Staff (editors). 2023. “The Climate Data Guide: Palmer Drought Severity Index (PDSI).” Available at: https://climatedataguide.ucar.edu/climate-data/palmer-drought-severity-index-pdsi. Accessed August 2025.

Dieter, C.A., M.A. Maupin, R.R. Caldwell, M.A. Harris, T.I. Ivahnenko, J.K. Lovelace, N.L. Barber, and K.S. Linsey. 2018. *Estimated Use of Water in the United States in 2015*. U.S. Geological Survey Circular 1441. Available at: https://pubs.er.usgs.gov/publication/cir1441. Accessed August 2025.

Fay, R.O., S.A. Friedman, K.S. Johnson, J.F. Roberts, W.D. Rose, and P.K. Sutherland. 1979. The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States–Oklahoma. *U.S. Geological Survey Professional Paper 1110-R*.

Fetkovich, E.J., A.S. Morris, I.A. Dale, E.A. Kirby, C.A. Baciocoo, I.M.J. Rogers, D.L. Wagner, Z.D. Tomlinson, and E.G. Fiorentino. 2025. *Hydrogeologic Investigation, Framework, and Conceptual Flow Model of the Antlers Aquifer, Southeastern Oklahoma, 1980-2022.* U.S. Department of the Interior and U.S. Geological Survey Scientific Investigations Report 2025-5013. Available at: https://doi.org/10.3133/sir20255013. Accessed June 2025.

FracFocus. 2025. The National Hydraulic Fracturing Chemical Disclosure Registry. Available at: https://fracfocus.org/. Accessed May 2025.

Gaines, G.T., Ph.D. 2022. Historical and current usage of per-and polyfluoroalkyl substances (PFAS): A literature review. *American Journal of Industrial Medicine* 66(5):353–378. Available at: https://onlinelibrary.wiley.com/doi/10.1002/ajim.23362. Accessed August 2024.

Ground Water Protection Council (GWPC). 2021a. *U.S. Produced Water Volumes and Management Practices in 2021*. Available at: https://www.gwpc.org/wp-content/uploads/2021/09/2021_Produced_Water_Volumes.pdf. Accessed July 2025.

———. 2021b. Potential Induced Seismicity Guide: A Resource of Technical & Regulatory Considerations Associated with Fluid Injection. 2021 Update. March 2021. Available at: https://www.gwpc.org/wp-content/uploads/2022/12/FINAL_Induced_Seismicity_2021_Guide_33021.pdf. Accessed June 2025.

Henry, M.E. 1988. *Review of the geology of the southern Oklahoma fold belt province as a basis for estimates of undiscovered hydrocarbon resources.* USGS Department of the Interior Open-File Report 87-450w. Available at: web.archive.org/web/20170303003117id_/https://pubs.usgs.gov/of/1987/0450w/report.pdf. Accessed June 2025.

Higley, D.K., S.B. Gaswirth, M.M. Abbott, R.R. Charpentier, T.A. Cook, G.S. Ellis, N.J. Gianoutsos, J.R. Hatch, T.R. Klett, P.H. Nelson, M.J. Pawlewicz, O.N. Pearson, R.M. Pollastro, and C.J. Schenk. 2014. *Assessment of undiscovered oil and gas resources of the Anadarko Basin Province of Oklahoma, Kansas, Texas, and Colorado, 2010 (U.S. Geological Survey Digital Data Series DDS–69–EE, 409 p.).* U.S. Geological Survey. Available at: https://pubs.usgs.gov/dds/dds-069/dds-069-ee/. Accessed June 2025.

Integrated Drought Management Programme. 2025a. Palmer Z Index. Available at: https://www.droughtmanagement.info/palmer-z-index/. Accessed August 2025.

———. 2025b. Palmer Hydrological Drought Index. Available at: https://www.droughtmanagement.info/palmer-hydrological-drought-index-phdi/. Accessed August 2025.

Kansas Corporation Commission (KCC). 2024. Clean up Guidelines for Spills and Escapes Exempted from Notification Requirements. Available at: https://www.kcc.ks.gov/oil-gas/clean-up-guidelines. Accessed August 2025.

———. 2025a. Personal Communication, Kansas Spill Data. Electronic communication, Kansas Corporation Commission to SWCA. Accessed May 2025.

———. 2025b. Oil & Gas. Available at: https://www.kcc.ks.gov/oil-gas. Accessed May 2025.

______. 2025c. About the Conservation Division. Available at: https://www.kcc.ks.gov/oil-gas/about-the-conservation-division. Accessed July 2025.

Kansas Department of Health and Environment (KDHE). 2024a. *Kansas 303(d) List of Impaired Waters.* Available at: https://www.kdhe.ks.gov/999/303d-Methodology-List-of-Impaired-Waters. Accessed June 2025.

———. 2024b. Per- & Polyfluoroalkyl Substances. Available at: https://www.kdhe.ks.gov/635/Per--Polyfluoroalkyl-Substances. Accessed August 2025.

Kansas Geological Survey (KGS). 1993. Kansas Ground Water. Available at: https://www.kgs.ku.edu/Publications/Bulletins/ED10/04_occur.html. Accessed August 2025.

———. 2025a. Hugoton Natural Gas Area of Kansas. Available at: https://kgs.ku.edu/hugoton-natural-gas-area-kansas. Accessed August 2025.

———. 2025b. The University of Kansas Earthquake Catalog. Written communication to Halle Haudrich, Staff Water Resource Scientist.

Kansas Water Authority. 2025. Annual Report to the Governor and Legislature. Available at: https://www.kwo.ks.gov/home/showpublisheddocument/3222/638723820672716746. Accessed June 2025.

Kansas Water Office (KWO). 2015. A Long-Term Vision for the Future of Water Supply in Kansas. Available at: https://www.kwo.ks.gov/home/showpublisheddocument/1180/638338156260670000. Accessed June 2025.

———. 2022. Kansas Water Plan. Available at: https://kansas-water-plan-ksdot.hub.arcgis.com/documents/b0a512f60c6048d8b8ad728238777c49/explore. Accessed July 2025.

Keyantash, John and National Center for Atmospheric Research Staff. 2025. The Climate Data Guide: Standardized Precipitation Index. Available at: https://climatedataguide.ucar.edu/climate-data/standardized-precipitation-index-spi. Accessed August 2025.

McGuire, V.L., Lund, K.D., Densmore, B.K. 2012. *Saturated Thickness and Water in Storage in the High Plains Aquifer, 2009, and Water-Level Changes and Changes in Water in Storage in the High Plains Aquifer, 1980 to 1955, 1995 to 2000, 2000 to 2005, and 2005 to 2009.* Available at: https://doi.org/10.3133/sir20125177. Accessed August 2025.

McGuire, V.L, and K.R. Strauch. 2024. *Water-Level and Recoverable Water in Storage Changes, High Plains Aquifer, Predevelopment to 2019 and 2017 to 2019.* Available at: https://pubs.usgs.gov/sir/2023/5143/sir20235143.pdf. Accessed August 2025.

Meyer, J.E., M.R. Wise, and S. Kalaswad. 2012. *Pecos Valley Aquifer, West Texas: Structure and Brackish Groundwater.* Prepared for the Texas Water Development Board. Available at: https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R382_PecosValley.pdf. Accessed August 2025.

Murray, K.E. 2015. Class II Saltwater Disposal for 2009–2014 at the Annual-, State-, and County- Scales by Geologic Zones of Completion, Oklahoma. Oklahoma Geological Survey Open-File Report (OF5-2015). Norman, OK. pp. 18. Accessed June 2025.

National Earthquake Prediction Evaluation Council and U.S. Geological Survey (USGS). 2020. *Induced Seismicity: Strategic Vision, 2020–2030.* U.S. Geological Survey Circular. Available at: https://doi.org/10.3133/cir1509. Accessed June 2025.

Nicoll, Gayle. 2012. *Radiation Sources In Natural Gas Well Activities*. Available at: https://eplanning.blm.gov/public_projects/2015538/200495187/20062614/250068796/Exhibit%20113%20-%20Occupational%20Health%20and%20Safety%202012.pdf. Accessed July 2025.

NOAA National Integrated Drought Information System. 2025. NASA SPoRT-LiS Soil Moisture Products. Available at: https://www.drought.gov/data-maps-tools/nasa-sport-lis-soil-moisture-products. Accessed August 2025.

Oklahoma Corporation Commission (OCC). 2018. *Moving Forward: New protocol to further address seismicity in state's largest oil and gas play*. News release, February 27, 2018. Available at: https://oklahoma.gov/content/dam/ok/en/occ/documents/og/02-27-18protocol.pdf. Accessed July 2025.

———. 2024a. Oil and Gas Conservation Division. Available at: https://oklahoma.gov/occ/divisions/oil-gas.html. Accessed August 2025.

———. 2024b. What the Oil & Gas Industry Should Know About Reporting and Responding to Spills in Oklahoma. Available at: https://oklahoma.gov/occ/divisions/oil-gas/oil-and-gas-faq.html#:~:text=A%20verbal%20spill%20report%20must,(405)%20521%2D4170. Accessed August 2025.

———. 2024c. OCC Daily Earthquake Update. Available at: https://oklahoma.gov/occ/divisions/oil-gas/induced-seismicity-and-uic-department/occ-daily-earthquake-update.html. Accessed August 2025.

———. 2025. Oil and Gas Conservation Division Incident Search. Available at: https://gis.occ.ok.gov/portal/apps/experiencebuilder/experience/?id=75bcb0b2c7f943dfa6cec75a50c9205a. Accessed July 2025.

Oklahoma Department of Environmental Quality (ODEQ). 2022. Integrated Report. Available at: https://www.deq.ok.gov/water-quality-division/watershed-planning/integrated-report/. Accessed July 2024.

———. 2025. Draft Integrated Report. Available at: https://www.deq.ok.gov/wp-content/uploads/water-division/2024_Integrated-Report.pdf. Accessed June 2025.

Oklahoma Water Resources Board (OWRB). n.d. *Oklahoma groundwater resources: Major and minor aquifers of Oklahoma* [map]. Scale 1:1,500,000. Oklahoma City: Oklahoma Water Resources Board. Available at: https://www.owrb.ok.gov/maps/pdf_map/GW%20Aquifers.pdf. Accessed June 2025.

———. 1997. Oklahoma Drought Management Plan. Available at: https://oklahoma.gov/content/dam/ok/en/owrb/documents/maps-and-data/drought_plan.pdf. Accessed August 2025.

———. 2012a. 2012 Oklahoma Comprehensive Water Plan. Available at: https://oklahoma.gov/owrb/water-planning/2012-oklahoma-comprehensive-water-plan.html. Accessed July 2025.

———. 2012b. Oklahoma Surface Water Resources: Lakes and Streams. Oklahoma Water Resources Board. Available at: https://www.owrb.ok.gov/maps/pdf_map/SW%20Lakes%20and%20Streams%20Topo.pdf. Accessed July 2025.

———. 2024. Drought Monitoring. Available at: https://oklahoma.gov/owrb/water-planning/drought-and-flooding.html. Accessed August 2025.

———. 2025a. Water Planning. Available at: https://oklahoma.gov/owrb/water-planning.html. Accessed July 2025.

———. 2025b. Oklahoma Comprehensive Water Plan, OWRB Fact Sheet. Available at: https://oklahoma.gov/content/dam/ok/en/owrb/documents/water-planning/ocwp/oklahoma-comprehensive-water-plan-fact-sheet.pdf. Accessed July 2025.

———. 2025c. Hydrologic Investigations Report of Reaches I and II of the Red River Alluvial and Terrace Aquifer in Southwest and South-Central Oklahoma. Available at: https://oklahoma.gov/content/dam/ok/en/owrb/documents/science-and-research/hydrologic-investigations/red-river.pdf. Accessed July 2025.

———. 2025d. Hydrologic Investigations. Available at: https://oklahoma.gov/owrb/data-and-maps/hydrologic-investigations.html. Accessed July 2025.

Palmer, W.C. 1965. *Meteorological Drought.* Research Paper No. 45, U.S. Weather Bureau, Washington, DC.

Petersen, M.D., C.S. Mueller, M.P. Moschetti, S.M. Hoover, K.S. Rukstales, D.E. McNamara, R.A. Williams, A.M. Shumway, P.M. Powers, P.S. Earle, A.L. Llenos, A.J. Michael, J.L. Rubinstein, J.H. Norbeck, and E.S. Cochran. 2018. One-year seismic hazard forecast for the central and eastern United States from induced and natural earthquakes. *Seismological Research Letters* 89(3):1049–1061.

Reutter, D.C., and D.D. Dunn. 2000. *Water Quality Assessment of the Trinity Rive Basin, Texas—Ground-water Quality of the Trinity, Carrizo-Wilcox, and Gulf Coast Aquifers*. Water-Resources Investigations Report 99-4233. Available at: pubs.usgs.gov/wri/wri99-4233/pdf/wri99-4233.pdf. Accessed August 2025.

Rogers, I.M.J., S.J. Smith, N.C. Gammill, N.J. Gillard, K.A. Lockmiller, E.J. Fetkovich, J.S. Correll, and S.P. Hussey. 2023. *Hydrogeology and simulated groundwater availability in reaches 3 and 4 of the Washita River aquifer, southern Oklahoma, 1980–2017*. U.S. Geological Survey Scientific Investigations Report 2023–5072, 83 p. Available at: https://doi.org/10.3133/sir20235072. Accessed August 2025.

Ryder, P.D. 1988. *Hydrogeology and Predevelopment Flow in the Texas Gulf Coast Aquifer Systems.* Prepared for the U.S. Geological Survey. Available at: https://pubs.usgs.gov/wri/1987/4248/report.pdf. Accessed August 2025.

Sunderland, E.M., X.C. Hu, C. Dassuncao, A.K. Tikranov, C.C. Wagner, and J.G. Allen. 2018. A Review of the Pathways of Human Exposure to Poly- and Perfluoroalkyl Substances (PFASs) and Present Understanding of Health Effects. *Journal of Exposure Science & Environmental Epidemiology* 29:131–147 (2019). Available at: https://www.nature.com/articles/s41370-018-0094-1. Accessed July 2025.

Texas Bureau of Economic Geology. 2024. Texas Seismological Network and Seismology Research (TexNet). Available at: https://www.beg.utexas.edu/texnet-cisr/texnet. Accessed August 2025.

Texas Commission on Environmental Quality (TCEQ). 2022. Spills: Rules and Laws Available at: https://www.tceq.texas.gov/response/spills/spill_rules.html. Accessed July 2025.

———. 2024a. 2024 Texas Integrated Report of Surface Water Quality for Clean Water Act Section 305(b) and 303(d). Available at: https://www.tceq.texas.gov/waterquality/assessment/2024-integrated-report/24txir. Accessed June 2025.

———. 2024b. Texas Surface Water Quality Standards. Available at: https://www.tceq.texas.gov/waterquality Accessed July 2025.

———. 2024c. *2024 Texas Integrated Report - Potential Sources of Impairments and Concerns*. Available at: https://www.tceq.texas.gov/downloads/water-quality/assessment/integrated-report-2024/2024-sources. Accessed July 2025.

———. 2024d. *Groundwater Assessment: 2024 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)*. Available at: https://www.tceq.texas.gov/downloads/water-quality/assessment/integrated-report-2024/2024-groundwater-as-465-24.pdf. Accessed June 2025.

———. 2025a. Spills, Discharges, and Releases. Available at: https://data.texas.gov/dataset/Texas-Commission-on-Environmental-Quality-Emergenc/xagr-a3x2/about_data. Accessed June 2025.

______. 2025b. Water. Available at: https://www.tceq.texas.gov/agency/water_main.html. Accessed July 2025.

Texas General Land Office. 2025. Oil Spill. Available at: https://www.glo.texas.gov/coastal/oil-spill-prevention-and-response. Accessed June 2025.

Texas Railroad Commission (RRC). 2024. Oil & Gas. Available at: https://www.rrc.texas.gov/oil-and-gas/. Accessed July 2025.

———. 2025a. Granite Wash: Information and Statistics. Available at: https://rrc.texas.gov/oil-and-gas/major-oil-and-gas-formations/granite-wash/. Accessed August 2025.

———. 2025b. Barnett Shale: Information and Statistics. Available at: https://rrc.texas.gov/oil-and-gas/major-oil-and-gas-formations/barnett-shale/. Accessed August 2025.

Texas Secretary of the State. 1996. Texas Administrative Code. Available at: https://texas-sos.appianportalsgov.com/rules-and-meetings?interface=VIEW_TAC. Accessed June 2025.

Texas Water Development Board (TWDB). 2024a. State Water Planning. Available at: https://www.twdb.texas.gov/waterplanning/swp/index.asp. Accessed July 2025.

———. 2024b. 2022 State Water Plan, Water for Texas. Available at: https://www.twdb.texas.gov/waterplanning/swp/2022/index.asp. Accessed July 2025.

———. 2024c. Groundwater. Available at: https://www.twdb.texas.gov/groundwater/. Accessed August 2025.

———. 2024d. Drought Outlook. Available at: https://www.twdb.texas.gov/drought/outlook/index.asp. Accessed August 2025.

U.S. Drought Monitor. 2025. Comprehensive Statistics. Available at: https://droughtmonitor.unl.edu/DmData/DataDownload/ComprehensiveStatistics.aspx. Accessed June 2025.

U.S. Energy Information Administration. 2020. *Permian Basin Part 1 Wolfcamp, Bone Spring, Delaware Shale Palys of the Delaware Basin.* Available at: https://www.eia.gov/maps/pdf/Permian-pI_Wolfcamp-Bonespring-Delaware.pdf. Accessed June 2025.

———. 2025. *Kansas State Energy Profile.* Available at: https://www.eia.gov/state/print.php?sid=KS. Accessed July 2025.

U.S. Environmental Protection Agency (EPA). 2016. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. Available at: https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990. Accessed August 2025.

———. 2024a. *Polluted Runoff: Nonpoint Source (NPS) Pollution.* Available at: https://www.epa.gov/nps. Accessed August 2025.

———. 2024b. *CompTox Chemicals Dashboard v2.5.3. Navigation Panel to PFAS Structure Lists.* Available at: https://comptox.epa.gov/dashboard/chemical-lists/PFASSTRUCT. Accessed June 2025.

———. 2024c. *Our Current Understand of the Human Health and Environmental Risks of PFAS.* Available at: https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas. Accessed August 2025.

———. 2024d. *PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024.* Available at: https://www.epa.gov/pfas/pfas-strategic-roadmap-epas-commitments-action-2021-2024. Accessed August 2025.

———. 2024e. Radionuclides Rule. Available at: https://www.epa.gov/dwreginfo/radionuclides-rule. Accessed July 2025.

———. 2025a. *Class II Oil and Gas Related Injection Wells.* Available at: https://www.epa.gov/uic/class-ii-oil-and-gas-related-injection-wells#well_reqs. Accessed July 2025.

———. 2025b. *TENORM: Oil and Gas Production Wastes*. Available at: https://www.epa.gov/radiation/tenorm-oil-and-gas-production-wastes. Accessed July 2025.

U.S. Geological Survey (USGS). 1987. *Review of the geology of the SOFB province*. Available at: https://pubs.usgs.gov/of/1987/0450w/report.pdf. Accessed July 2025.

———. 1995. Ground Water Atlas of The United States, Arizona, Colorado, New Mexico, Utah**.** Available at: https://pubs.usgs.gov/ha/ha730/ch_c/. Accessed July 2025.

———. 1999a. Groundwater Atlas of the United States, Oklahoma, Texas. Available at: https://pubs.usgs.gov/ha/ha730/ch_e/E-text3.html. Accessed August 2025.

———. 1999b. *Naturally Occurring Radioactive Materials (NORM) in Produced Water and Oil-Field Equipment—An Issue for the Energy Industry*. Available at: https://pubs.usgs.gov/fs/fs-0142-99/fs-0142-99.pdf. Accessed June 2025.

———. 2003. *Principal Aquifers of the 48 Conterminous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands: U.S. Geological Survey data release*. Available at: https://doi.org/10.5066/P9Y2HOUJ. Accessed June 2025.

———. 2017. *Groundwater Quality in the Rio Grande Aquifer System, Southwestern United States*. Available at: https://pubs.usgs.gov/fs/2017/3047/fs20173047.pdf. Accessed July 2025.

