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

BLM WATER SUPPORT DOCUMENT FOR OIL AND GAS DEVELOPMENT IN NEW MEXICO

BLM WSD 2025

2025

Prepared by

U.S. Department of the Interior
Bureau of Land Management:
New Mexico State Office
301 Dinosaur Trail
Santa Fe, New Mexico 87508
505-954-2000

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

AF	acre-feet
AFFF	aqueous film-forming foam
APD	Application for Permit to Drill
AU	assessment unit
bbl	barrel(s)
BLM	Bureau of Land Management
CAS	Chemical Abstracts Service
CFO	Carlsbad Field Office
C.F.R.	Code of Federal Regulations
COA	condition of approval
CWA	Clean Water Act
DDT	dichlorodiphenyltrichloroethane
EIA	U.S. Energy Information Administration
EIS	environmental impact statement
EMNRD-OCD	New Mexico Energy, Minerals and Natural Resources Department-Oil Conservation Division
EPA	U.S. Environmental Protection Agency
FCWU	federal cumulative water use
FDO	Farmington District Office
FFO	Farmington Field Office
FWU	federal water use
gpm	gallons per minute
GWPC	Ground Water Protection Council
HPA	high-potential area
HUC	Hydrologic Unit Code
IOGCC	Interstate Oil and Gas Compact Commission
IR	Integrated Report
Mbbls	thousand barrels of liquid
Mcf	thousand cubic feet
mg/L	milligrams per liter
Mgal	million gallons
MOU	memorandum of understanding

N/A	not applicable
NDMC	National Drought Mitigation Center
NEPA	National Environmental Policy Act of 1969
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMISC	New Mexico Interstate Stream Commission
NMOCD	New Mexico Oil Conservation Division
NMOSE	New Mexico Office of the State Engineer
NMSO	New Mexico State Office
NMSWP	New Mexico State Water Plan
NMWQCC	New Mexico Water Quality Control Commission
NORM	naturally occurring radioactive materials
NTL	Notice to Lessees
NTL-3A	Notice to Lessees and Operators of Onshore Federal and Indian Oil and Gas Leases-3A
PCB	polychlorinated biphenyls
PDO	Pecos District Office
PET	petroleum engineering technician
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
ppm	parts per million
RFD	reasonably foreseeable development
RFFA	reasonably foreseeable future action
RFO	Roswell Field Office
RMP	resource management plan
RPFO	Rio Puerco Field Office
SRA	Seismic Response Area
TDS	total dissolved solids
TENORM	technologically enhanced naturally occurring radioactive materials
TMDL	total maximum daily load
USGS	U.S. Geological Survey
WSD	Water Support Document

CHAPTER 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 analysis to be incorporated by reference into National Environmental Policy Act of 1969 (NEPA) documents, most specifically NEPA analysis related to federal oil and gas leasing and development under the jurisdiction of the Bureau of Land Management (BLM) New Mexico State Office (NMSO). This includes federally managed oil and gas within the Pecos District Office (PDO) area, the Farmington Field Office (FFO) area, and the Rio Puerco Field Office (RPFO) area.

The content of this report focuses on existing water uses and projections of future water use based on past use, as well as planned use. The report also provides information regarding existing water quality and 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 quality impacts from leasing and development: Surface water that is used in oil and gas production comes from a previously approved water source. Although this report summarizes existing water quality and potential sources of surface and groundwater contamination from oil and gas spills, surface 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 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: In New Mexico, the New Mexico Environment Department (NMED) administers Clean Water Act (CWA) Sections 303(d), 305(b), and 314 related to surface water quality assessment and reporting. The NMED defines surface water quality beneficial uses and water quality criteria to evaluate if these uses are being attained. The BLM does not have responsibility to make use attainment or impairment evaluations based on water chemistry data.
- Water quality information for other areas mandated by the NMSO: The NMSO also manages federal oil and gas leasing and development within the Oklahoma Field Office area (which includes Texas, Oklahoma, and Kansas). Due to the scattered nature of leases, the lack of defined focal areas where leasing regularly occurs (such as the four field offices described in this report), and the number of counties within each state for which data would need to be compiled (254 counties in Texas, 77 in Oklahoma, and 105 in Kansas), the BLM determined that water quality and quantity information for the Oklahoma Field Office area will be gathered and evaluated in the BLM's Oklahoma Field Office's WSD for oil and gas development. The NMSO also manages federal oil and gas leasing and development for other field offices and districts within New Mexico; however, these are not areas in which leasing and subsequent development typically occur and therefore those field offices are not analyzed in this report.
- 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 and/or produced 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. The BLM, the NMED, and the New Mexico Oil Conservation Division (NMOCD) have put in place numerous requirements for oil and gas producers to prevent the contamination of surface water and groundwater resources in New Mexico.

1.2 REPORT ORGANIZATION

Chapter 1 introduces the topic, including purpose and scope, data sources, and this document in relation to prior years' reports. Chapter 2 contains a summary of water use data for New Mexico, including water use by industry or use category as well as water use by oil and gas wells. Chapter 2 also summarizes the most frequently disclosed chemical constituents used in hydraulic fracturing operations in New Mexico, as well as general information related to drought and water availability, per- and polyfluoroalkyl substances (PFAS), and naturally occurring radiological materials and technologically enhanced naturally occurring radiological materials. Chapter 3 summarizes water quantity and quality data for the PDO area, which comprises the Carlsbad Field Office (CFO) and the Roswell Field Office (RFO). Chapters 4 and 5 summarize water quantity and quality data for the FFO area and the RPFO area, respectively. Chapter 6 contains the references pertinent to the analysis. This report is organized so authors and data analysts may use field office chapters as stand-alone reports when evaluating impacts to water resources associated with proposed future federal oil and gas leasing and development.

1.3 DATA SOURCES

This section describes the primary data sources that are used throughout this report to evaluate impacts to water resources from oil and gas leasing and development activities in New Mexico.

1.3.1 State and County 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). Domestic water use includes self-supplied water and deliveries from the public supply; industrial and thermoelectric power are both 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."

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 fall 2025 (self-supplied industrial, domestic, mining, livestock, and aquaculture). The updated USGS water use data will be incorporated into the 2026 update of the New Mexico WSD 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.

1.3.2 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 (IOGCC). FracFocus was initially created to provide a place for publicly available information regarding chemicals used during hydraulic fracturing. Currently, 27 states require or allow oil and gas companies to disclose chemical data to FracFocus for any hydraulically fractured well, with many states allowing operators to meet reporting requirements via disclosure through FracFocus (FracFocus 2022). Currently, the states that require chemical disclosure to FracFocus are Alabama, Alaska, California, Colorado, Idaho, Kansas, Kentucky, Louisiana, Mississippi, Nebraska, Nevada, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, Utah, and West Virginia (FracFocus 2022).

In New Mexico, the New Mexico Administrative Code (NMAC) 19.15.16.19(B) states that “for a hydraulically fractured well, the operator shall also complete and file with the FracFocus chemical disclosure registry a completed hydraulic fracturing disclosure within 45 days after completion, recompletion, or other hydraulic fracturing treatment of the