———. 2019. Groundwater Quality in the High Plains Aquifer. Available at: https://pubs.usgs.gov/fs/2019/3055/fs20193055.pdf. Accessed August 2025.

———. 2021. Induced Earthquakes – Myths and Misconceptions. Available at: https://www.usgs.gov/programs/earthquake-hazards/myths-and-misconceptions-about-induced-earthquakes. Accessed August 2025.

———. 2023. Water use in the United States. Available at: https://www.usgs.gov/mission-areas/water-resources/science/water-use-united-states. Accessed July 2025.

———. 2025. High Plains Water-Level Monitoring Study. Available at: https://ne.water.usgs.gov/projects/HPA/hpa.html. Accessed August 2025.

Valder, J.F., R.R. McShane, J.N. Thamke, J.S. McDowell, G.P. Ball, N.A. Houston, and A.E. Galanter. 2021. *Estimates of Water Use Associated with Continuous Oil and Gas Development in the Permian Bain, Texas and New Mexico 2010–19.* Scientific Investigations Report 2021–5090. Available at: https://pubs.usgs.gov/sir/2021/5090/sir20215090.pdf. Accessed August 2025.

Weingarten, M., S. Ge, J.W. Godt, B.A. Bekins, and J.L. Rubinstein. 2015. High-rate injection is associated with the increase in U.S. mid-continent seismicity. *Science* (6241):1336–1340.

# APPENDIX A

## Data Inventory and Analysis Methodology Memorandum for the Oklahoma Water Support Document

U.S. Department of the Interior
Bureau of Land Management

# DATA INVENTORY AND ANALYSIS METHODOLOGY MEMORANDUM FOR THE OKLAHOMA WATER SUPPORT DOCUMENT

BLM WSD 2025

October 2025

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## Mission statement

The Bureau of Land Management sustains the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations.

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# 1 PURPOSE AND SCOPE

This memorandum outlines the data sources that will be utilized in the development of the Bureau of Land Management (BLM) Oklahoma Field Office (OFO) 2025 Water Support Document for Oil and Gas Development in Oklahoma, Kansas, and Texas (hereinafter referred to as the Water Support Document, or WSD). It also outlines the methodology for data analysis and processing, so that the process can be replicated accurately by others or updated in subsequent years, as needed, due to changes in technologies, the inclusion of other operators' data, or other factors. All acronyms and abbreviations that appear in Appendix A are tabulated following the "Contents" section in the main Water Support Document.

Section 2 describes the spatial scale of the analysis, whereas Section 3 presents the sources of data to be used for water quantity and water quality analyses, as well as the methodology for analyzing and processing data sources, as applicable. For each dataset described in this report, various data processing applications may be used to process the data, depending on user preference (e.g., Excel or R statistical software [R]) (R Core Team 2024). Additionally, there are multiple approaches within each application to generate the same information (e.g., in Excel, the use of pivot tables, copying data into new tabs to use the Remove Duplicates button, or using filters; in R, various functions to aggregate and summarize data). Therefore, these methods provide basic aggregation rules and specific column names in the datasets to accommodate different user preferences and styles of approaching data management.

# 2 SCALE OF ANALYSIS

The BLM OFO is responsible for the management of 4,810,900 acres of federal minerals across the 269,650,000-acre OFO planning area, which encompasses the states of Kansas, Oklahoma, and Texas, as well as one county in Nebraska (BLM 2020). The BLM OFO also assists the Bureau of Indian Affairs (BIA) with oil and gas permitting on 2,667,800 acres of BIA-managed mineral estate in the OFO planning area. The analysis area for this memorandum and the associated OFO WSD is the approximately 270 million-acre OFO planning area. Given the large geographic scale of the OFO planning area, a subset of targeted counties was identified within the planning area to allow for more focused data analysis efforts for the OFO WSD. Targeted counties include those where oil and gas development is currently happening, or is likely to happen (e.g., based on historic activity and/or resource potential) in the future, and are therefore most relevant to the WSD analysis. Targeted counties were selected through review of the following two data sources: 1) BLM OFO oil and gas lease sales over the last 11 years (BLM 2025) and 2) BLM OFO applications for permit to drill (APDs) over the last 11 years. Based on review of these two data sources, a total of 75 counties across Kansas, Oklahoma, and Texas were identified as having oil and gas lease sales or APDs over the last 11 years (Table 1, Figure 1). These 75 counties will be the focus of data gathering efforts for the 2025 OFO WSD. During subsequent annual WSD updates, this list of targeted counties should be re-visited and revised, as needed, to capture any changes in oil and gas developmental trends within the planning area.

**Table 1. Targeted Counties for the 2025 OFO WSD**

| State | Lease Sale Occurrence Counties (2014–2025) | APD Occurrence Counties (2014–2025) | Lease Sale and APD Occurrence Counties (2014–2025) |
|---|---|---|---|
| Kansas | Cheyenne, Decatur, Greeley, Lane, Logan, Meade, Norton | Finney, Franklin, Montgomery, Sherman, Woodson | Not applicable |
| Oklahoma | Alfalfa, Beaver, Beckham, Cimarron, Custer, Harper, Le Flore, Payne, Woods, Woodward | Blaine, Caddo, Canadian, Garvin, Hughes, Seminole, Tillman | Coal, Creek, Dewey, Ellis, Grady, Jackson, Kingfisher, Major, McClain, Pittsburg, Roger Mills |
| Texas | Andrews, Burleson, Cherokee, Culberson, Gaines, Grayson, Hemphill, Houston, Jackson, Lee, Loving, Montgomery, San Jacinto, Tarrant, Trinity, Walker, Washington, Winkler, Zapata | Calhoun, Comal, Delta, Denton, Galveston, Guadalupe, Hutchinson, Karnes, Kenedy, San Augustine | Jasper, Live Oak, McMullen, Sabine, Shelby, Wise |

Source: BLM (2024)

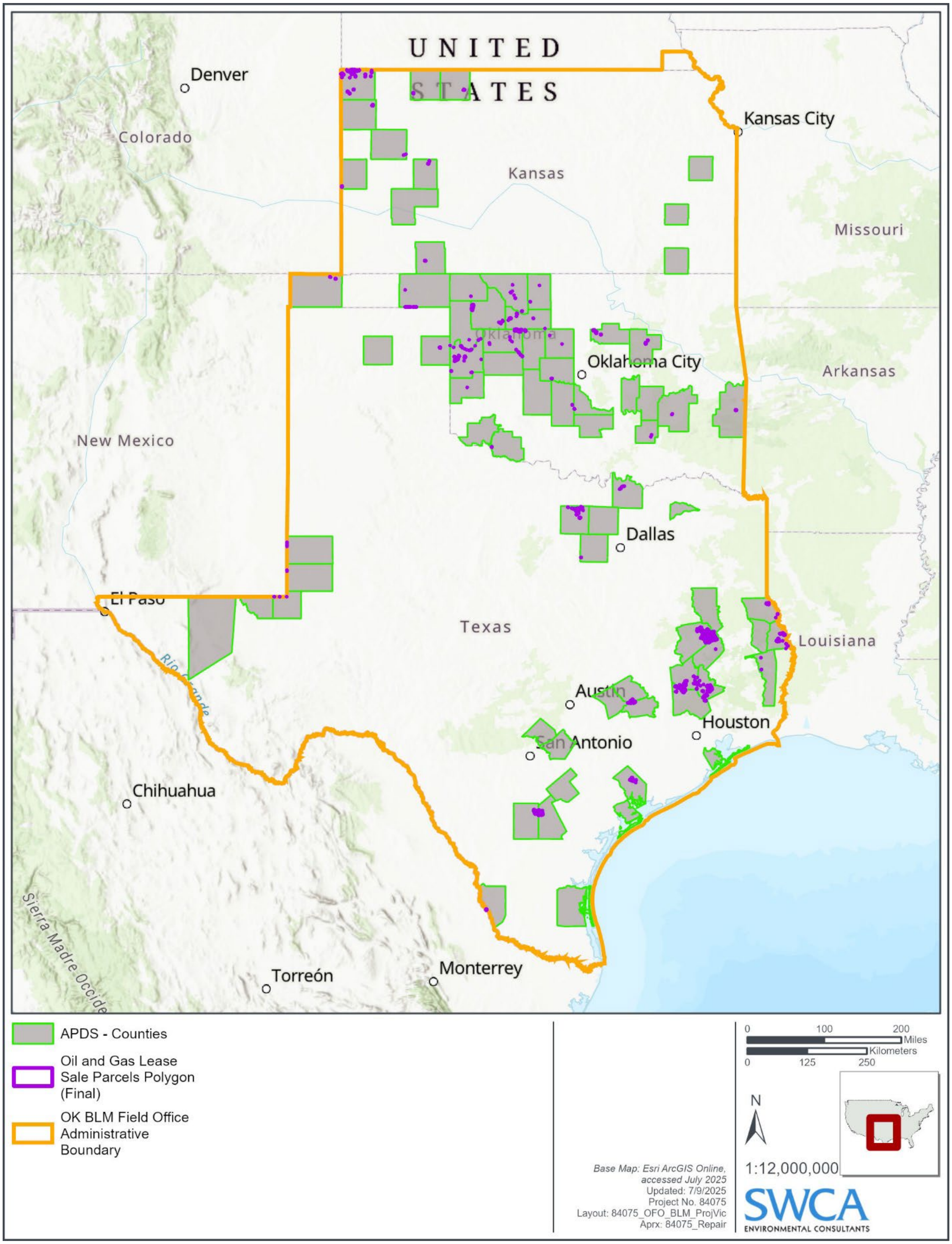


**Figure 1. Targeted counties in the 2025 BLM OFO WSD.**

# 3 DATA SOURCES

Several sources of data were reviewed, compiled, and analyzed where appropriate to address all relevant topics of the WSD. Table 2 provides a summary of data sources and the context in which they will be presented in the WSD. Data for three of the sources—FracFocus, U.S. Geological Survey (USGS) water use, and state spill data—will be downloaded and analyzed per the methodologies presented in Sections 3.1 through 3.3, respectively. Other sources of data include state and federal agency reports that will be reviewed and summarized to meet the informational needs of the WSD. Table 2 provides an overview of major data sources considered for the WSD; however, the data sources listed are not comprehensive, and the final document is expected to include some additional sources for a more comprehensive assessment.

**Table 2. Major Data Sources by WSD Topic**

| WSD Topics | Data Sources |
|---|---|
| Statewide water quality and quantity data associated with oil and gas development | USGS Estimated Use of Water in the United States in 2015<br>Kansas, Oklahoma, Texas Integrated Reports (Dieter et al. 2018) |
| Overview of regional water sources, hydraulic fracturing practices/technologies, and water use | 2016 Reasonably Foreseeable Development Scenario (BLM 2016)<br>BLM OFO Environmental Impact Statement (EIS) Resource Management Plan (RMP; BLM 2020) |
| Description of produced water reuse in oil and gas development | Oil and Gas Produced Water Reuse: Opportunities, Treatment Needs, and Challenges (Cooper et al. 2021) |
| Water sources utilized during oil and gas development on federally managed lands | 2016 Reasonably Foreseeable Development Scenario (BLM 2016) |
| Groundwater trends | USGS – A Dataset of Scanned Historical Well and Geophysical Logs From 96 Counties in Texas, 1925–2020 (USGS 2024a) |
| Overview of existing water quality and quantities within the OFO | USGS Estimated Use of Water in the United States in 2015 (Dieter et al. 2018)<br>BLM OFO EIS/RMP (BLM 2020)<br>Kansas (Kansas Water Office 2015, 2022), Oklahoma (ODEQ 2024), Texas (2024a) Integrated Reports |
| Summary of known impacts of hydraulic fracturing to water quality and quantity | U.S. Environmental Protection Agency's (EPA's) Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States<br>Kansas (Kansas Corporation Commission [KCC] 2025a), Oklahoma (Oklahoma Corporation Commission [OCC] 2025a), Texas spill data (Texas Commission of Environmental Quality [TCEQ] 2025a) |
| Summary of water use per well associated with oil and gas development | FracFocus (FracFocus 2024) |
| Future water use scenarios | 2016 Reasonably Foreseeable Development Scenario (BLM 2016) |
| Drought and water availability | Climate Engine State Water Agency planning documents for the states of Texas, Oklahoma, and Kansas (Climate Engine 2024) |
| Per- and polyfluoroalkyl substances (PFAS) | EPA Strategic Roadmap (EPA 2021)<br>EPA PFAS usage literature review (USGS 2024b) |
| Induced seismicity | Kansas, Oklahoma, Texas seismicity planning (USGS 2024c) |

For data sources where data will be downloaded and analyzed, all data will be read, cleaned, summarized, and aggregated in R. R serves as a powerful tool for data manipulation, cleaning, summarization, aggregation, and visualization. Data scientists use a variety of functions and techniques tailored to specific needs to process raw data efficiently and accurately. In addition to its manipulation and analytical capabilities, R enables data scientists to perform detailed data-quality checks, ensuring accuracy and reliability throughout the analysis process. The approach outlined herein represents the general approach and proposed methodology; however, the methodology is subject to change to accommodate factors such as poor data quality or unexpected issues encountered during the data processing and analysis phases in R. All code will be annotated and provided to the BLM with the final WSD to ensure ease of reproducibility.

The following is a dictionary of key functions and example functions commonly used in R:

- **Data Manipulation:**
  - **subset() or filter():** Subsetting data frames (data organized in a tabular format for data organization and analysis) based on conditions.
  - **merge()**: Merging multiple data frames by common variables.
  - **mutate()**: Adding new variables or modifying existing ones.
  - **transform()**: Creating new variables or transforming existing ones.
  - **sample()**: Random selection from within a dataset
- **Data Cleaning:**
  - **na.omit()**: Removing rows with missing values.
  - **outlier()**: Identifying and handling outliers.
  - **gsub()**: Replacing or modifying text patterns.
- **Data Summarization:**
  - **summarize()**: Generating summary statistics for data frames.
  - **table()**: Creating frequency tables.
- **Data Aggregation:**
  - **aggregate()**: Aggregating data by groups.
  - **group_by()**: Grouping data into subsets for analysis.
  - **summarize()**: Summarizes data.
- **Data Visualization:**
  - **ggplot2**: Creating customizable plots and visualizations.

## 3.1 Fracfocus Data

### *3.1.1 Data Summary*

The FracFocus database serves as the national registry for hydraulic fracturing chemicals and water used in hydraulic fracturing across the United States. When the site was initiated in 2011, many companies voluntarily disclosed hydraulic fracturing chemicals; however, some states later permitted disclosure to FracFocus to fulfill mandatory reporting requirements. Oklahoma and Texas began requiring disclosures to FracFocus in 2012, whereas Kansas began requiring reporting in 2015. As of August 2021, FracFocus emerged as the exclusive national regulatory reporting system used by many states. Housing a repository of data with over 184,000 disclosures and exceeding 5 million chemical records sourced from over 1,600 registered companies, FracFocus stands as the best available resource for hydraulic fracturing data (FracFocus 2025).

### *3.1.2 Data Preparation*

FracFocus data requires substantial cleaning, processing, and data checks prior to reporting. After the dataset is read into R, the data will be checked, reorganized, and summarized to develop summary reports for the WSD. A master dataset will be created that includes each state within the OFO. The master dataset will include many of the original columns from the FracFocus registry and additional columns created for ease of downstream grouping and summarizing (e.g., unit conversions).

The following data checks are intended to evaluate and validate the consistency, completeness, and uniqueness of FracFocus data. In this process, records that do not meet the specified data quality criteria are reviewed and addressed using case-specific techniques. The data is systematically evaluated, verified, and adjusted based on reasonable assumptions until all identified discrepancies are resolved. Data is not removed during the data cleaning process. The following steps will be taken to clean, organize, and generate the master dataset:

1. Download FracFocus data from https://fracfocus.org/data-download
    a. The 2025 Water Support Document will consider FracFocus data from 2014 to 2024.
    b. The file named readme.txt in the data download packet is the FracFocus data dictionary and should be retained with the original downloads.
2. FracFocus data is divided into registries (Registry 1 through Registry 14) to reduce file size. Each registry can be read into R simultaneously as a csv file.
3. Filter all data to Isolate data for desired years (e.g., 2014 through 2024) and states using column heading JobStartDate, which is the “date on which the hydraulic fracturing job was initiated” (FracFocus 2025) and state (e.g., Oklahoma).
4. Screen the data and perform quality control.
    a. Create a new column titled “Job” containing the well name and the start date. For the purpose of this analysis, a drilling activity (a job) is defined as the job start date (“JobStartDate”) and the well name (“WellName”).
    b. Create three new columns for month, day, and year based on the original job start date. Code will be applied to create three additional columns: Month, Day, and Year, each containing the corresponding parts of the date. For example, **"2024-04-11"** will be recoded as 2024, April, and 11 within three separate columns for each state.
        i. The same well may have multiple job start dates within the same year; however, these are not necessarily duplicate entries because multiple jobs may occur within the same year. The “Job” column will contain a hyper-unique ID based on the well, API number, month, day, year, and time that can be used to determine if there is a duplicate entry for any given job within a year.
        ii. Duplicate jobs are acceptable as long as each contains a unique water use volume. These entries are duplicated across jobs within FracFocus to account for each chemical used during hydraulic fracturing jobs. If a job includes multiple reported water use volumes, these volumes will be adjusted by randomly sampling from the duplicates and recoding all entries for a job to reflect a single reported volume. This random sampling ensures that unknown water usage is accounted for by assigning one water usage value without over- or underestimating usage or removing any data.
    c. American Petroleum Institute (API) well identification numbers are assumed to be a unique identifier in the data, and there should be a 1:1 relationship between API number and well name. To ensure a 1:1 relationship between well name and API number, the data

is first grouped by API number and well name to find the most common well name associated with each API. If there are multiple well names for the same API number (e.g., a 1:2 relationship), the most frequent well name is retained; if there is a tie, a random selection is made from the most frequent entries. The same process is applied for cases where a well name is associated with multiple API numbers. The most common API for each well is selected, and if there is a tie, a random API is chosen. This approach ensures consistency and avoids duplicate entries while resolving non-unique relationships through frequency-based selection and random sampling. See the example script below:

```
<script>

# Step 1: Identify the most common well name for each API
most_common_well_per_api <- frac_all1 %>%
  group_by(APINumber, WellName) %>%
  dplyr::summarise(count = n(), .groups = 'drop') %>%
  arrange(desc(count)) %>%
  group_by(APINumber) %>%
  filter(count == max(count)) %>%
  sample_n(1) %>%
  ungroup() %>%
  select(APINumber, WellName)

# Step 2: Recode all entries to match the most common well name for each API
frac_all1_intermediate <- frac_all1 %>%
  select(-WellName) %>%
  left_join(most_common_well_per_api, by = "APINumber")

# Step 3: Identify the most common API for each well
most_common_api_per_well <- frac_all1_intermediate %>%
  group_by(WellName, APINumber) %>%
  dplyr::summarise(count = n(), .groups = 'drop') %>%
  arrange(desc(count)) %>%
  group_by(WellName) %>%
  filter(count == max(count)) %>%
  sample_n(1) %>%
  ungroup() %>%
  select(WellName, APINumber)

# Step 4: Recode all entries to match the most common API for each well
frac_all1_final <- frac_all1_intermediate %>%
  select(-APINumber) %>%
  left_join(most_common_api_per_well, by = "WellName")

# Step 5: Check the ratio of API to WellName
frac_all1_final %>%
  summarise(count = n_distinct(WellName))

frac_all1_final %>%
  summarise(count = n_distinct(APINumber))
```

d. Federal well designation should be mutually exclusive. A well can either be federal or non-federal but not both. If any wells are given both designations, they will be reclassified as non-federal wells. Similarly, tribal well designation should be mutually exclusive. A well can either be tribal or non-tribal but not both. Wells that are given both designations will be reclassified as non-federal wells.
    i. **Note**: federal and tribal well reporting uses binary entries, including “TRUE” or “FALSE.” Therefore, any well marked as “FALSE” under Federal or Tribal ownership will be classified as “Non-federal/tribal.”

e. TotalBaseWaterVolume refers to the total volume of water used as a carrier fluid for the hydraulic fracturing job (in gallons) (FracFocus 2025). If a row shows TotalBaseWaterVolume = 0 gallons, it indicates that the well has been drilled but has not undergone hydraulic fracturing, resulting in zero water usage for the hydraulic fracturing job. Wells with TotalBaseWaterVolume = 0 still use water during drilling and will remain in the dataset. These wells are necessary during the summarization stage and will be corrected to account for water used during the drilling phase for all individual wells (See section 3.1.5).
    i. A new column will be created to classify wells that show TotalBaseWaterVolume = 0 gallons as “non-hydraulically fractured,” whereas all other wells will be classified as “hydraulically fractured.”

f. For each job (note that a job is the well name and job start date) in the FracFocus data, there are many rows to document the various ingredients and chemicals used in the drilling activity. As a result, the total base water volume is duplicated across multiple jobs to document each ingredient used in a hydraulic fracturing job (see step 4b above). To account for these duplicate entries while retaining all ingredient data, duplicate rows will be removed only when summarizing water use data, thereby ensuring that only one water use volume is reported for each hydraulic fracturing job. The master dataset will retain duplicate jobs which will permit accurate reporting of hydraulic fracturing ingredients. Duplicate rows can be removed during water use summarization using the Dplyr package in R (e.g., the “unique()” function) (Wickham et al. 2023).

g. The dataset now includes water usage associated with jobs. However, a new summary dataset will be created, and corrections will be applied to account for water usage during the drilling phase.
    i. **Note:** because FracFocus does not report on these values, these estimates will need to be applied to the summarized data (See section 3.1.5 for further details).

### 3.1.3 Unit Conversions

Water use in FracFocus is reported in gallons and water use in the Water Support Document is reported in acre-feet (AF). A new column will be created within the master dataset with converted units.
The following conversion factors can be used to convert from gallons to AF and vice versa:

$$1 \text{ AF} = 325{,}851 \text{ gallons}$$

$$1 \text{ gallon} = 3.0689 \times 10^{-6} \text{ AF}$$

### 3.1.4 FracFocus Data Aggregation and Summaries

To generate the summarized information in tables summarizing water use by oil and gas wells for hydraulic fracturing in the states of Oklahoma, Kansas, and Texas from 2014 through 2024, FracFocus data are processed and aggregated by various factors such as year and water use by both federal and non-federal wells. The following instructions describe the general process by which the summarized totals are obtained. The data totals do not include the records that were flagged in step 4 of Section 3.1.2.

Once the data has been cleaned and a master dataset has been generated with each state and associated counties, a within-state regional grouping scheme will be developed to group adjacent counties into single units for reporting. This grouping scheme will be based on concentration of oil and gas development and where water usage is clustered geographically across counties with oil and gas lease sales or APDs. Oklahoma, Kansas, and Texas include 28, 12, and 35 counties with oil and gas lease sales or APDs, respectively (see Figure 1). Once FracFocus data, water use data (see Section 3.2), and spill data (see

Section 3.3) have been evaluated to determine where data is clustered geographically, counties will be grouped into single units, representing multi-county regions (hereafter referred to as "region" or "regional grouping scheme"). This step is necessary to avoid reporting separately on 75 counties. This process will be conducted once data has been evaluated to ensure that counties or locations with minimal or zero quantities do not get reported as a region. Furthermore, this measure will ensure that locations with similar levels of oil and gas development get grouped accordingly. Regions will be included as a new column in the dataset and all datasets hereafter. Data will be grouped and summarized at the state level and the regional level within the WSD. While Kansas represents a single oil and gas play within this WSD, Texas and Oklahoma are broken down as shown below.

The state of Oklahoma and its two regional oil and gas plays, including

- the Western Oklahoma Anadarko Basin Stratigraphy and
- the Southern Oklahoma Fold Belt and Eastern Oklahoma Stratigraphies.

The state of Texas and its two regional oil and gas plays, including

- the Central and North Texas and Texas-Oklahoma Panhandles, Hugoton Embayment Play and
- the East Texas Gulf Coast & Permian Basin oil and gas Play.

Data aggregation and table construction will be conducted at the state level and at the regional level using the Dplyr package in R, which easily summarizes data based on defined grouping schemes (e.g., mean county water usage by year). Data tables will be built in R and used to populate tables within the WSD. The following data summaries will be conducted at the state and regional level and will only include water usage associated with hydraulic fracturing jobs:

1. **Federal Water Use**: the sum of the total base water volumes for each job on federal lands in AF.
2. **Tribal Water Use**: the sum of the total base water volumes for each job on tribal lands in AF.
3. **Non-Federal Water**: the sum of the total base water volumes for each non-federal job in AF on non-federal lands.
4. **Total Water Use**: the cumulative base water volumes for federal, tribal, and non-federal jobs from 2014 to 2024 in AF.
5. **Federal Water Use (%)**: The percentage of federal water use out of the total water use.
6. **Federal Combined Water Use:** For any given year in the FracFocus data, the federal cumulative water use is that year's federal water use plus the sum of all previously reported federal water use estimates.
    a. For example: $2020_{FCWU} = 2020_{FWU} + 2019_{FWU} + 2018_{FWU} + 2017_{FWU} + 2016_{FWU} + 2015_{FWU} + 2014_{FWU}$
        i. Where FCWU is federal cumulative water use and FWU is federal water use
7. **Total Combined Water Use**: the year's total water use plus the sum of all previously reported total water use estimates.
8. **Average Water Use Per Well**: The average water use for federal, tribal, and non-federal wells
9. **Total Well Count**: The total number of federal, tribal, and non-federal wells in a given year.
10. **Percentage of hydraulically fractured wells**: the percentage of wells out of the total that have been hydraulically fractured.

### 3.1.5 Total Water Usage Calculations and Summaries

The FracFocus data aggregation and summaries in Section 3.1.4 are based on the total water usage for hydraulic fracturing jobs across the planning area. FracFocus does not include the water usage associated with the initial drilling process. Non-hydraulic fracturing water usage can significantly increase the total water usage for individual wells, and as a result, the overall water use across the OFO planning area will be substantially higher when accounting for this additional water use. In order to incorporate these estimates, a literature review will be conducted to determine the estimated water usage for drilling of wells (referred to as “non-hydraulic fracturing water usage”). Depending on the quality and depth of the available data on non-hydraulic fracturing water usage, one of the following approaches will be used to generate water use estimates: if the data is less detailed or incomplete, Option A will be applied as a more general approach. However, if comprehensive data is available, Option B will be used for a more detailed and accurate estimation.

A. Option A: A non-hydraulic fracturing water use estimate will be determined following a literature review. The estimate will be applied to each well across the planning area to generate total water use estimates.

B. Option B: The preliminary assessment of FracFocus data reveals at least two distinct distributions in total water use data per well across the planning area. In Kansas and Oklahoma, the distribution is significantly bimodal, indicating that there are two currently unaccounted for distinct classifications within the dataset. It is believed that bimodality is related to differences in water use between vertical and horizontal wells because vertical wells are known to use significantly less water than horizontal wells. Under this assumption, a Gaussian Mixture Model (GMM) approach can be used to differentiate between vertical and horizontal wells. The GMM is a statistical technique that models the distribution of data as a combination of multiple Gaussian (normal) distributions, each representing a different subgroup within the dataset. In this context, relevant well attributes such as total water usage can be used. The GMM algorithm will analyze the attributes and identify patterns by fitting two distinct Gaussian distributions to the data, determining well type based on known differences in water use (e.g., horizontal vs. vertical well water use). Each well will then be assigned a probability of belonging to either one of two distinct distributions based on its characteristics. This probabilistic clustering allows for a more flexible and accurate classification, especially in cases where the features of vertical and horizontal wells may overlap. The resulting groups will be used to estimate the proportion of each well type and to calculate associated water usage. A preliminary analysis yielded that by separating the data into two distinct distributions, the model effectively distinguishes two separate well groupings based on significant differences in water use; it is assumed that these differences are at least, in part, due to differences in water use between vertical and horizontal wells. This allows for clear estimates of water use and estimated well counts by type across Kansas and Oklahoma. The model is less definitive for Texas, likely due to significant noise within the data that cannot be accurately accounted for (e.g., significant variation in geology, well depth, stimulation technique). Although the model is less definitive for Texas, the upper bound water use estimates for vertical well type in Kansas and Texas are similar, which may serve to provide an estimated well count and estimated water use per vertical well in Texas.

   The analysis begins with cleaning and filtering the dataset to retain only valid, positive AF values. For each state, the AF values are log-transformed to better capture the distribution and scale differences in water usage. The GMM is then fitted with two components, corresponding to the expected underlying populations of vertical and horizontal wells, each characterized by distinct water usage profiles. Each well is probabilistically assigned to a cluster based on its log-transformed AF value, enabling flexible classification even when the distributions overlap. The resulting clusters are summarized for each state, reporting the mean, minimum, and maximum AF as well as well counts for each group. This approach can be further evaluated and refined for application within the next iteration of this WSD.

## 3.2 U.S. Geological Survey Data

### 3.2.1 Data Summary

The USGS provides water use estimates for 2015 at the county level across the United States, compiled by the USGS's National Water Use Science Project in collaboration with local, state, and federal agencies. These data offer insights into water resource management and utilization trends at the state and county levels (Dieter et al. 2018).

### 3.2.2 Data Preparation

To present the summarized water use data in tables throughout the WSD, USGS data will be processed and aggregated by state and county. The following instructions describe the process by which the summarized totals will be obtained.

**State Water Use and County Water Use:** For each county in the USGS data, there are many columns to document the various types of water usage. The total water use is listed per county in each state, so total water use per category for the state must be manually generated through summing county-level data. Water use for counties within Oklahoma, Kansas, and Texas and state totals can be generated by:

1. Download *Estimated Use of Water in the United States County-Level Data for 2015* from https://www.sciencebase.gov/catalog/item/get/5af3311be4b0da30c1b245d8
    a. File name: usco2015v2.0.xlsx "All Data XLSX"
2. Reading the *Estimated Use of Water in the United States County-Level Data for 2015* into R.
3. Reading the data dictionary into R (The excel tab named DataDictionary in the downloaded data file is the data dictionary and should be retained with the original data; see Table 1 for data dictionary).
4. The data dictionary can be used to change the column names from abbreviations to the associated description to allow for ease of grouping schemes and table creation. See the following script:

```
<script>

# Iterate over column names of data and replace those with matching abbreviations from the data
dictionary
for (i in seq_along(names(data))) {
  match_index <- match(names(data)[i], dataset_two$Abbreviation)
  if (!is.na(match_index)) {
    names(data)[i] <- dataset_two$Description[match_index]
  }
}
```

5. Begin by filtering data according to the state of interest (e.g., Texas).
6. Because the water use estimates are broken down into county-level estimates, a new data frame is created that sums all county-level numeric water use values to develop state-level estimates. The new data frame will include column headers with water use category, and associated state total estimates.

   a. This dataset can then be gathered (i.e., converting column headers into levels within a single column) in R to provide a dataset with two columns for the state summary: Water Use Type and Water Use Estimate.

7. To develop county-level projections, similarly filter the data by state to generate data that includes only counties within the state of interest (e.g., Texas).
8. The data can then be split into a list of separate data frames according to each county. In R, a list is a versatile data structure that can contain elements of different types, such as vectors, matrices, and data frames. Lists allow you to store and organize data (e.g., county-level water use data) in a single object for further summarization and analysis. See the following script:

```
<script>

# Split the gathered data into separate data frames for each county. The data will be stored within
a list.
county_dfs <- gathered_data %>%
  group_split(COUNTY) %>%
  setNames(unique(gathered_data$COUNTY))

#now View the dataframe of interest for the county.
View(county_dfs["Beckham County"])
```

9. Once county-level data frames have been generated and stored within a list, counties will be cross-referenced with the FracFocus data, and counties that do not include oil and gas development will be filtered out for the final summary.
10. Counties with oil and gas development will be grouped into regional grouping schemes based on oil and gas development across adjacent counties. This step will eliminate the need for reporting at the level of individual counties. The final county grouping scheme will be the same grouping scheme used for FracFocus data (see Section 3.1.4).
   a. This can be done in R using the list of county-level data frames constructed above. From the list, a new data frame can be created that sums water use values for combined counties within each region (e.g., sum of total water use for Adair County and Alfalfa County). The example script below takes two county-level data frames with the same structure, adds their corresponding column values together, and stores the sums in a new data frame, maintaining the original column structure.

```
<script>

# Use apply() to apply the addition operation to each column within the county-level
dataframes.
Regional.df <- apply(County1 + County2, MARGIN = 2, FUN = identity) %>% as.data.frame()

# Assign column names to the new dataframe
colnames(Regional.df) <- colnames(County1)
```

   b. The regional water use data frame will be stored separately from the state-level data frames for further downstream summarization (see Section 3.2.4)

### 3.2.3 Unit Conversions

Water use in the USGS data is reported in million gallons per day (MGD), and water use in the Water Support Document is reported in AF. The following conversion factors can be used to convert from gallons to AF.

$$\text{Grand total in AF per year} = (\text{Grand Total [MGD]} \times 1.121) \times 1{,}000$$

### 3.2.4 Data Aggregation and Summaries

Once the data has been cleaned and grouped by state and then separately by the regional grouping scheme defined in Step 10 of Section 3.2.2, data aggregation and table construction will be conducted. Water usage is broken down into the following categories for the combined state and regional data:

- Aquaculture
- Domestic
- Industrial
- Irrigation
- Livestock
- Mining
- Public Water Supply
- Thermoelectric Power

The above variables are broken down separately and totaled for fresh water and saline water usage between groundwater and surface water sources (see Table 3).

Data will be aggregated and summarized in tables using the Dplyr package in R. The summary tables will be grouped by state and region therein. The Dplyr package provides a set of functions that offer a consistent and intuitive way to perform common data manipulation tasks such as filtering, sorting, summarizing, and joining data frames such as the summarize() function in combination with other functions such as group_by() for grouping summaries. Table 3 provides a template summary table that will be used for water use data in the WSD.

**Table 3. Example Water Use Table for State and Regional Water Use Summaries**

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline | Total | Total Use (%) | Fresh | Saline | Total | Total Use (%) | Fresh | Total Use (%) | Saline | Total Use (%) | | |
| Aquaculture | | | | | | | | | | | | | | |
| Domestic | | | | | | | | | | | | | | |
| Industrial | | | | | | | | | | | | | | |
| Irrigation | | | | | | | | | | | | | | |
| Livestock | | | | | | | | | | | | | | |
| Mining | | | | | | | | | | | | | | |
| Public Water Supply | | | | | | | | | | | | | | |
| Thermoelectric Power | | | | | | | | | | | | | | |
| **County Totals** | | | | | | | | | | | | | | |

## 3.3 Spill Data

### *3.3.1 Data Summary*

Oklahoma (OCC 2025a), Kansas (Kansas Department of Health and Environment 2025a), and Texas (TCEQ 2025a) require reporting of spills to the state. State agencies are required to make this data publicly available either online or through open records requests. Spill data for each state will be acquired, quality-checked, and aggregated to report spill quantities across each state. It is important to note that each state has separate reporting criteria; therefore, one state dataset may be limited in scope or quality of data relative to another state dataset. Spill data should not be compared across states. However, for this analysis, it is assumed that any within-state reporting error is consistent across the data, and therefore, spill data can be compared within each state. Additionally, each dataset includes different date ranges for spill reporting and different quantities of entries; therefore, it is assumed that reported totals represent the best available spill data for the state. It is not assumed that spill data accurately and equally reflect spill totals and quantities recovered for the state-specified date range. Nonetheless, each dataset will be similarly cleaned and evaluated for data quality and erroneous data entries. The final cleaned dataset will inform summaries within the report with the following information:

- The date on which the spill occurred.
- The material that was spilled.
- The location of the spill.
- The quantity of the spill.
- The amount of the spill that was recovered.
- Impacts to surface waters or groundwater.

**Oklahoma**

Spill data for Oklahoma is made available upon public records request from the OCC (2025b). The entire spills database contains records with incident dates ranging from 2009 to 2025 (through the month in which this report was written). Spill data for Oklahoma includes data on the quantity of each reported spill, the amount recovered, and impacts on surface water. Information on groundwater impacts is not provided.

**Kansas**

Spill data for Kansas is made available upon public records request from the KCC (2025b). The entire spills database contains records with incident dates ranging from 1989 to 2025 (through the month in which this report was written). Spill data for Kansas includes data on the quantity of each reported spill, the amount recovered, impacts on surface water, and impacts on groundwater.

**Texas**

Spill data are available for download from the TCEQ Spills database located at the Emergency Response Spills Open Data Portal (TCEQ 2025b).

The entire spills database contains records with incident dates ranging from 2001 to 2025 (through the month in which this report was written). The database includes records of all types of spills, including records of spills, many of which are not relevant to this WSD (e.g., sewage, smoke, and dead fish). For this analysis, reporting that is not related to oil and gas will be filtered out of the data, leaving only oil and gas and water-related spills. Many data entries represent oil spill incidents; however, many spill entries are missing a specified amount.

Texas spill data includes information on the quantity of each reported spill and impacts on surface water. Texas spill data does not include data on the quantity of oil that was recovered from the spill; therefore, the percentage of oil recovered cannot be calculated. Additionally, information on groundwater impacts is not available for Texas.

### 3.3.2 Spill Data Processing

The OCC, the KCC, and the TCEQ do not include data dictionaries with spill data reporting. Therefore, several assumptions were made and definitions were applied to the data. These assumptions are summarized above, and additional data-related assumptions are detailed below.

After each state dataset is read into R, a master dataset will be created that includes all states, or a single data set will be developed for each state, depending on similarities in state-level datasets. Datasets will be a subset of the state-level data, including relevant data for this analysis. Spill datasets will include the following columns:

- State
- County
- Date of incident
- Type of spill
- Quantity of spill
- Quantity of spill recovered
- Percentage of spill recovered
- Waterway or groundwater affected

To create this data, the following steps will be taken:

1. The above columns will be extracted or calculated when applicable from each state dataset in R and stored in a new data frame with the same column order as listed above.
    a. This will remove all additional column data that are not relevant to this report.
    b. This will yield three data frames for each state.
2. The three state datasets will then be merged, yielding one master dataset with the same data for each state.

The above steps will yield data that will be easy to use and filter according to a variable of interest. However, data entries will still need to be checked for quality, and spill entries with no defined quantity will need to be quantified, if any available metadata provides information on spill quantity (e.g., spill notes). These data checks are intended to evaluate and validate the consistency, completeness, and uniqueness of spill data. In this process, records that do not meet the specified data quality criteria are reviewed and addressed using case-specific techniques. The data is systematically evaluated, verified, and adjusted based on reasonable assumptions until all identified discrepancies are resolved. In general, data is not removed during the data cleaning process. For example, if a spill type is not clear, the entry would be reclassified as “Spill Type: Unknown,” or if a spill volume represented an outlier in the data, the volume would be recoded as “Unknown.” To further clean and process the master spill dataset, the following general steps will be applied for each of the data columns defined above. These steps outline a broad workflow but do not account for potential data discrepancies, unexpected patterns, or challenges that may arise during the deeper analysis phase. Adjustments will be made as needed to address unforeseen issues as they emerge.

1. *State* will be a column with factors including three levels: Oklahoma, Kansas, Texas.
2. *County* will be a column with factors including *x* levels, with *x* equaling the total counties within each state in which oil spills have been reported.
3. *Date of Incident* will be broken apart into month, day, and year. Code will be applied to create three additional columns: Month, Day, and Year, each containing the corresponding parts of the date. For example, **"2024-04-11"** will be recoded as 2024, April, and 11 within three separate columns for each state.
    a. Data structure will be checked, and problematic date entries will be corrected, if possible; otherwise, data will be mutated and defined as “Unknown Date.”
4. *Type of Spill* will be factored (a process of converting data into distinct categories) to ensure that all entries are consistent. Ambiguous entries will be corrected (e.g., misspelling) if possible; otherwise, ambiguous or undefined data entries will be mutated and defined as “Other.” Spill type data will include multiple levels based on the types of spills reported (e.g., Gasoline, Pipeline, Crude Oil, Water, Natural Gas, Other).
5. *Quantity of Spill* will require numeric data quality checks.
    a. An upper threshold will be used to flag entries that may be erroneous (e.g., accidental additional digit added). For this analysis, outlier entries are defined as spills that are greater than 1,000 barrels. Spills greater than 1,000 barrels will be flagged and checked against the spill notes to determine if the entry is valid. If it is determined that the value is erroneous., the value will be mutated and reclassified as “Unknown.” To do this, outliers can be calculated, flagged, and visualized in R, allowing the user to manually check the entry ID against the “spill notes” to determine the validity of the entry. See the following example script:

```
<script>

#outliers
# Calculate outliers (using IQR method)
spill6$is_outlier <- with(spill6, Volume.Released < quantile(Volume.Released, 0.25) - 1.5 *
IQR(Volume.Released) | Volume.Released > quantile(Volume.Released, 0.75) + 1.5 * IQR(Volume.Released))

# Create the plot
# Go in and check outliers if necessary. This plot is very useful for checking outiers against their notes.

ggplot(spill6, aes(x = Incident_year, y = Volume.Released)) +
  geom_jitter() +  # Add jittered points
  geom_point(data = filter(spill6, is_outlier), aes(color = "Outlier"), size = 3) +  # Highlight outliers in red
  geom_text(data = filter(spill6, is_outlier), aes(label = Incident.Number), vjust = -0.5, color = "red") +  # Label
outliers
  scale_color_manual(values = c(Outlier = "red", "black")) +  # Color scale for outliers
  theme_minimal()  # Optional: Choose your desired theme
```

    b. In addition, a lower threshold numeric data check will be required. Many spill data entries are ambiguous or deductively erroneous (e.g., “Null” or “0”), thereby necessitating global corrections based on the following assumption*: If a spill was reported, it is assumed that the quantity of the material spilled is non-zero; therefore, all* *data entries represent a spill quantity greater than zero and may be greater than one barrel.*

c. Corrections based on the above assumption will vary between each state due to observed differences in the quality of oil spill reporting. The following corrections will be applied to the three states within this analysis:
    i. For the Oklahoma spill data, the majority of oil spill quantity entries are classified as "Null" or "0." For this analysis, it is assumed that Oklahoma spill data reporting does not provide sufficient evidence to quantify ambiguous entries. Therefore, all such entries will be reclassified as "Quantity of Oil Spilled: Unknown." This ensures that each entry is reclassified as unspecified, but non-zero.
    ii. Kansas spill data generally includes sufficient numeric data on spill quantity and quantity recovered. However, occasional spill entries are not defined or are classified as "0." Often, these entries coincide with small-scale spills. For this analysis, it is assumed that quantity of oil spill reporting in Kansas is sufficiently stringent, and that "0" or missing entries can be mutated and reclassified as "less than or equal to 1" to reflect a small-scale oil spill with a quantity no greater than one barrel of oil.
    iii. Texas spill data includes numeric entries for oil spilled, including "0." For this analysis, it is assumed that quantity of oil spill reporting in Texas is sufficiently stringent, and that "0" can be mutated and reclassified as "less than or equal to 1" to reflect a small-scale oil spill with a quantity no greater than one barrel of oil.

6. *Quantity of Spill Recovered* pertains to Oklahoma and Kansas; however, this value is not reported for Texas. Therefore, this entry will be coded as "ND" (No Data) for Texas. For this column, the quantity of oil recovered will be denoted as percentage of the original volume of oil spilled.
7. *Waterway or Groundwater Affected* is reported for each state; however, the level of reporting is not assumed to be equally stringent between states. The final column will include factored data with the following four levels: Unknown, Surface Water, Non-Surface Water, and Groundwater. The following corrections will be applied to each state to eliminate ambiguity and ensure consistency in reporting:
    a. Oklahoma reports if the spill affected a waterbody with "Yes," "No," or "NULL."
        i. All "NULL" entries will be mutated and reclassified as "Unknown."
        ii. All "Yes" entries will be mutated and reclassified as "Surface Water."
        iii. All "No" entries will be mutated and reclassified as "Non-Surface Water."
    b. Kansas reports if the spill affected a waterway with "Soil," "Groundwater," or "Surface Water."
        i. All "Soil" entries will be mutated and reclassified as "Non-Surface Water."
        ii. All "Surface Water" entries will remain "Surface Water."
        iii. All "Groundwater" entries will remain "Groundwater."
    c. Texas reports if the spill affected a waterway with details related to the specific waterway (e.g., Rio Grande). Due to the quantity of various entries including misspellings and variation (e.g., NA, na, N/A), a sweeping mutation will be applied to the dataset to split the data between non-surface water spills and surface water spills.
        i. The sweeping mutation will use the Ifelse function in R to split data into surface water spills and non-surface water spills. The function applies the correction based on the following logic: *If the data is defined as non-surface water spills (e.g., "None," N/A), then classify as "Non-Surface Water"; otherwise, classify as "Surface Water" (e.g., Rio Grande, Gulf of Mexico).*

### 3.3.3 Unit Conversions

Spills within each dataset may be reported differently. All oil spills will be reported in barrels (Bbl), all gaseous spills will be reported in thousands of cubic feet (MCF), and all water spills will be reported in gallons (Gal). In R, code will be applied to universalize spill reporting and ensure all spill types are reported correctly and consistently. Values will be converted accordingly, and units will be updated. See the following example R code, which first converts gallons to barrels and then changes “GAL” to “Bbl”:

```
<script>

convert all Gal reports to Bbl in spill6 and drop unused levels. This will globally get rid of gallons.
# Convert all gallon measurements to BBL for Volume.Released, Volume.Recovered, and Volume.Lost
spill6 <- spill5 %>%
  mutate(
    Volume.Released = if_else(Unit.Of.Volume == "GAL", Volume.Released / 42, Volume.Released),
    Volume.Recovered = if_else(Unit.Of.Volume == "GAL", Volume.Recovered / 42, Volume.Recovered),
    Volume.Lost = if_else(Unit.Of.Volume == "GAL", Volume.Lost / 42, Volume.Lost)
  ) %>%
  # Convert all GAL entries in Unit.Of.Volume to BBL
 mutate(Unit.Of.Volume = if_else(Unit.Of.Volume == "GAL", "BBL", Unit.Of.Volume)) %>%
 mutate(Unit.Of.Volume = as.factor(Unit.Of.Volume)) %>% #factor units
 mutate(Unit.Of.Volume = droplevels(Unit.Of.Volume)) #Drop unused levels.

levels(spill6$Unit.Of.Volume) #gallons dropped.
summary(spill6$Volume.Released)
summary(spill6$Volume.Recovered)
summary(spill6$Volume.Lost)
```

Conversion examples:

- Acre-feet to gallons: $Gal = AF \times 325{,}851$
- Gallons to barrels: $Bbl = Gal \times 0.023810$
- Barrels to thousands of cubic feet: $MCF = Bbl / 5.615$

### 3.3.4 Data Aggregation and Summaries

Once the data has been cleaned and a master dataset has been generated that consists of spills at the county and state levels, data will be filtered and grouped by the regional grouping scheme outlined in Section 3.1.4. This grouping scheme consists of grouping targeted counties (see Table 1) into single units based on proximity and similarities in oil and gas development.

Data aggregation and table construction will be conducted using the Dplyr package in R, which easily summarizes data based on defined grouping schemes (e.g., mean spill quantity by year). State and regional data will be grouped by date of spill and type of spill, and summary tables will be generated to report quantity of spill, quantity of spill recovered, and percentage of spill recovered. Finally, the tables will also include a column that specifies if a waterway was affected by the spill. Note, some states will not include certain summaries due to incomplete, missing, or insufficient reporting. See example script for summarizing spill data below:

```
<script>
#generating summaries for the state of NM for the year 2024.
spill6 %>%
  filter(Incident_year == 2024) %>%
  group_by(Material) %>%
  summarise(
    Spill.Count = n(),
    Volume.Spilled = sum(Volume.Released),
    Volume.Lost = sum(Volume.Lost),
    Units = first(Unit.Of.Volume),  # Unit of volume should be the same for rows within groups.
    Average_spill.V = mean(Volume.Released),
    Mean_Perc_lost = 100 - mean(Percent.recovery),
    Waterway.Affected = sum(ifelse(Waterway.Affected == "Yes", 1, 0)),  # Count "Yes" values
    Groundwater.affected = sum(ifelse(Ground.Water.Impact == "Yes", 1, 0))  # Count "Yes" values
  ) %>% as_tibble() -> sum.state.1
View(sum.state.1)
```

# 3.4 USGS – A Dataset of Scanned Historical Well and Geophysical Logs From 96 Counties in Texas, 1925–2020

This dataset was compiled to digitally preserve the historical collection of well and geophysical logs housed at the USGS Oklahoma-Texas Water Science Center. This dataset was published in 2024; however, it was temporarily retracted in 2024 and will not be available for analysis in the 2025 iteration of the Oklahoma WSD. The dataset facilitates public access to data on hydrogeological conditions from wells spanning across 96 Texas counties. The dataset consists of 6,058 scanned and indexed records in PDF format, organized by county and supplemented by a publicly accessible Microsoft Access database and a comma-separated values (CSV) text file containing comprehensive well header information (USGS 2024a).

The dataset includes data related to groundwater from various wells across Texas, reporting on well top depth, well bottom depth, and static water levels over time. Upon availability of this dataset, the average change in depth to groundwater will be calculated over time at the county level. To do this, the following steps will be taken:

1. A county-level baseline will be calculated based on the average depth to groundwater. Baseline conditions will be defined as the average depth to groundwater for the first 5 years of reporting within the dataset. A new column will be created with county-level baseline conditions.
2. County-level average depths to groundwater will be calculated for each year of reporting. A new column will be created to store county-level averages for each year.

3. Change in groundwater from baseline conditions will be calculated by subtracting county-level baseline conditions from county-level depths to groundwater. A new column will be created to store county-level changes in groundwater depth for each year.
4. County-level average groundwater depth and associated changes in groundwater depth relative to the baseline period will be aggregated and visualized within the report.

## 3.5 Other Relevant Reports and Studies

### *3.5.1 Per-and Polyfluoroalkyl Substances*

Consideration of water quality and water quantity should take into account the pervasive presence of per- and polyfluoroalkyl substances (PFAS) throughout the nation's water resources, particularly as the oil and gas industry can be a source of contamination (Gaines 2022). No data processing will be conducted for this data source but a review of reports and studies regarding PFAS contamination in surface water and groundwater, the impact of the oil and gas industry on PFAS contamination, and strategies to address contamination will be summarized. Studies to be reviewed include but are not limited to the following:

- U.S. Environmental Protection Agency (EPA) *Historical and current usage of per- and polyfluoroalkyl substances (PFAS): A literature review* (Gaines 2022)
- EPA *PFAS Strategic Roadmap: EPA's Commitments to Action 2021–2024* (EPA 2021)

Additionally, PFAS used in hydraulic fracturing are categorized into four distinct groups in the FracFocus database; perfluoroalkyl alkanes/cycloalkanes, fluoroalkyl alcohol substituted polyethylene glycol, nonionic fluorosurfactants, and polytetrafluoroethylene (Connor et al. 2021). Chemicals in FracFocus will be categorized according to these four PFAS groupings.

PFAS chemicals reported in FracFocus include misspellings, ambiguity, alternative naming, etc. Additionally, the large occurrence of non-disclosed and proprietary chemicals presents an additional challenge in determining the occurrence of PFAS chemicals. To account for these discrepancies, key words and phrase will be used to identify PFAS chemicals groupings within FracFocus by searching for relevant terms, phrases, and patterns used to classify PFAS chemicals and ensuring that irrelevant spacing, punctuation, and ordering is omitted in PFAS determination. This approach allows for a more thorough and accurate process of PFAS chemical identification by capturing a wide range of variations in how they may be reported; however, due to the complex nature of chemical reporting within FracFocus, this approach fails to capture the true occurrence of PFAS chemicals.

### *3.5.2 Induced Seismic Activity*

There is evidence that seismic activity can be induced by disposal of high volumes of produced water from oil and gas production into disposal wells in underlying formations. Several sources will be reviewed and summarized to present the state-specific scenarios for induced seismicity due to oil and gas development and the mitigation strategies that federal and state agencies are conducting to address issues. No data will be processed for this source, but the following resources will be summarized:

- Congressional Research Service *Earthquakes Inducted by Underground Fluid Injection and the Federal Role in Mitigation* (Congressional Research Service 2023)
- Kansas Seismic Action Plan (Kansas Geological Survey 2015)
- Oklahoma Induced Seismicity and UIC Resources (OCC 2024)

- Texas Railroad Commission Seismicity Review and Response (Texas Railroad Commission 2023)

### 3.5.3 Other Reports

Several additional reports and analyses were identified as relevant sources of data and information to be used in development of the WSD, each of which is described below in more detail and listed by relevant WSD topic in Table 2.

- Reasonably Foreseeable Development Scenario: The latest Reasonably Foreseeable Development (RFD) Scenario was created in 2016 to provide a long-term 20-year projection of fluid mineral exploration, development, and production for the Kansas, Oklahoma, and Texas Resource Management Plan (BLM 2016). This is comprehensive documentation of development scenarios not only for oil and gas, but also for minerals and geothermal, wind, and solar resources. A discussion of data sources, methodology for predicting exploration, and understanding the relationship between resource occurrence and activity is presented in the RFD that includes relevant information for the OFO WSD development, such as 1) information on hydraulic fracturing and water use, 2) source of water commonly used, and 3) water use by USGS-defined Hydrologic Unit Code 8 watersheds.
- BLM OFO Joint Environmental Impact Statement/Proposed BLM Resource Management Plan and BIA Integrated Resource Management Plan (BLM 2019) and Oklahoma, Kansas and Texas BLM Record of Decision and Approved Resource Management Plan (BLM 2020): The RMP provides information on water resources data specific to the OFO that includes quantity, quality, and source information.
- EPA’s Hydraulic Fracturing for Oil and Gas: This 2016 report provides a comprehensive look at the impacts of hydraulic fracturing on water quality and covers spills, withdrawal impacts, fluid injection impacts on groundwater and surface water, and disposal practices that result in contamination (EPA 2016).
- EPA’s Demonstrating the Impacts of Oil and Gas Exploration on Water Quality: A comprehensive analysis of oil and gas activities and impacts to water quality, particularly during storm runoff events (EPA 2015).
- Kansas, Oklahoma, and Texas Integrated Reports: Each state produces a report every 2 years documenting the status of surface water quality. These reports will be reviewed to better understand the water quality condition of streams and lakes within the targeted counties (Kansas Department of Health and Environment 2025b; ODEQ 2024; TCEQ 2025c).
- Oil and Gas Produced Water Reuse: Opportunities, Treatment Needs, and Challenges: This 2021 report provides several case studies regarding the reclamation and reuse of produced water and how incorporating standardized analytical techniques is critical to maximizing reuse in the future (Cooper et al. 2021).

# 4 LITERATURE CITED

Bureau of Land Management (BLM). 2016. Reasonably Foreseeable Development Scenario, Kansas Oklahoma Texas. Available upon request. Accessed April 2024.

———. 2019. Oklahoma, Kansas, and Texas Final Joint Environmental Impact Statement/ Proposed BLM Resource Management Plan and Proposed BIA Integrated Resource Management Plan. Available at: https://eplanning.blm.gov/public_projects/lup/72142/161930/197548/OKT_Draft_Joint_EIS/BLM_RMP_and_BIA_Integrated_RMP_-_Vol_I.pdf. Accessed August 2025.

———. 2020. Oklahoma, Kansas and Texas BLM Record of Decision and Approved Resource Management Plan. Available at: https://eplanning.blm.gov/public_projects/lup/72142/20014631/250019725/BIA_EORO_ROD_&_Approved_IRMP_March_2020_-_508.pdf. Accessed August 2025.

———. 2024. BLM Water Support Document for Oil and Gas Development in New Mexico. Available at: https://www.blm.gov/sites/default/files/docs/2024-09/oil-and-gas-wsd-nm-2024.pdf. Accessed October 2024.

———. 2025. New Mexico Oil and Gas Lease Sales. Available at: https://www.blm.gov/programs/energy-and-minerals/oil-and-gas/leasing/regional-lease-sales/new-mexico. Accessed August 2025.

Climate Engine. 2024. Desert Research Institute and University of California, Merced. Version 2.1. Available at: https://www.climateengine.org/. Accessed April 2024.

Climatology Lab. 2024. Gridmet. Available at: https://www.climatologylab.org/gridmet.html. Accessed April 2024.

Congressional Research Service. 2023. Earthquakes Induced by Underground Fluid Injection and the Federal Role in Mitigation. Available at: https://crsreports.congress.gov/product/pdf/R/R47386. Accessed April 2024.

Connor, J.A., I. Rhodes, C.C. Stanley, E. Gie, K.A. Graham, J.K. Anderson, A.D. Daus, and D.T. Adamson. 2021. Comment on “Fracking with Forever Chemicals. GSI Environmental. Available at: https://www.gsienv.com/wp-content/uploads/2021/09/Comment-on-Fracking-with-Forever-Chemicals-by-Physicians-for-Social-Responsibility-issued-July-2021-2.pdf. Accessed October 2024.

Cooper, C.M., J. McCall, S.C. Stokes, C. McKay, M.J. Bentley, J.S. Rosenblum, T.A. Blewett, Z. Huang, A. Miara, M. Talmadge, A. Evans, K.A. Sitterley, P. Kurup, J.R. Stokes-Draut, J. Macknick, T. Borch, T.Y. Cath, and L.E. Katz. 2021. Oil and Gas Produced Water Reuse: Opportunities, Treatment Needs, and Challenges. Available at: https://www.env.nm.gov/wp-content/uploads/sites/13/2024/05/75-79.pdf. Accessed August 2025.

Dieter, C.A., M.A. Maupin, R.R. Caldwell, M.A. Harris, T.I. Ivahnenko, J.K. Lovelace, N.L. Barber, and K.S. Linsey. 2018. *Estimated Use of Water in the United States in 2015*. U.S. Geological Survey Circular 1441. Available at: https://pubs.er.usgs.gov/publication/cir1441. Accessed April 2024.

FracFocus. 2024. The National Hydraulic Fracturing Chemical Disclosure Registry. Available at: https://fracfocus.org/. Accessed April 2024.

Gaines, G.T., PhD. 2022. Historical and current usage of per-and polyfluoroalkyl substances (PFAS): A literature review. American Journal of Industrial Medicine 66:5:353-378. Available at: https://onlinelibrary.wiley.com/doi/10.1002/ajim.23362. Accessed August 2024.

Kansas Corporation Commission (KCC). 2025a. Oil & Gas. Available at: https://www.kcc.ks.gov/oil-gas. Accessed October 2024.

———. 2025b. Kansas Spill Data. Electronic communication, Kansas Corporation Commission to SWCA. May 2025.

Kansas Department of Health and Environment. 2025a. Kansas Spill Notification. Available at: https://www.kdhe.ks.gov/DocumentCenter/View/2417/Kansas-Spill-Reporting-Instructions-2023-PDF?bidId=. Accessed June 2025.

———. 2025b. 2024 Kansas Integrated Water Quality Assessment. Available at: https://www.kdhe.ks.gov/Archive.aspx?AMID=71. Accessed August 2025.

Kansas Geological Survey. 2015. Kansas Seismic Action Plan. Available at: https://www.kgs.ku.edu/PRS/Seismicity/2015/Seismic_Action_Plan.pdf. Accessed October 2024.

Kansas Water Office. 2015. A Long-Term Vision for the Future of Water Supply in Kansas. Available at: https://www.kwo.ks.gov/home/showpublisheddocument/1180/638338156260670000. Accessed June 2025.

———. 2022. Kansas Water Plan. Available at: https://kansas-water-plan-ksdot.hub.arcgis.com/documents/b0a512f60c6048d8b8ad728238777c49/explore. Accessed July 2024.

National Aeronautics and Space Administration (NASA) and U.S. Geological Survey (USGS). 2024. Landsat Science. Available at: https://landsat.gsfc.nasa.gov/. Accessed April 2024.

Oklahoma Corporation Commission (OCC). 2024. Oil and Gas Conservation Division, Induced Seismicity and UIC Departments. Available at: https://oklahoma.gov/occ/divisions/oil-gas/induced-seismicity-and-uic-department.html. Accessed August 2025.

———. 2025a. Oil and Gas Conservation Division. Available at: https://oklahoma.gov/occ/divisions/oil-gas.html. Accessed August 2025.

———. 2025b. Oil and Gas Conservation Incident Search. Available at: https://gis.occ.ok.gov/portal/apps/experiencebuilder/experience/?id=75bcb0b2c7f943dfa6cec75a50c9205a. Accessed: July 2025.

Oklahoma Department of Environmental Quality (ODEQ). 2024. Water Quality in Oklahoma: 2024 Integrated Report. Available at: https://www.deq.ok.gov/water-quality-division/watershed-planning/integrated-report. Accessed August 2025.

R Core Team. 2024. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: https://www.r-project.org/. Accessed August 2025.

Texas Commission of Environmental Quality (TCEQ). 2025a. Spills, Discharges, and Releases. Available at: https://www.tceq.texas.gov/response/spills. Accessed June 2025.

———. 2025b. Texas Commission on Environmental Quality – Emergency Response Spills. Available at: https://data.texas.gov/dataset/Texas-Commission-on-Environmental-Quality-Emergenc/xagr-a3x2/about_data. Accessed July 2025.

______. 2025c. 2024 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d). Available at: https://www.tceq.texas.gov/waterquality/assessment/2024-integrated-report. Accessed August 2025.

Texas Railroad Commission. 2023. Seismicity Response. Available at: https://www.rrc.texas.gov/oil-and-gas/applications-and-permits/injection-storage-permits/oil-and-gas-waste-disposal/injection-disposal-permit-procedures/seismicity-review/seismicity-response/. Accessed October 2024.

U.S. Environmental Protection Agency (EPA). 2015. Demonstrating the Impacts of Oil and Gas Exploration on Water Quality and How to Minimize these Impacts Through Targeted Monitoring Activities and Local Ordinances. Available at: https://www.epa.gov/sites/default/files/2015-11/documents/oilandgas_impactgrant.pdf. Accessed October 2024.

———. 2016. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. Available at: https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990. Accessed October 2024.

———. 2021. PFAS Strategic Roadmap: EPA's Commitments to Action 2021–2024. Available at: https://www.epa.gov/pfas/pfas-strategic-roadmap-epas-commitments-action-2021-2024. Accessed October 2024.

U.S. Geological Survey (USGS). 2024a. A Dataset of Scanned Historical Well and Geophysical Logs From 96 Counties in Texas, 1925–2020. Available at: https://www.usgs.gov/data/a-dataset-scanned-historical-well-and-geophysical-logs-96-counties-texas-1925-2020. Accessed April 2024.

———. 2024b. Assessment of per-and polyfluoroalkyle substances in water resources of New Mexico, 2021 – 21. Available at: https://www.usgs.gov/publications/assessment-and-polyfluoroalkyl-substances-water-resources-new-mexico-2020-21. Accessed October 2024.

———. 2024c. Induced Earthquakes Overview. Available at: https://www.usgs.gov/programs/earthquake-hazards/science/induced-earthquakes. Accessed October 2024.

Wickham, H., R. Francois, L. Henry, K. Muller, D. Vaughan. 2023. _dplyr: A Grammar of Data Manipulation_. Available at: 10.32614/CRAN.package.dplyr https://doi.org/10.32614/CRAN.package.dplyr, R package version 1.1.4, https://CRAN.R-project.org/package=dplyr. Accessed August 2025.

# APPENDIX B

# Oklahoma Field Office Water Use by County for Targeted APD Counties

# CONTENTS



## Tables

# KANSAS

**Table B-1. Kansas - Cheyenne County Water Use by Category in 2015**

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 246 | 0 | 246 | <1% | 246 | <1% | 0 | 0% | 246 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 109,841 | 0 | 109,841 | 98% | 109,841 | 98% | 0 | 0% | 109,841 | 98% |
| Livestock | 0 | 0 | 0 | 0% | 930 | 0 | 930 | <1% | 930 | <1% | 0 | 0% | 930 | <1% |
| Mining | 0 | 0 | 0 | 0% | 34 | 0 | 34 | <1% | 34 | <1% | 0 | 0% | 34 | <1% |
| Public Water Supply | 0 | 0 | 0 | 0% | 526 | 0 | 526 | <1% | 526 | <1% | 0 | 0% | 526 | <1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **111,577** | **0** | **111,577** | **>99%** | **111,577** | **>99%** | **0** | **0%** | **111,577** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

### Table B-2. Kansas - Decatur County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 235 | 0 | 235 | 1% | 235 | 1% | 0 | 0% | 235 | 1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 20,342 | 0 | 20,342 | 93% | 20,342 | 93% | 0 | 0% | 20,342 | 93% |
| Livestock | 0 | 0 | 0 | 0% | 818 | 0 | 818 | 4% | 818 | 4% | 0 | 0% | 818 | 4% |
| Mining | 0 | 0 | 0 | 0% | 34 | 0 | 34 | <1% | 34 | <1% | 0 | 0% | 34 | <1% |
| Public Water Supply | 0 | 0 | 0 | 0% | 414 | 0 | 414 | 2% | 414 | 2% | 0 | 0% | 414 | 2% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **21,843** | **0** | **21,843** | **100%** | **21,843** | **100%** | **0** | **0%** | **21,843** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

### Table B-3. Kansas - Finney County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 202 | 0 | 202 | <1% | 202 | <1% | 0 | 0% | 202 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 4,257 | 0 | 4,257 | <1% | 4,257 | <1% | 0 | 0% | 4,257 | <1% |
| Irrigation | 0 | 0 | 0 | 0% | 479,466 | 0 | 479,466 | 96% | 479,466 | 96% | 0 | 0% | 479,466 | 96% |
| Livestock | 0 | 0 | 0 | 0% | 3,640 | 0 | 3,640 | <1% | 3,640 | <1% | 0 | 0% | 3,640 | <1% |
| Mining | 0 | 0 | 0 | 0% | 67 | 0 | 67 | <1% | 67 | <1% | 0 | 0% | 67 | <1% |
| Public Water Supply | 0 | 0 | 0 | 0% | 8,535 | 0 | 8,535 | 2% | 8,535 | 2% | 0 | 0% | 8,535 | 2% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 5,041 | 0 | 5,041 | 1% | 5,041 | 1% | 0 | 0% | 5,041 | 1% |
| **Total** | **0** | **0** | **0** | **0%** | **501,208** | **0** | **501,208** | **100%** | **501,208** | **100%** | **0** | **0%** | **501,208** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-4. Kansas - Franklin County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 101 | 0 | 101 | 2% | 101 | 2% | 0 | 0% | 101 | 2% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 627 | 0 | 627 | 14% | 919 | 0 | 919 | 20% | 1,546 | 33% | 0 | 0% | 1,546 | 33% |
| Livestock | 739 | 0 | 739 | 16% | 34 | 0 | 34 | <1% | 773 | 17% | 0 | 0% | 773 | 17% |
| Mining | 56 | 0 | 56 | 1% | 0 | 0 | 0 | 0% | 56 | 1% | 0 | 0% | 56 | 1% |
| Public Water Supply | 2,039 | 0 | 2,039 | 44% | 123 | 0 | 123 | 3% | 2,162 | 47% | 0 | 0% | 2,162 | 47% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **3,461** | **0** | **3,461** | **75%** | **1,177** | **0** | **1,177** | **25%** | **4,638** | **100%** | **0** | **0%** | **4,638** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-5. Kansas - Greeley County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 123 | 0 | 123 | <1% | 123 | <1% | 0 | 0% | 123 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Irrigation | 0 | 0 | 0 | 0% | 32,081 | 0 | 32,081 | 96% | 32,081 | 96% | 0 | 0% | 32,081 | 96% |
| Livestock | 0 | 0 | 0 | 0% | 1,042 | 0 | 1,042 | 3% | 1,042 | 3% | 0 | 0% | 1,042 | 3% |
| Mining | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Public Water Supply | 0 | 0 | 0 | 0% | 280 | 0 | 280 | <1% | 280 | <1% | 0 | 0% | 280 | <1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **33,582** | **0** | **33,582** | **100%** | **33,582** | **100%** | **0** | **0%** | **33,582** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-6. Kansas - Lane County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 90 | 0 | 90 | <1% | 90 | <1% | 0 | 0% | 90 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 25,853 | 0 | 25,853 | 94% | 25,853 | 94% | 0 | 0% | 25,853 | 94% |
| Livestock | 0 | 0 | 0 | 0% | 1,165 | 0 | 1,165 | 4% | 1,165 | 4% | 0 | 0% | 1,165 | 4% |
| Mining | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Public Water Supply | 0 | 0 | 0 | 0% | 302 | 0 | 302 | 1% | 302 | 1% | 0 | 0% | 302 | 1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **27,410** | **0** | **27,410** | **100%** | **27,410** | **100%** | **0** | **0%** | **27,410** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-7. Kansas - Logan County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 112 | 0 | 112 | <1% | 112 | <1% | 0 | 0% | 112 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Irrigation | 0 | 0 | 0 | 0% | 15,436 | 0 | 15,436 | 93% | 15,436 | 93% | 0 | 0% | 15,436 | 93% |
| Livestock | 0 | 0 | 0 | 0% | 414 | 0 | 414 | 2% | 414 | 2% | 0 | 0% | 414 | 2% |
| Mining | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Public Water Supply | 0 | 0 | 0 | 0% | 650 | 0 | 650 | 4% | 650 | 4% | 0 | 0% | 650 | 4% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **16,634** | **0** | **16,634** | **>99%** | **16,634** | **>99%** | **0** | **0%** | **16,634** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-8. Kansas - Meade County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 504 | 0 | 504 | <1% | 504 | <1% | 0 | 0% | 504 | <1% |
| Domestic | 0 | 0 | 0 | 0% | 246 | 0 | 246 | <1% | 246 | <1% | 0 | 0% | 246 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 287,137 | 0 | 287,137 | 99% | 287,137 | 99% | 0 | 0% | 287,137 | 99% |
| Livestock | 0 | 0 | 0 | 0% | 1,434 | 0 | 1,434 | <1% | 1,434 | <1% | 0 | 0% | 1,434 | <1% |
| Mining | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Public Water Supply | 0 | 0 | 0 | 0% | 728 | 0 | 728 | <1% | 728 | <1% | 0 | 0% | 728 | <1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **290,049** | **0** | **290,049** | **>99%** | **290,049** | **>99%** | **0** | **0%** | **290,049** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-9. Kansas - Montgomery County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Industrial | 7,505 | 0 | 7,505 | 51% | 0 | 0 | 0 | 0% | 7,505 | 51% | 0 | 0% | 7,505 | 51% |
| Irrigation | 470 | 0 | 470 | 3% | 0 | 0 | 0 | 0% | 470 | 3% | 0 | 0% | 470 | 3% |
| Livestock | 762 | 0 | 762 | 5% | 56 | 0 | 56 | <1% | 818 | 6% | 0 | 0% | 818 | 6% |
| Mining | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Public Water Supply | 5,791 | 0 | 5,791 | 40% | 0 | 0 | 0 | 0% | 5,791 | 40% | 0 | 0% | 5,791 | 40% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **14,528** | **0** | **14,528** | **>99%** | **112** | **0** | **112** | **<1%** | **14,640** | **>99%** | **0** | **0%** | **14,640** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-10. Kansas - Norton County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 224 | 0 | 224 | <1% | 224 | <1% | 0 | 0% | 224 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 426 | 0 | 426 | 2% | 24,195 | 0 | 24,195 | 89% | 24,621 | 90% | 0 | 0% | 24,621 | 90% |
| Livestock | 67 | 0 | 67 | <1% | 1,523 | 0 | 1,523 | 6% | 1,591 | 6% | 0 | 0% | 1,591 | 6% |
| Mining | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Public Water Supply | 358 | 0 | 358 | 1% | 482 | 0 | 482 | 2% | 840 | 3% | 0 | 0% | 840 | 3% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **851** | **0** | **851** | **3%** | **26,424** | **0** | **26,424** | **97%** | **27,276** | **100%** | **0** | **0%** | **27,276** | **100%** |

Source: Dieter et al. (2018)
Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.
† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-11. Kansas - Sherman County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 347 | 0 | 347 | <1% | 347 | <1% | 0 | 0% | 347 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 157 | 0 | 157 | <1% | 157 | <1% | 0 | 0% | 157 | <1% |
| Irrigation | 0 | 0 | 0 | 0% | 229,920 | 0 | 229,920 | 99% | 229,920 | 99% | 0 | 0% | 229,920 | 99% |
| Livestock | 0 | 0 | 0 | 0% | 482 | 0 | 482 | <1% | 482 | <1% | 0 | 0% | 482 | <1% |
| Mining | 0 | 0 | 0 | 0% | 22 | 0 | 22 | <1% | 22 | <1% | 0 | 0% | 22 | <1% |
| Public Water Supply | 0 | 0 | 0 | 0% | 1,501 | 0 | 1,501 | <1% | 1,501 | <1% | 0 | 0% | 1,501 | <1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **232,429** | **0** | **232,429** | **>99%** | **232,429** | **>99%** | **0** | **0%** | **232,429** | **100%** |

Source: Dieter et al. (2018)
Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.
† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-12. Kansas - Woodson County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 258 | 0 | 258 | 19% | 0 | 0 | 0 | 0% | 258 | 19% | 0 | 0% | 258 | 19% |
| Domestic | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 134 | 0 | 134 | 10% | 0 | 0 | 0 | 0% | 134 | 10% | 0 | 0% | 134 | 10% |
| Livestock | 661 | 0 | 661 | 48% | 0 | 0 | 0 | 0% | 661 | 48% | 0 | 0% | 661 | 48% |
| Mining | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Public Water Supply | 336 | 0 | 336 | 24% | 0 | 0 | 0 | 0% | 336 | 24% | 0 | 0% | 336 | 24% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,389** | **0** | **1,389** | **100%** | **0** | **0** | **0** | **0%** | **1,389** | **100%** | **0** | **0%** | **1,389** | **100%** |

Source: Dieter et al. (2018)
Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.
† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

# OKLAHOMA

### Table B-13. Oklahoma - Alfalfa County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 22 | 0 | 22 | <1% | 0 | 0 | 0 | 0% | 22 | <1% | 0 | 0% | 22 | <1% |
| Domestic | 0 | 0 | 0 | 0% | 90 | 0 | 90 | 1% | 90 | 1% | 0 | 0% | 90 | 1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 258 | 0 | 258 | 4% | 3,293 | 0 | 3,293 | 50% | 3,551 | 54% | 0 | 0% | 3,551 | 54% |
| Livestock | 0 | 0 | 0 | 0% | 773 | 0 | 773 | 12% | 773 | 12% | 0 | 0% | 773 | 12% |
| Mining | 1,131 | 0 | 1,131 | 17% | 0 | 246 | 246 | 4% | 1,131 | 17% | 246 | 4% | 1,378 | 21% |
| Public Water Supply | 0 | 0 | 0 | 0% | 784 | 0 | 784 | 12% | 784 | 12% | 0 | 0% | 784 | 12% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,411** | **0** | **1,411** | **21%** | **4,940** | **246** | **5,186** | **79%** | **6,351** | **96%** | **246** | **4%** | **6,598** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

### Table B-14. Oklahoma - Beaver County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 235 | 0 | 235 | <1% | 235 | <1% | 0 | 0% | 235 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 370 | 0 | 370 | <1% | 370 | <1% | 0 | 0% | 370 | <1% |
| Irrigation | 67 | 0 | 67 | <1% | 61,809 | 0 | 61,809 | 93% | 61,877 | 93% | 0 | 0% | 61,877 | 93% |
| Livestock | 0 | 0 | 0 | 0% | 2,386 | 0 | 2,386 | 4% | 2,386 | 4% | 0 | 0% | 2,386 | 4% |
| Mining | 0 | 0 | 0 | 0% | 11 | 1,176 | 1,187 | 2% | 11 | <1% | 1,176 | 2% | 1,187 | 2% |
| Public Water Supply | 0 | 0 | 0 | 0% | 538 | 0 | 538 | <1% | 538 | <1% | 0 | 0% | 538 | <1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **67** | **0** | **67** | **<1%** | **65,349** | **1,176** | **66,525** | **>99%** | **65,417** | **98%** | **1,176** | **2%** | **66,593** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

### Table B-15. Oklahoma - Beckham County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 549 | 0 | 549 | 3% | 549 | 3% | 0 | 0% | 549 | 3% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 448 | 0 | 448 | 2% | 12,422 | 0 | 12,422 | 69% | 12,870 | 71% | 0 | 0% | 12,870 | 71% |
| Livestock | 493 | 0 | 493 | 3% | 168 | 0 | 168 | <1% | 661 | 4% | 0 | 0% | 661 | 4% |
| Mining | 325 | 0 | 325 | 2% | 11 | 0 | 11 | <1% | 336 | 2% | 0 | 0% | 336 | 2% |
| Public Water Supply | 0 | 0 | 0 | 0% | 3,640 | 0 | 3,640 | 20% | 3,640 | 20% | 0 | 0% | 3,640 | 20% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,266** | **0** | **1,266** | **7%** | **16,790** | **0** | **16,790** | **93%** | **18,056** | **>99%** | **0** | **0%** | **18,056** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-16. Oklahoma - Blaine County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 101 | 0 | 101 | <1% | 101 | <1% | 0 | 0% | 101 | <1% |
| Industrial | 67 | 0 | 67 | <1% | 190 | 0 | 190 | 1% | 258 | 2% | 0 | 0% | 258 | 2% |
| Irrigation | 504 | 0 | 504 | 3% | 5,926 | 0 | 5,926 | 41% | 6,430 | 44% | 0 | 0% | 6,430 | 44% |
| Livestock | 694 | 0 | 694 | 5% | 336 | 0 | 336 | 2% | 1,031 | 7% | 0 | 0% | 1,031 | 7% |
| Mining | 4,481 | 0 | 4,481 | 31% | 224 | 851 | 1,075 | 7% | 4,705 | 32% | 851 | 6% | 5,556 | 38% |
| Public Water Supply | 0 | 0 | 0 | 0% | 1,199 | 0 | 1,199 | 8% | 1,199 | 8% | 0 | 0% | 1,199 | 8% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **5,746** | **0** | **5,746** | **39%** | **7,976** | **851** | **8,827** | **61%** | **13,724** | **94%** | **851** | **6%** | **14,575** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-17. Oklahoma - Caddo County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 818 | 0 | 818 | <1% | 818 | <1% | 0 | 0% | 818 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Irrigation | 3,584 | 0 | 3,584 | 4% | 65,416 | 0 | 65,416 | 77% | 69,001 | 82% | 0 | 0% | 69,001 | 82% |
| Livestock | 1,154 | 0 | 1,154 | 1% | 526 | 0 | 526 | <1% | 1,680 | 2% | 0 | 0% | 1,680 | 2% |
| Mining | 56 | 0 | 56 | <1% | 157 | 1,893 | 2,050 | 2% | 213 | <1% | 1,893 | 2% | 2,106 | 2% |
| Public Water Supply | 5,937 | 0 | 5,937 | 7% | 2,072 | 0 | 2,072 | 2% | 8,009 | 9% | 0 | 0% | 8,009 | 9% |
| Thermoelectric Power | 2,912 | 0 | 2,912 | 3% | 0 | 0 | 0 | 0% | 2,912 | 3% | 0 | 0% | 2,912 | 3% |
| **Total** | **13,643** | **0** | **13,643** | **16%** | **69,000** | **1,893** | **70,893** | **84%** | **82,644** | **98%** | **1,893** | **2%** | **84,537** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-18. Oklahoma - Canadian County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 437 | 0 | 437 | 3% | 437 | 3% | 0 | 0% | 437 | 3% |
| Industrial | 0 | 0 | 0 | 0% | 101 | 0 | 101 | <1% | 101 | <1% | 0 | 0% | 101 | <1% |
| Irrigation | 2,207 | 0 | 2,207 | 14% | 2,677 | 0 | 2,677 | 18% | 4,884 | 32% | 0 | 0% | 4,884 | 32% |
| Livestock | 896 | 0 | 896 | 6% | 258 | 0 | 258 | 2% | 1,154 | 8% | 0 | 0% | 1,154 | 8% |
| Mining | 2,800 | 0 | 2,800 | 18% | 235 | 448 | 683 | 4% | 3,036 | 20% | 448 | 3% | 3,484 | 23% |
| Public Water Supply | 0 | 0 | 0 | 0% | 4,749 | 0 | 4,749 | 31% | 4,749 | 31% | 0 | 0% | 4,749 | 31% |
| Thermoelectric Power | 224 | 0 | 224 | 1% | 224 | 0 | 224 | 1% | 448 | 3% | 0 | 0% | 448 | 3% |
| **Total** | **6,127** | **0** | **6,127** | **40%** | **8,681** | **448** | **9,129** | **60%** | **14,809** | **97%** | **448** | **3%** | **15,257** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-19. Oklahoma - Cimarron County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 2,980 | 0 | 2,980 | 2% | 149,953 | 0 | 149,953 | 96% | 152,933 | 98% | 0 | 0% | 152,933 | 98% |
| Livestock | 0 | 0 | 0 | 0% | 1,759 | 0 | 1,759 | 1% | 1,759 | 1% | 0 | 0% | 1,759 | 1% |
| Mining | 0 | 0 | 0 | 0% | 11 | 392 | 403 | <1% | 11 | <1% | 392 | <1% | 403 | <1% |
| Public Water Supply | 0 | 0 | 0 | 0% | 381 | 0 | 381 | <1% | 381 | <1% | 0 | 0% | 381 | <1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **2,980** | **0** | **2,980** | **2%** | **152,160** | **392** | **152,552** | **98%** | **155,140** | **>99%** | **392** | **<1%** | **155,532** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-20. Oklahoma - Coal County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 67 | 0 | 67 | 4% | 67 | 4% | 0 | 0% | 67 | 4% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 11 | 0 | 11 | <1% | 0 | 0 | 0 | 0% | 11 | <1% | 0 | 0% | 11 | <1% |
| Livestock | 414 | 0 | 414 | 26% | 45 | 0 | 45 | 3% | 459 | 29% | 0 | 0% | 459 | 29% |
| Mining | 414 | 0 | 414 | 26% | 0 | 112 | 112 | 7% | 414 | 26% | 112 | 7% | 526 | 33% |
| Public Water Supply | 515 | 0 | 515 | 33% | 0 | 0 | 0 | 0% | 515 | 33% | 0 | 0% | 515 | 33% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,354** | **0** | **1,354** | **86%** | **112** | **112** | **224** | **14%** | **1,466** | **93%** | **112** | **7%** | **1,578** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-21. Oklahoma - Creek County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 1,042 | 0 | 1,042 | 5% | 1,042 | 5% | 0 | 0% | 1,042 | 5% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 224 | 0 | 224 | <1% | 0 | 0 | 0 | 0% | 224 | <1% | 0 | 0% | 224 | <1% |
| Livestock | 482 | 0 | 482 | 2% | 56 | 0 | 56 | <1% | 538 | 2% | 0 | 0% | 538 | 2% |
| Mining | 101 | 0 | 101 | <1% | 0 | 14,416 | 14,416 | 63% | 101 | <1% | 14,416 | 63% | 14,517 | 63% |
| Public Water Supply | 4,604 | 0 | 4,604 | 20% | 1,994 | 0 | 1,994 | 9% | 6,598 | 29% | 0 | 0% | 6,598 | 29% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **5,411** | **0** | **5,411** | **24%** | **3,092** | **14,416** | **17,508** | **76%** | **8,503** | **37%** | **14,416** | **63%** | **22,919** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-22. Oklahoma - Custer County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 45 | 0 | 45 | <1% | 45 | <1% | 0 | 0% | 45 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 190 | 0 | 190 | <1% | 15,279 | 0 | 15,279 | 73% | 15,469 | 74% | 0 | 0% | 15,469 | 74% |
| Livestock | 627 | 0 | 627 | 3% | 302 | 0 | 302 | 1% | 930 | 4% | 0 | 0% | 930 | 4% |
| Mining | 269 | 0 | 269 | 1% | 11 | 0 | 11 | <1% | 280 | 1% | 0 | 0% | 280 | 1% |
| Public Water Supply | 1,848 | 0 | 1,848 | 9% | 2,240 | 0 | 2,240 | 11% | 4,089 | 20% | 0 | 0% | 4,089 | 20% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **2,934** | **0** | **2,934** | **14%** | **17,877** | **0** | **17,877** | **86%** | **20,813** | **100%** | **0** | **0%** | **20,813** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-23. Oklahoma - Dewey County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 134 | 0 | 134 | 2% | 134 | 2% | 0 | 0% | 134 | 2% |
| Industrial | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Irrigation | 0 | 0 | 0 | 0% | 4,951 | 0 | 4,951 | 58% | 4,951 | 58% | 0 | 0% | 4,951 | 58% |
| Livestock | 459 | 0 | 459 | 5% | 146 | 0 | 146 | 2% | 605 | 7% | 0 | 0% | 605 | 7% |
| Mining | 560 | 0 | 560 | 7% | 0 | 2,117 | 2,117 | 25% | 560 | 7% | 2,117 | 25% | 2,677 | 31% |
| Public Water Supply | 0 | 0 | 0 | 0% | 123 | 0 | 123 | 1% | 123 | 1% | 0 | 0% | 123 | 1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,019** | **0** | **1,019** | **12%** | **5,410** | **2,117** | **7,527** | **88%** | **6,429** | **75%** | **2,117** | **25%** | **8,546** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-24. Oklahoma - Ellis County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 168 | 0 | 168 | 1% | 168 | 1% | 0 | 0% | 168 | 1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 112 | 0 | 112 | <1% | 12,982 | 0 | 12,982 | 83% | 13,094 | 83% | 0 | 0% | 13,094 | 83% |
| Livestock | 0 | 0 | 0 | 0% | 1,232 | 0 | 1,232 | 8% | 1,232 | 8% | 0 | 0% | 1,232 | 8% |
| Mining | 504 | 0 | 504 | 3% | 0 | 0 | 0 | 0% | 504 | 3% | 0 | 0% | 504 | 3% |
| Public Water Supply | 0 | 0 | 0 | 0% | 728 | 0 | 728 | 5% | 728 | 5% | 0 | 0% | 728 | 5% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **616** | **0** | **616** | **4%** | **15,110** | **0** | **15,110** | **96%** | **15,726** | **>99%** | **0** | **0%** | **15,726** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-25. Oklahoma - Garvin County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 605 | 0 | 605 | 5% | 605 | 5% | 0 | 0% | 605 | 5% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 493 | 0 | 493 | 4% | 291 | 0 | 291 | 3% | 784 | 7% | 0 | 0% | 784 | 7% |
| Livestock | 863 | 0 | 863 | 8% | 90 | 0 | 90 | <1% | 952 | 9% | 0 | 0% | 952 | 9% |
| Mining | 627 | 0 | 627 | 6% | 0 | 5,892 | 5,892 | 53% | 627 | 6% | 5,892 | 53% | 6,519 | 59% |
| Public Water Supply | 1,243 | 0 | 1,243 | 11% | 986 | 0 | 986 | 9% | 2,229 | 20% | 0 | 0% | 2,229 | 20% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **3,226** | **0** | **3,226** | **29%** | **1,972** | **5,892** | **7,864** | **71%** | **5,197** | **47%** | **5,892** | **53%** | **11,089** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-26. Oklahoma - Grady County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 2,162 | 0 | 2,162 | 5% | 2,162 | 5% | 0 | 0% | 2,162 | 5% |
| Industrial | 616 | 0 | 616 | 1% | 11 | 0 | 11 | <1% | 627 | 1% | 0 | 0% | 627 | 1% |
| Irrigation | 20,342 | 0 | 20,342 | 47% | 10,843 | 0 | 10,843 | 25% | 31,185 | 71% | 0 | 0% | 31,185 | 71% |
| Livestock | 1,837 | 0 | 1,837 | 4% | 224 | 0 | 224 | <1% | 2,061 | 5% | 0 | 0% | 2,061 | 5% |
| Mining | 2,700 | 0 | 2,700 | 6% | 22 | 2,207 | 2,229 | 5% | 2,722 | 6% | 2,207 | 5% | 4,929 | 11% |
| Public Water Supply | 0 | 0 | 0 | 0% | 2,688 | 0 | 2,688 | 6% | 2,688 | 6% | 0 | 0% | 2,688 | 6% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **25,495** | **0** | **25,495** | **58%** | **15,950** | **2,207** | **18,157** | **42%** | **41,445** | **95%** | **2,207** | **5%** | **43,652** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-27. Oklahoma - Harper County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 34 | 0 | 34 | <1% | 34 | <1% | 0 | 0% | 34 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 9,174 | 0 | 9,174 | 42% | 10,933 | 0 | 10,933 | 50% | 20,107 | 92% | 0 | 0% | 20,107 | 92% |
| Livestock | 0 | 0 | 0 | 0% | 1,131 | 0 | 1,131 | 5% | 1,131 | 5% | 0 | 0% | 1,131 | 5% |
| Mining | 11 | 0 | 11 | <1% | 0 | 0 | 0 | 0% | 11 | <1% | 0 | 0% | 11 | <1% |
| Public Water Supply | 0 | 0 | 0 | 0% | 672 | 0 | 672 | 3% | 672 | 3% | 0 | 0% | 672 | 3% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **9,185** | **0** | **9,185** | **42%** | **12,770** | **0** | **12,770** | **58%** | **21,955** | **100%** | **0** | **0%** | **21,955** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-28. Oklahoma - Hughes County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 1,019 | 0 | 1,019 | 9% | 11 | 0 | 11 | <1% | 1,031 | 9% | 0 | 0% | 1,031 | 9% |
| Domestic | 0 | 0 | 0 | 0% | 22 | 0 | 22 | <1% | 22 | <1% | 0 | 0% | 22 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 2,341 | 0 | 2,341 | 21% | 2,218 | 0 | 2,218 | 20% | 4,559 | 42% | 0 | 0% | 4,559 | 42% |
| Livestock | 1,165 | 0 | 1,165 | 11% | 358 | 0 | 358 | 3% | 1,523 | 14% | 0 | 0% | 1,523 | 14% |
| Mining | 694 | 0 | 694 | 6% | 0 | 190 | 190 | 2% | 694 | 6% | 190 | 2% | 885 | 8% |
| Public Water Supply | 2,543 | 0 | 2,543 | 23% | 336 | 0 | 336 | 3% | 2,879 | 26% | 0 | 0% | 2,879 | 26% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **7,762** | **0** | **7,762** | **71%** | **2,945** | **190** | **3,135** | **29%** | **10,708** | **98%** | **190** | **2%** | **10,899** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-29. Oklahoma - Jackson County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Industrial | 0 | 0 | 0 | 0% | 101 | 0 | 101 | <1% | 101 | <1% | 0 | 0% | 101 | <1% |
| Irrigation | 63,378 | 0 | 63,378 | 81% | 12,221 | 0 | 12,221 | 16% | 75,598 | 97% | 0 | 0% | 75,598 | 97% |
| Livestock | 224 | 0 | 224 | <1% | 78 | 0 | 78 | <1% | 302 | <1% | 0 | 0% | 302 | <1% |
| Mining | 0 | 0 | 0 | 0% | 0 | 1,893 | 1,893 | 2% | 0 | 0% | 1,893 | 2% | 1,893 | 2% |
| Public Water Supply | 0 | 0 | 0 | 0% | 235 | 0 | 235 | <1% | 235 | <1% | 0 | 0% | 235 | <1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **63,602** | **0** | **63,602** | **81%** | **12,635** | **1,893** | **14,528** | **19%** | **76,236** | **98%** | **1,893** | **2%** | **78,129** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-30. Oklahoma - Kingfisher County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 493 | 0 | 493 | 2% | 493 | 2% | 0 | 0% | 493 | 2% |
| Industrial | 67 | 0 | 67 | <1% | 11 | 0 | 11 | <1% | 78 | <1% | 0 | 0% | 78 | <1% |
| Irrigation | 627 | 0 | 627 | 3% | 12,098 | 0 | 12,098 | 52% | 12,725 | 55% | 0 | 0% | 12,725 | 55% |
| Livestock | 1,411 | 0 | 1,411 | 6% | 728 | 0 | 728 | 3% | 2,139 | 9% | 0 | 0% | 2,139 | 9% |
| Mining | 3,607 | 0 | 3,607 | 16% | 661 | 1,501 | 2,162 | 9% | 4,268 | 19% | 1,501 | 7% | 5,769 | 25% |
| Public Water Supply | 0 | 0 | 0 | 0% | 1,859 | 0 | 1,859 | 8% | 1,859 | 8% | 0 | 0% | 1,859 | 8% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **5,712** | **0** | **5,712** | **25%** | **15,850** | **1,501** | **17,351** | **75%** | **21,562** | **93%** | **1,501** | **7%** | **23,063** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-31. Oklahoma – Le Flore County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Industrial | 134 | 0 | 134 | <1% | 0 | 0 | 0 | 0% | 134 | <1% | 0 | 0% | 134 | <1% |
| Irrigation | 3,069 | 0 | 3,069 | 14% | 2,240 | 0 | 2,240 | 10% | 5,309 | 24% | 0 | 0% | 5,309 | 24% |
| Livestock | 1,669 | 0 | 1,669 | 8% | 605 | 0 | 605 | 3% | 2,274 | 10% | 0 | 0% | 2,274 | 10% |
| Mining | 0 | 0 | 0 | 0% | 0 | 213 | 213 | <1% | 0 | 0% | 213 | <1% | 213 | <1% |
| Public Water Supply | 7,953 | 0 | 7,953 | 36% | 0 | 0 | 0 | 0% | 7,953 | 36% | 0 | 0% | 7,953 | 36% |
| Thermoelectric Power | 6,004 | 0 | 6,004 | 27% | 0 | 0 | 0 | 0% | 6,004 | 27% | 0 | 0% | 6,004 | 27% |
| **Total** | **18,829** | **0** | **18,829** | **86%** | **2,845** | **213** | **3,058** | **14%** | **21,674** | **>99%** | **213** | **<1%** | **21,887** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-32. Oklahoma – McClain County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 78 | 0 | 78 | <1% | 78 | <1% | 0 | 0% | 78 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 426 | 0 | 426 | 1% | 21,148 | 0 | 21,148 | 71% | 21,574 | 72% | 0 | 0% | 21,574 | 72% |
| Livestock | 0 | 0 | 0 | 0% | 1,635 | 0 | 1,635 | 5% | 1,635 | 5% | 0 | 0% | 1,635 | 5% |
| Mining | 168 | 0 | 168 | <1% | 101 | 168 | 269 | <1% | 269 | <1% | 168 | <1% | 437 | 1% |
| Public Water Supply | 0 | 0 | 0 | 0% | 6,183 | 0 | 6,183 | 21% | 6,183 | 21% | 0 | 0% | 6,183 | 21% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **594** | **0** | **594** | **2%** | **29,145** | **168** | **29,313** | **98%** | **29,739** | **>99%** | **168** | **<1%** | **29,907** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-33. Oklahoma – Major County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 1,322 | 0 | 1,322 | 24% | 1,322 | 24% | 0 | 0% | 1,322 | 24% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 986 | 0 | 986 | 18% | 638 | 0 | 638 | 12% | 1,624 | 29% | 0 | 0% | 1,624 | 29% |
| Livestock | 717 | 0 | 717 | 13% | 90 | 0 | 90 | 2% | 807 | 15% | 0 | 0% | 807 | 15% |
| Mining | 202 | 0 | 202 | 4% | 0 | 34 | 34 | <1% | 202 | 4% | 34 | <1% | 235 | 4% |
| Public Water Supply | 146 | 0 | 146 | 3% | 1,400 | 0 | 1,400 | 25% | 1,546 | 28% | 0 | 0% | 1,546 | 28% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **2,051** | **0** | **2,051** | **37%** | **3,450** | **34** | **3,484** | **63%** | **5,501** | **>99%** | **34** | **<1%** | **5,534** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-34. Oklahoma – Payne County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 11 | 0 | 11 | <1% | 0 | 0 | 0 | 0% | 11 | <1% | 0 | 0% | 11 | <1% |
| Domestic | 0 | 0 | 0 | 0% | 493 | 0 | 493 | 7% | 493 | 7% | 0 | 0% | 493 | 7% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 314 | 0 | 314 | 4% | 482 | 0 | 482 | 7% | 795 | 11% | 0 | 0% | 795 | 11% |
| Livestock | 560 | 0 | 560 | 8% | 56 | 0 | 56 | <1% | 616 | 8% | 0 | 0% | 616 | 8% |
| Mining | 739 | 0 | 739 | 10% | 0 | 616 | 616 | 8% | 739 | 10% | 616 | 8% | 1,355 | 18% |
| Public Water Supply | 1,311 | 0 | 1,311 | 18% | 1,647 | 0 | 1,647 | 22% | 2,957 | 40% | 0 | 0% | 2,957 | 40% |
| Thermoelectric Power | 1,120 | 0 | 1,120 | 15% | 0 | 0 | 0 | 0% | 1,120 | 15% | 0 | 0% | 1,120 | 15% |
| **Total** | **4,055** | **0** | **4,055** | **55%** | **2,678** | **616** | **3,294** | **45%** | **6,731** | **92%** | **616** | **8%** | **7,347** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-35. Oklahoma – Pittsburgh County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Industrial | 538 | 0 | 538 | 4% | 0 | 0 | 0 | 0% | 538 | 4% | 0 | 0% | 538 | 4% |
| Irrigation | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Livestock | 963 | 0 | 963 | 8% | 101 | 0 | 101 | <1% | 1,064 | 9% | 0 | 0% | 1,064 | 9% |
| Mining | 986 | 0 | 986 | 8% | 0 | 56 | 56 | <1% | 986 | 8% | 56 | <1% | 1,042 | 8% |
| Public Water Supply | 6,385 | 0 | 6,385 | 52% | 224 | 0 | 224 | 2% | 6,609 | 53% | 0 | 0% | 6,609 | 53% |
| Thermoelectric Power | 3,069 | 0 | 3,069 | 25% | 0 | 0 | 0 | 0% | 3,069 | 25% | 0 | 0% | 3,069 | 25% |
| **Total** | **11,941** | **0** | **11,941** | **96%** | **381** | **56** | **437** | **4%** | **12,322** | **>99%** | **56** | **<1%** | **12,378** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-36. Oklahoma – Roger Mills County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 123 | 0 | 123 | 2% | 123 | 2% | 0 | 0% | 123 | 2% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 381 | 0 | 381 | 7% | 3,338 | 0 | 3,338 | 60% | 3,719 | 67% | 0 | 0% | 3,719 | 67% |
| Livestock | 504 | 0 | 504 | 9% | 168 | 0 | 168 | 3% | 672 | 12% | 0 | 0% | 672 | 12% |
| Mining | 448 | 0 | 448 | 8% | 0 | 0 | 0 | 0% | 448 | 8% | 0 | 0% | 448 | 8% |
| Public Water Supply | 224 | 0 | 224 | 4% | 403 | 0 | 403 | 7% | 627 | 11% | 0 | 0% | 627 | 11% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,557** | **0** | **1,557** | **28%** | **4,032** | **0** | **4,032** | **72%** | **5,589** | **>99%** | **0** | **0%** | **5,589** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-37. Oklahoma – Seminole County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 504 | 0 | 504 | 4% | 504 | 4% | 0 | 0% | 504 | 4% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Livestock | 437 | 0 | 437 | 4% | 56 | 0 | 56 | <1% | 493 | 4% | 0 | 0% | 493 | 4% |
| Mining | 258 | 0 | 258 | 2% | 0 | 5,108 | 5,108 | 43% | 258 | 2% | 5,108 | 43% | 5,365 | 46% |
| Public Water Supply | 975 | 0 | 975 | 8% | 2,610 | 0 | 2,610 | 22% | 3,584 | 31% | 0 | 0% | 3,584 | 31% |
| Thermoelectric Power | 1,747 | 0 | 1,747 | 15% | 0 | 0 | 0 | 0% | 1,747 | 15% | 0 | 0% | 1,747 | 15% |
| **Total** | **3,417** | **0** | **3,417** | **29%** | **3,226** | **5,108** | **8,334** | **71%** | **6,642** | **57%** | **5,108** | **43%** | **11,749** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-38. Oklahoma – Tillman County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | – | 0 | 0% | 0 | – | 0 | 0% | 0 | 0% | – | 0% | 0 | 0% |
| Domestic | 0 | – | 0 | 0% | 34 | – | 34 | <1% | 34 | <1% | – | 0% | 34 | <1% |
| Industrial | 0 | – | 0 | 0% | 0 | – | 0 | 0% | 0 | 0% | – | 0% | 0 | 0% |
| Irrigation | 728 | – | 728 | 3% | 17,609 | – | 17,609 | 85% | 18,337 | 88% | – | 0% | 18,337 | 88% |
| Livestock | 717 | – | 717 | 3% | 235 | – | 235 | 1% | 952 | 5% | – | 0% | 952 | 5% |
| Mining | 0 | – | 0 | 0% | 112 | 134 | 246 | 1% | 112 | <1% | 134 | <1% | 246 | 1% |
| Public Water Supply | 1,064 | – | 1,064 | 5% | 179 | – | 179 | <1% | 1,243 | 6% | – | 0% | 1,243 | 6% |
| Thermoelectric Power | 0 | – | 0 | 0% | 0 | – | 0 | 0% | 0 | 0% | – | 0% | 0 | 0% |
| **Total** | **2,509** | **–** | **2,509** | **12%** | **18,169** | **134** | **18,303** | **88%** | **20,678** | **>99%** | **134** | **<1%** | **20,812** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-39. Oklahoma – Woods County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 146 | 0 | 146 | 2% | 146 | 2% | 0 | 0% | 146 | 2% |
| Industrial | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Irrigation | 0 | 0 | 0 | 0% | 5,690 | 0 | 5,690 | 59% | 5,690 | 59% | 0 | 0% | 5,690 | 59% |
| Livestock | 0 | 0 | 0 | 0% | 952 | 0 | 952 | 10% | 952 | 10% | 0 | 0% | 952 | 10% |
| Mining | 1,176 | 0 | 1,176 | 12% | 67 | 773 | 840 | 9% | 1,243 | 13% | 773 | 8% | 2,016 | 21% |
| Public Water Supply | 0 | 0 | 0 | 0% | 829 | 0 | 829 | 9% | 829 | 9% | 0 | 0% | 829 | 9% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,176** | **0** | **1,176** | **12%** | **7,695** | **773** | **8,468** | **88%** | **8,871** | **92%** | **773** | **8%** | **9,644** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-40. Oklahoma – Woodward County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 146 | 0 | 146 | <1% | 146 | <1% | 0 | 0% | 146 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 325 | 0 | 325 | 2% | 325 | 2% | 0 | 0% | 325 | 2% |
| Irrigation | 437 | 0 | 437 | 2% | 6,026 | 0 | 6,026 | 31% | 6,463 | 33% | 0 | 0% | 6,463 | 33% |
| Livestock | 0 | 0 | 0 | 0% | 1,445 | 0 | 1,445 | 7% | 1,445 | 7% | 0 | 0% | 1,445 | 7% |
| Mining | 34 | 0 | 34 | <1% | 0 | 818 | 818 | 4% | 34 | <1% | 818 | 4% | 851 | 4% |
| Public Water Supply | 0 | 0 | 0 | 0% | 7,057 | 0 | 7,057 | 36% | 7,057 | 36% | 0 | 0% | 7,057 | 36% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 3,338 | 0 | 3,338 | 17% | 3,338 | 17% | 0 | 0% | 3,338 | 17% |
| **Total** | **471** | **0** | **471** | **2%** | **18,337** | **818** | **19,155** | **98%** | **18,808** | **96%** | **818** | **4%** | **19,625** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

# TEXAS

### Table B-41. Texas – Andrews County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 582 | 0 | 582 | <1% | 582 | <1% | 0 | 0% | 582 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 14,618 | 0 | 14,618 | 18% | 14,618 | 18% | 0 | 0% | 14,618 | 18% |
| Livestock | 0 | 0 | 0 | 0% | 190 | 0 | 190 | <1% | 190 | <1% | 0 | 0% | 190 | <1% |
| Mining | 0 | 0 | 0 | 0% | 1,411 | 60,656 | 62,067 | 77% | 1,411 | 2% | 60,656 | 76% | 62,067 | 77% |
| Public Water Supply | 0 | 0 | 0 | 0% | 2,644 | 0 | 2,644 | 3% | 2,644 | 3% | 0 | 0% | 2,644 | 3% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **19,445** | **60,656** | **80,101** | **>99%** | **19,445** | **24%** | **60,656** | **76%** | **80,101** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-42. Texas – Burleson County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Domestic | 0 | 0 | 0 | 0% | 650 | 0 | 650 | 3% | 650 | 3% | 0 | 0% | 650 | 3% |
| Industrial | 0 | 0 | 0 | 0% | 112 | 0 | 112 | <1% | 112 | <1% | 0 | 0% | 112 | <1% |
| Irrigation | 4,346 | 0 | 4,346 | 22% | 8,311 | 0 | 8,311 | 42% | 12,658 | 64% | 0 | 0% | 12,658 | 64% |
| Livestock | 773 | 0 | 773 | 4% | 336 | 0 | 336 | 2% | 1,109 | 6% | 0 | 0% | 1,109 | 6% |
| Mining | 224 | 0 | 224 | 1% | 2,016 | 1,165 | 3,181 | 16% | 2,240 | 11% | 1,165 | 6% | 3,405 | 17% |
| Public Water Supply | 0 | 0 | 0 | 0% | 1,971 | 0 | 1,971 | 10% | 1,971 | 10% | 0 | 0% | 1,971 | 10% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **5,343** | **0** | **5,343** | **27%** | **13,407** | **1,165** | **14,572** | **73%** | **18,751** | **94%** | **1,165** | **6%** | **19,916** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-43. Texas – Calhoun County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 157 | 0 | 157 | <1% | 157 | <1% | 0 | 0% | 157 | <1% |
| Domestic | 0 | 0 | 0 | 0% | 291 | 0 | 291 | 1% | 291 | 1% | 0 | 0% | 291 | 1% |
| Industrial | 14,685 | 0 | 14,685 | 76% | 0 | 0 | 0 | 0% | 14,685 | 76% | 0 | 0% | 14,685 | 76% |
| Irrigation | 3,002 | 0 | 3,002 | 15% | 358 | 0 | 358 | 2% | 3,360 | 17% | 0 | 0% | 3,360 | 17% |
| Livestock | 78 | 0 | 78 | <1% | 190 | 0 | 190 | <1% | 269 | 1% | 0 | 0% | 269 | 1% |
| Mining | 0 | 0 | 0 | 0% | 0 | 381 | 381 | 2% | 0 | 0% | 381 | 2% | 381 | 2% |
| Public Water Supply | 0 | 0 | 0 | 0% | 280 | 0 | 280 | 1% | 280 | 1% | 0 | 0% | 280 | 1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **17,765** | **0** | **17,765** | **91%** | **1,276** | **381** | **1,657** | **9%** | **19,042** | **98%** | **381** | **2%** | **19,423** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-44. Texas – Cherokee County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 717 | 0 | 717 | <1% | 717 | <1% | 0 | 0% | 717 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 179 | 0 | 179 | <1% | 314 | 0 | 314 | <1% | 493 | <1% | 0 | 0% | 493 | <1% |
| Livestock | 1,490 | 0 | 1,490 | <1% | 269 | 0 | 269 | <1% | 1,759 | <1% | 0 | 0% | 1,759 | <1% |
| Mining | 22 | 0 | 22 | <1% | 56 | 4,537 | 4,593 | <1% | 78 | <1% | 4,537 | <1% | 4,615 | <1% |
| Public Water Supply | 941 | 0 | 941 | <1% | 6,127 | 0 | 6,127 | <1% | 7,068 | <1% | 0 | 0% | 7,068 | <1% |
| Thermoelectric Power | 823,887 | 0 | 823,887 | 98% | 0 | 0 | 0 | 0% | 823,887 | 98% | 0 | 0% | 823,887 | 98% |
| **Total** | **826,519** | **0** | **826,519** | **99%** | **7,483** | **4,537** | **12,020** | **1%** | **834,002** | **>99%** | **4,537** | **<1%** | **838,539** | **100%** |

Source: Dieter et al. (2018)
Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.
† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-45. Texas – Comal County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 594 | 0 | 594 | 2% | 594 | 2% | 0 | 0% | 594 | 2% |
| Industrial | 0 | 0 | 0 | 0% | 3,551 | 0 | 3,551 | 14% | 3,551 | 14% | 0 | 0% | 3,551 | 14% |
| Irrigation | 291 | 0 | 291 | 1% | 235 | 0 | 235 | <1% | 526 | 2% | 0 | 0% | 526 | 2% |
| Livestock | 168 | 0 | 168 | <1% | 78 | 0 | 78 | <1% | 246 | <1% | 0 | 0% | 246 | <1% |
| Mining | 0 | 0 | 0 | 0% | 2,554 | 0 | 2,554 | 10% | 2,554 | 10% | 0 | 0% | 2,554 | 10% |
| Public Water Supply | 7,673 | 0 | 7,673 | 29% | 11,033 | 0 | 11,033 | 42% | 18,706 | 71% | 0 | 0% | 18,706 | 71% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **8,132** | **0** | **8,132** | **31%** | **18,045** | **0** | **18,045** | **69%** | **26,177** | **>99%** | **0** | **0%** | **26,177** | **100%** |

Source: Dieter et al. (2018)
Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.
† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-46. Texas – Culberson County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 45,679 | 0 | 45,679 | 90% | 45,679 | 90% | 0 | 0% | 45,679 | 90% |
| Livestock | 11 | 0 | 11 | <1% | 280 | 0 | 280 | <1% | 291 | <1% | 0 | 0% | 291 | <1% |
| Mining | 0 | 0 | 0 | 0% | 437 | 3,618 | 4,055 | 8% | 437 | <1% | 3,618 | 7% | 4,055 | 8% |
| Public Water Supply | 0 | 0 | 0 | 0% | 907 | 0 | 907 | 2% | 907 | 2% | 0 | 0% | 907 | 2% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **11** | **0** | **11** | **<1%** | **47,314** | **3,618** | **50,932** | **>99%** | **47,325** | **93%** | **3,618** | **7%** | **50,943** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-47. Texas – Delta County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 381 | 0 | 381 | <1% | 381 | <1% | 0 | 0% | 381 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 109,292 | 0 | 109,292 | 87% | 109,292 | 87% | 0 | 0% | 109,292 | 87% |
| Livestock | 1,098 | 0 | 1,098 | <1% | 9,891 | 0 | 9,891 | 8% | 10,989 | 9% | 0 | 0% | 10,989 | 9% |
| Mining | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Public Water Supply | 0 | 0 | 0 | 0% | 4,761 | 0 | 4,761 | 4% | 4,761 | 4% | 0 | 0% | 4,761 | 4% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,098** | **0** | **1,098** | **<1%** | **124,325** | **0** | **124,325** | **>99%** | **125,423** | **100%** | **0** | **0%** | **125,423** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-48. Texas – Denton County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 4,716 | 0 | 4,716 | 41% | 56 | 0 | 56 | <1% | 4,772 | 42% | 0 | 0% | 4,772 | 42% |
| Livestock | 582 | 0 | 582 | 5% | 101 | 0 | 101 | <1% | 683 | 6% | 0 | 0% | 683 | 6% |
| Mining | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Public Water Supply | 5,522 | 0 | 5,522 | 48% | 493 | 0 | 493 | 4% | 6,015 | 52% | 0 | 0% | 6,015 | 52% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **10,820** | **0** | **10,820** | **94%** | **661** | **0** | **661** | **6%** | **11,481** | >99% | **0** | **0%** | **11,481** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-49. Texas – Gaines County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 863 | 0 | 863 | <1% | 863 | <1% | 0 | 0% | 863 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 213 | 101 | 314 | <1% | 213 | <1% | 101 | <1% | 314 | <1% |
| Irrigation | 0 | 0 | 0 | 0% | 312,116 | 0 | 312,116 | 82% | 312,116 | 82% | 0 | 0% | 312,116 | 82% |
| Livestock | 11 | 0 | 11 | <1% | 123 | 0 | 123 | <1% | 134 | <1% | 0 | 0% | 134 | <1% |
| Mining | 0 | 0 | 0 | 0% | 4,850 | 52,792 | 57,643 | 15% | 4,850 | 1% | 52,792 | 14% | 57,643 | 15% |
| Public Water Supply | 0 | 0 | 0 | 0% | 9,196 | 0 | 9,196 | 2% | 9,196 | 2% | 0 | 0% | 9,196 | 2% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **11** | **0** | **11** | **<1%** | **327,361** | **52,893** | **380,255** | **>99%** | **327,372** | 86% | **52,893** | **14%** | **380,266** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-50. Texas – Galveston County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 627 | 0 | 627 | 6% | 627 | 6% | 0 | 0% | 627 | 6% |
| Industrial | 0 | 0 | 0 | 0% | 101 | 0 | 101 | 1% | 101 | 1% | 0 | 0% | 101 | 1% |
| Irrigation | 3,002 | 0 | 3,002 | 31% | 157 | 0 | 157 | 2% | 3,159 | 32% | 0 | 0% | 3,159 | 32% |
| Livestock | 112 | 0 | 112 | 1% | 101 | 0 | 101 | 1% | 213 | 2% | 0 | 0% | 213 | 2% |
| Mining | 0 | 0 | 0 | 0% | 0 | 650 | 650 | 7% | 0 | 0% | 650 | 7% | 650 | 7% |
| Public Water Supply | 0 | 0 | 0 | 0% | 258 | 0 | 258 | 3% | 258 | 3% | 0 | 0% | 258 | 3% |
| Thermoelectric Power | 4,794 | 0 | 4,794 | 49% | 0 | 0 | 0 | 0% | 4,794 | 49% | 0 | 0% | 4,794 | 49% |
| **Total** | **7,908** | **0** | **7,908** | **81%** | **1,244** | **650** | **1,894** | **19%** | **9,152** | **93%** | **650** | **7%** | **9,802** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-51. Texas – Grayson County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 269 | 0 | 269 | <1% | 2,005 | 0 | 2,005 | 6% | 2,274 | 7% | 0 | 0% | 2,274 | 7% |
| Livestock | 975 | 0 | 975 | 3% | 325 | 0 | 325 | <1% | 1,299 | 4% | 0 | 0% | 1,299 | 4% |
| Mining | 22 | 0 | 22 | <1% | 101 | 1,210 | 1,311 | 4% | 123 | <1% | 1,210 | 4% | 1,333 | 4% |
| Public Water Supply | 12,747 | 0 | 12,747 | 37% | 11,392 | 67 | 11,459 | 34% | 24,139 | 71% | 67 | <1% | 24,206 | 71% |
| Thermoelectric Power | 4,906 | 0 | 4,906 | 14% | 0 | 0 | 0 | 0% | 4,906 | 14% | 0 | 0% | 4,906 | 14% |
| **Total** | **18,919** | **0** | **18,919** | **56%** | **13,879** | **1,277** | **15,156** | **44%** | **32,797** | **96%** | **1,277** | **4%** | **34,074** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-52. Texas – Guadalupe County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 885 | 0 | 885 | 2% | 885 | 2% | 0 | 0% | 885 | 2% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 246 | 0 | 246 | <1% | 538 | 0 | 538 | <1% | 784 | 1% | 0 | 0% | 784 | 1% |
| Livestock | 493 | 0 | 493 | <1% | 493 | 0 | 493 | <1% | 986 | 2% | 0 | 0% | 986 | 2% |
| Mining | 0 | 0 | 0 | 0% | 11 | 39,911 | 39,922 | 68% | 11 | <1% | 39,911 | 68% | 39,922 | 68% |
| Public Water Supply | 3,741 | 0 | 3,741 | 6% | 3,932 | 0 | 3,932 | 7% | 7,673 | 13% | 0 | 0% | 7,673 | 13% |
| Thermoelectric Power | 8,535 | 0 | 8,535 | 15% | 0 | 0 | 0 | 0% | 8,535 | 15% | 0 | 0% | 8,535 | 15% |
| **Total** | **13,015** | **0** | **13,015** | **22%** | **5,859** | **39,911** | **45,770** | **78%** | **18,874** | **32%** | **39,911** | **68%** | **58,785** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-53. Texas – Hemphill County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 78 | 0 | 78 | <1% | 78 | <1% | 0 | 0% | 78 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 3,080 | 0 | 3,080 | 36% | 3,080 | 36% | 0 | 0% | 3,080 | 36% |
| Livestock | 179 | 0 | 179 | 2% | 1,042 | 0 | 1,042 | 12% | 1,221 | 14% | 0 | 0% | 1,221 | 14% |
| Mining | 78 | 0 | 78 | <1% | 314 | 3,148 | 3,461 | 41% | 392 | 5% | 3,148 | 37% | 3,540 | 42% |
| Public Water Supply | 0 | 0 | 0 | 0% | 560 | 0 | 560 | 7% | 560 | 7% | 0 | 0% | 560 | 7% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **257** | **0** | **257** | **3%** | **5,074** | **3,148** | **8,221** | **97%** | **5,331** | **63%** | **3,148** | **37%** | **8,479** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-54. Texas – Houston County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 414 | 0 | 414 | 4% | 414 | 4% | 0 | 0% | 414 | 4% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 1,143 | 0 | 1,143 | 12% | 112 | 0 | 112 | 1% | 1,255 | 13% | 0 | 0% | 1,255 | 13% |
| Livestock | 1,255 | 0 | 1,255 | 13% | 134 | 0 | 134 | 1% | 1,389 | 14% | 0 | 0% | 1,389 | 14% |
| Mining | 22 | 0 | 22 | <1% | 56 | 3,999 | 4,055 | 42% | 78 | <1% | 3,999 | 41% | 4,077 | 42% |
| Public Water Supply | 0 | 0 | 0 | 0% | 2,621 | 0 | 2,621 | 27% | 2,621 | 27% | 0 | 0% | 2,621 | 27% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **2,420** | **0** | **2,420** | **25%** | **3,337** | **3,999** | **7,336** | **75%** | **5,757** | **59%** | **3,999** | **41%** | **9,756** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-55. Texas – Hutchinson County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 168 | 0 | 168 | <1% | 168 | <1% | 0 | 0% | 168 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 4,973 | 0 | 4,973 | 8% | 4,973 | 8% | 0 | 0% | 4,973 | 8% |
| Irrigation | 1,927 | 0 | 1,927 | 3% | 49,533 | 0 | 49,533 | 77% | 51,459 | 80% | 0 | 0% | 51,459 | 80% |
| Livestock | 90 | 0 | 90 | <1% | 269 | 0 | 269 | <1% | 358 | <1% | 0 | 0% | 358 | <1% |
| Mining | 0 | 0 | 0 | 0% | 0 | 1,210 | 1,210 | 2% | 0 | 0% | 1,210 | 2% | 1,210 | 2% |
| Public Water Supply | 0 | 0 | 0 | 0% | 5,937 | 0 | 5,937 | 9% | 5,937 | 9% | 0 | 0% | 5,937 | 9% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **2,017** | **0** | **2,017** | **3%** | **60,880** | **1,210** | **62,090** | **97%** | **62,895** | **98%** | **1,210** | **2%** | **64,105** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-56. Texas – Jackson County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 986 | 0 | 986 | 2% | 986 | 2% | 0 | 0% | 986 | 2% |
| Domestic | 0 | 0 | 0 | 0% | 370 | 0 | 370 | <1% | 370 | <1% | 0 | 0% | 370 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 1,512 | 0 | 1,512 | 3% | 1,512 | 3% | 0 | 0% | 1,512 | 3% |
| Irrigation | 493 | 0 | 493 | 1% | 39,037 | 0 | 39,037 | 80% | 39,530 | 81% | 0 | 0% | 39,530 | 81% |
| Livestock | 280 | 0 | 280 | <1% | 515 | 0 | 515 | 1% | 795 | 2% | 0 | 0% | 795 | 2% |
| Mining | 0 | 0 | 0 | 0% | 0 | 4,626 | 4,626 | 9% | 0 | 0% | 4,626 | 9% | 4,626 | 9% |
| Public Water Supply | 0 | 0 | 0 | 0% | 1,008 | 0 | 1,008 | 2% | 1,008 | 2% | 0 | 0% | 1,008 | 2% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **773** | **0** | **773** | **2%** | **43,428** | **4,626** | **48,054** | **98%** | **44,201** | **91%** | **4,626** | **9%** | **48,827** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-57. Texas – Jasper County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 314 | 0 | 314 | <1% | 235 | 0 | 235 | <1% | 549 | <1% | 0 | 0% | 549 | <1% |
| Domestic | 0 | 0 | 0 | 0% | 661 | 0 | 661 | 1% | 661 | 1% | 0 | 0% | 661 | 1% |
| Industrial | 5,802 | 0 | 5,802 | 10% | 44,066 | 0 | 44,066 | 79% | 49,869 | 90% | 0 | 0% | 49,869 | 90% |
| Irrigation | 101 | 0 | 101 | <1% | 22 | 0 | 22 | <1% | 123 | <1% | 0 | 0% | 123 | <1% |
| Livestock | 157 | 0 | 157 | <1% | 112 | 0 | 112 | <1% | 269 | <1% | 0 | 0% | 269 | <1% |
| Mining | 0 | 0 | 0 | 0% | 0 | 661 | 661 | 1% | 0 | 0% | 661 | 1% | 661 | 1% |
| Public Water Supply | 0 | 0 | 0 | 0% | 3,327 | 0 | 3,327 | 6% | 3,327 | 6% | 0 | 0% | 3,327 | 6% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **6,374** | **0** | **6,374** | **11%** | **48,423** | **661** | **49,084** | **89%** | **54,798** | **99%** | **661** | **1%** | **55,459** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

### Table B-58. Texas – Karnes County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 381 | 0 | 381 | 2% | 426 | 0 | 426 | 2% | 807 | 4% | 0 | 0% | 807 | 4% |
| Livestock | 358 | 0 | 358 | 2% | 437 | 0 | 437 | 2% | 795 | 4% | 0 | 0% | 795 | 4% |
| Mining | 739 | 0 | 739 | 4% | 6,676 | 6,866 | 13,543 | 71% | 7,415 | 39% | 6,866 | 36% | 14,282 | 75% |
| Public Water Supply | 0 | 0 | 0 | 0% | 1,221 | 1,859 | 3,080 | 16% | 1,221 | 6% | 1,859 | 10% | 3,080 | 16% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,478** | **0** | **1,478** | **8%** | **8,816** | **8,725** | **17,542** | **92%** | **10,294** | **54%** | **8,725** | **46%** | **19,020** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

### Table B-59. Texas – Kenedy County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 11 | 0 | 11 | 1% | 11 | 1% | 0 | 0% | 11 | 1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Livestock | 34 | 0 | 34 | 3% | 582 | 0 | 582 | 60% | 616 | 63% | 0 | 0% | 616 | 63% |
| Mining | 0 | 0 | 0 | 0% | 0 | 269 | 269 | 28% | 0 | 0% | 269 | 28% | 269 | 28% |
| Public Water Supply | 0 | 0 | 0 | 0% | 78 | 0 | 78 | 8% | 78 | 8% | 0 | 0% | 78 | 8% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **34** | **0** | **34** | **3%** | **671** | **269** | **940** | **96%** | **705** | **72%** | **269** | **28%** | **974** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-60. Texas – Lee County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 112 | 0 | 112 | <1% | 112 | <1% | 0 | 0% | 112 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 515 | 0 | 515 | 4% | 515 | 4% | 0 | 0% | 515 | 4% |
| Livestock | 750 | 0 | 750 | 6% | 325 | 0 | 325 | 2% | 1,075 | 8% | 0 | 0% | 1,075 | 8% |
| Mining | 22 | 0 | 22 | <1% | 6,878 | 560 | 7,438 | 55% | 6,900 | 51% | 560 | 4% | 7,460 | 55% |
| Public Water Supply | 0 | 0 | 0 | 0% | 4,447 | 0 | 4,447 | 33% | 4,447 | 33% | 0 | 0% | 4,447 | 33% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **772** | **0** | **772** | **6%** | **12,277** | **560** | **12,837** | **94%** | **13,049** | **96%** | **560** | **4%** | **13,609** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-61. Texas – Live Oak County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 179 | 0 | 179 | 2% | 179 | 2% | 0 | 0% | 179 | 2% |
| Industrial | 0 | 0 | 0 | 0% | 907 | 0 | 907 | 11% | 907 | 11% | 0 | 0% | 907 | 11% |
| Irrigation | 661 | 0 | 661 | 8% | 302 | 0 | 302 | 4% | 963 | 12% | 0 | 0% | 963 | 12% |
| Livestock | 224 | 0 | 224 | 3% | 526 | 0 | 526 | 7% | 750 | 9% | 0 | 0% | 750 | 9% |
| Mining | 101 | 0 | 101 | 1% | 907 | 1,008 | 1,915 | 24% | 1,008 | 13% | 1,008 | 13% | 2,016 | 25% |
| Public Water Supply | 2,251 | 0 | 2,251 | 28% | 840 | 0 | 840 | 11% | 3,092 | 39% | 0 | 0% | 3,092 | 39% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **3,237** | **0** | **3,237** | **41%** | **3,661** | **1,008** | **4,669** | **59%** | **6,899** | **87%** | **1,008** | **13%** | **7,907** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-62. Texas – Loving County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Livestock | 0 | 0 | 0 | 0% | 34 | 0 | 34 | <1% | 34 | <1% | 0 | 0% | 34 | <1% |
| Mining | 0 | 0 | 0 | 0% | 885 | 15,133 | 16,018 | >99% | 885 | 6% | 15,133 | 94% | 16,018 | >99% |
| Public Water Supply | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **930** | **15,133** | **16,063** | **100%** | **930** | **6%** | **15,133** | **94%** | **16,063** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-63. Texas – McMullen County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 146 | 0 | 146 | <1% | 146 | <1% | 0 | 0% | 146 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 35,486 | 0 | 35,486 | 62% | 35,486 | 62% | 0 | 0% | 35,486 | 62% |
| Livestock | 22 | 0 | 22 | <1% | 56 | 0 | 56 | <1% | 78 | <1% | 0 | 0% | 78 | <1% |
| Mining | 0 | 0 | 0 | 0% | 4,548 | 15,223 | 19,771 | 35% | 4,548 | 8% | 15,223 | 27% | 19,771 | 35% |
| Public Water Supply | 0 | 0 | 0 | 0% | 1,658 | 0 | 1,658 | 3% | 1,658 | 3% | 0 | 0% | 1,658 | 3% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **22** | **0** | **22** | **<1%** | **41,894** | **15,223** | **57,117** | **>99%** | **41,916** | **73%** | **15,223** | **27%** | **57,139** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-64. Texas – Montgomery County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 5,253 | 0 | 5,253 | 6% | 5,253 | 6% | 0 | 0% | 5,253 | 6% |
| Industrial | 0 | 0 | 0 | 0% | 1,243 | 0 | 1,243 | 1% | 1,243 | 1% | 0 | 0% | 1,243 | 1% |
| Irrigation | 1,165 | 0 | 1,165 | 1% | 1,613 | 0 | 1,613 | 2% | 2,778 | 3% | 0 | 0% | 2,778 | 3% |
| Livestock | 22 | 0 | 22 | <1% | 470 | 0 | 470 | <1% | 493 | <1% | 0 | 0% | 493 | <1% |
| Mining | 0 | 0 | 0 | 0% | 0 | 12,859 | 12,859 | 14% | 0 | 0% | 12,859 | 14% | 12,859 | 14% |
| Public Water Supply | 0 | 0 | 0 | 0% | 64,173 | 0 | 64,173 | 71% | 64,173 | 71% | 0 | 0% | 64,173 | 71% |
| Thermoelectric Power | 3,764 | 0 | 3,764 | 4% | 0 | 0 | 0 | 0% | 3,764 | 4% | 0 | 0% | 3,764 | 4% |
| **Total** | **4,951** | **0** | **4,951** | **5%** | **72,752** | **12,859** | **85,611** | **95%** | **77,704** | **86%** | **12,859** | **14%** | **90,563** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-65. Texas – Sabine County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 549 | 0 | 549 | 36% | 549 | 36% | 0 | 0% | 549 | 36% |
| Industrial | 22 | 0 | 22 | 1% | 0 | 0 | 0 | 0% | 22 | 1% | 0 | 0% | 22 | 1% |
| Irrigation | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Livestock | 90 | 0 | 90 | 6% | 22 | 0 | 22 | 1% | 112 | 7% | 0 | 0% | 112 | 7% |
| Mining | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Public Water Supply | 336 | 0 | 336 | 22% | 515 | 0 | 515 | 34% | 851 | 55% | 0 | 0% | 851 | 55% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **448** | **0** | **448** | **29%** | **1,086** | **0** | **1,086** | **71%** | **1,534** | **>99%** | **0** | **0%** | **1,534** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

### Table B-66. Texas – San Augustine County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 381 | 0 | 381 | 9% | 381 | 9% | 0 | 0% | 381 | 9% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Livestock | 1,781 | 0 | 1,781 | 43% | 202 | 0 | 202 | 5% | 1,983 | 48% | 0 | 0% | 1,983 | 48% |
| Mining | 134 | 0 | 134 | 3% | 325 | 403 | 728 | 18% | 459 | 11% | 403 | 10% | 863 | 21% |
| Public Water Supply | 650 | 0 | 650 | 16% | 258 | 0 | 258 | 6% | 907 | 22% | 0 | 0% | 907 | 22% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **2,565** | **0** | **2,565** | **62%** | **1,166** | **403** | **1,569** | **38%** | **3,730** | **90%** | **403** | **10%** | **4,134** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

### Table B-67. Texas – San Jacinto County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 627 | 0 | 627 | 16% | 627 | 16% | 0 | 0% | 627 | 16% |
| Industrial | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Irrigation | 0 | 0 | 0 | 0% | 67 | 0 | 67 | 2% | 67 | 2% | 0 | 0% | 67 | 2% |
| Livestock | 269 | 0 | 269 | 7% | 67 | 0 | 67 | 2% | 336 | 9% | 0 | 0% | 336 | 9% |
| Mining | 0 | 0 | 0 | 0% | 0 | 414 | 414 | 11% | 0 | 0% | 414 | 11% | 414 | 11% |
| Public Water Supply | 0 | 0 | 0 | 0% | 2,386 | 0 | 2,386 | 62% | 2,386 | 62% | 0 | 0% | 2,386 | 62% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **269** | **0** | **269** | **7%** | **3,158** | **414** | **3,572** | **93%** | **3,427** | **89%** | **414** | **11%** | **3,841** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-68. Texas – Shelby County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 975 | 0 | 975 | 4% | 975 | 4% | 0 | 0% | 975 | 4% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 0 | 0 | 0 | 0% | 11 | 0 | 11 | <1% | 11 | <1% | 0 | 0% | 11 | <1% |
| Livestock | 10,137 | 0 | 10,137 | 46% | 1,792 | 0 | 1,792 | 8% | 11,930 | 54% | 0 | 0% | 11,930 | 54% |
| Mining | 34 | 0 | 34 | <1% | 78 | 3,876 | 3,954 | 18% | 112 | <1% | 3,876 | 17% | 3,988 | 18% |
| Public Water Supply | 3,898 | 0 | 3,898 | 18% | 1,456 | 0 | 1,456 | 7% | 5,354 | 24% | 0 | 0% | 5,354 | 24% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **14,069** | **0** | **14,069** | **63%** | **4,312** | **3,876** | **8,188** | **37%** | **18,382** | **83%** | **3,876** | **17%** | **22,258** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-69. Texas – Tarrant County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 571 | 0 | 571 | <1% | 571 | <1% | 0 | 0% | 571 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 336 | 0 | 336 | <1% | 336 | <1% | 0 | 0% | 336 | <1% |
| Irrigation | 2,364 | 0 | 2,364 | 2% | 1,927 | 0 | 1,927 | 1% | 4,290 | 3% | 0 | 0% | 4,290 | 3% |
| Livestock | 347 | 0 | 347 | <1% | 67 | 0 | 67 | <1% | 414 | <1% | 0 | 0% | 414 | <1% |
| Mining | 1,131 | 0 | 1,131 | <1% | 280 | 3,327 | 3,607 | 2% | 1,411 | <1% | 3,327 | 2% | 4,738 | 3% |
| Public Water Supply | 20,454 | 0 | 20,454 | 13% | 9,252 | 0 | 9,252 | 6% | 29,706 | 19% | 0 | 0% | 29,706 | 19% |
| Thermoelectric Power | 115,643 | 0 | 115,643 | 74% | 0 | 0 | 0 | 0% | 115,643 | 74% | 0 | 0% | 115,643 | 74% |
| **Total** | **139,939** | **0** | **139,939** | **90%** | **12,433** | **3,327** | **15,760** | **10%** | **152,371** | **98%** | **3,327** | **2%** | **155,698** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-70. Texas – Trinity County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 179 | 0 | 179 | 9% | 179 | 9% | 0 | 0% | 179 | 9% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 426 | 0 | 426 | 20% | 34 | 0 | 34 | 2% | 459 | 22% | 0 | 0% | 459 | 22% |
| Livestock | 302 | 0 | 302 | 14% | 11 | 0 | 11 | <1% | 314 | 15% | 0 | 0% | 314 | 15% |
| Mining | 0 | 0 | 0 | 0% | 0 | 78 | 78 | 4% | 0 | 0% | 78 | 4% | 78 | 4% |
| Public Water Supply | 314 | 0 | 314 | 15% | 762 | 0 | 762 | 36% | 1,075 | 51% | 0 | 0% | 1,075 | 51% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,042** | **0** | **1,042** | **49%** | **986** | **78** | **1,064** | **51%** | **2,027** | **96%** | **78** | **4%** | **2,105** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-71. Texas – Walker County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 1,165 | 0 | 1,165 | 20% | 1,165 | 20% | 0 | 0% | 1,165 | 20% |
| Industrial | 179 | 0 | 179 | 3% | 179 | 0 | 179 | 3% | 358 | 6% | 0 | 0% | 358 | 6% |
| Irrigation | 112 | 0 | 112 | 2% | 123 | 0 | 123 | 2% | 235 | 4% | 0 | 0% | 235 | 4% |
| Livestock | 538 | 0 | 538 | 9% | 235 | 0 | 235 | 4% | 773 | 13% | 0 | 0% | 773 | 13% |
| Mining | 0 | 0 | 0 | 0% | 11 | 302 | 314 | 5% | 11 | <1% | 302 | 5% | 314 | 5% |
| Public Water Supply | 0 | 0 | 0 | 0% | 2,991 | 0 | 2,991 | 51% | 2,991 | 51% | 0 | 0% | 2,991 | 51% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **829** | **0** | **829** | **14%** | **4,704** | **302** | **5,007** | **86%** | **5,533** | **95%** | **302** | **5%** | **5,836** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-72. Texas – Washington County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 750 | 0 | 750 | 21% | 750 | 21% | 0 | 0% | 750 | 21% |
| Industrial | 0 | 0 | 0 | 0% | 347 | 0 | 347 | 10% | 347 | 10% | 0 | 0% | 347 | 10% |
| Irrigation | 0 | 0 | 0 | 0% | 168 | 0 | 168 | 5% | 168 | 5% | 0 | 0% | 168 | 5% |
| Livestock | 1,187 | 0 | 1,187 | 33% | 134 | 0 | 134 | 4% | 1,322 | 36% | 0 | 0% | 1,322 | 36% |
| Mining | 0 | 0 | 0 | 0% | 11 | 45 | 56 | 2% | 11 | <1% | 45 | 1% | 56 | 2% |
| Public Water Supply | 0 | 0 | 0 | 0% | 997 | 0 | 997 | 27% | 997 | 27% | 0 | 0% | 997 | 27% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **1,187** | **0** | **1,187** | **33%** | **2,407** | **45** | **2,452** | **67%** | **3,595** | **99%** | **45** | **1%** | **3,640** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-73. Texas – Winkler County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Industrial | 0 | 0 | 0 | 0% | 56 | 0 | 56 | <1% | 56 | <1% | 0 | 0% | 56 | <1% |
| Irrigation | 0 | 0 | 0 | 0% | 1,624 | 0 | 1,624 | 9% | 1,624 | 9% | 0 | 0% | 1,624 | 9% |
| Livestock | 0 | 0 | 0 | 0% | 90 | 0 | 90 | <1% | 90 | <1% | 0 | 0% | 90 | <1% |
| Mining | 0 | 0 | 0 | 0% | 235 | 13,834 | 14,069 | 80% | 235 | 1% | 13,834 | 79% | 14,069 | 80% |
| Public Water Supply | 0 | 0 | 0 | 0% | 1,624 | 0 | 1,624 | 9% | 1,624 | 9% | 0 | 0% | 1,624 | 9% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **0** | **0** | **0** | **0%** | **3,685** | **13,834** | **17,519** | **>99%** | **3,685** | **21%** | **13,834** | **79%** | **17,519** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-74. Texas – Wise County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 11 | 0 | 11 | <1% | 11 | 0 | 11 | <1% | 22 | <1% | 0 | 0% | 22 | <1% |
| Domestic | 0 | 0 | 0 | 0% | 2,341 | 0 | 2,341 | 11% | 2,341 | 11% | 0 | 0% | 2,341 | 11% |
| Industrial | 0 | 0 | 0 | 0% | 90 | 0 | 90 | <1% | 90 | <1% | 0 | 0% | 90 | <1% |
| Irrigation | 56 | 0 | 56 | <1% | 1,367 | 0 | 1,367 | 6% | 1,423 | 7% | 0 | 0% | 1,423 | 7% |
| Livestock | 1,031 | 0 | 1,031 | 5% | 258 | 0 | 258 | 1% | 1,288 | 6% | 0 | 0% | 1,288 | 6% |
| Mining | 1,501 | 0 | 1,501 | 7% | 134 | 3,047 | 3,181 | 15% | 1,635 | 8% | 3,047 | 14% | 4,682 | 22% |
| Public Water Supply | 1,400 | 0 | 1,400 | 7% | 941 | 157 | 1,098 | 5% | 2,341 | 11% | 157 | <1% | 2,498 | 12% |
| Thermoelectric Power | 8,984 | 0 | 8,984 | 42% | 0 | 0 | 0 | 0% | 8,984 | 42% | 0 | 0% | 8,984 | 42% |
| **Total** | **12,983** | **0** | **12,983** | **61%** | **5,142** | **3,204** | **8,346** | **39%** | **18,124** | **85%** | **3,204** | **15%** | **21,328** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

## Table B-75. Texas – Zapata County Water Use by Category in 2015

| Category | Surface Water | | | | Groundwater | | | | Total Withdrawals | | | | Total | Total Use (%)† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fresh | Saline* | Total | Total Use (%)† | Fresh | Saline* | Total | Total Use (%)† | Fresh | Total Use (%) | Saline* | Total Use (%)† | | |
| Aquaculture | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Domestic | 0 | 0 | 0 | 0% | 67 | 0 | 67 | 1% | 67 | 1% | 0 | 0% | 67 | 1% |
| Industrial | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| Irrigation | 1,019 | 0 | 1,019 | 22% | 11 | 0 | 11 | <1% | 1,031 | 23% | 0 | 0% | 1,031 | 23% |
| Livestock | 134 | 0 | 134 | 3% | 302 | 0 | 302 | 7% | 437 | 10% | 0 | 0% | 437 | 10% |
| Mining | 0 | 0 | 0 | 0% | 0 | 549 | 549 | 12% | 0 | 0% | 549 | 12% | 549 | 12% |
| Public Water Supply | 2,464 | 0 | 2,464 | 54% | 0 | 0 | 0 | 0% | 2,464 | 54% | 0 | 0% | 2,464 | 54% |
| Thermoelectric Power | 0 | 0 | 0 | 0% | 0 | 0 | 0 | 0% | 0 | 0% | 0 | 0% | 0 | 0% |
| **Total** | **3,617** | **0** | **3,617** | **80%** | **380** | **549** | **929** | **20%** | **3,999** | **88%** | **549** | **12%** | **4,548** | **100%** |

Source: Dieter et al. (2018)

Note: Values may not sum to totals because of independent rounding (Dieter et al. 2018). Water use data are in acre-feet/year unless otherwise indicated.

† Total Use percentages for surface water, groundwater, and overall totals represent the proportion of each water use category out of the total water usage in 2015.

# LITERATURE CITED

Dieter, C.A., M.A. Maupin, R.R. Caldwell, M.A. Harris, T.I. Ivahnenko, J.K. Lovelace, N.L. Barber, and K.S. Linsey. 2018. *Estimated Use of Water in the United States in 2015*. U.S. Geological Survey Circular 1441. Available at: https://pubs.er.usgs.gov/publication/cir1441. Accessed May 2025.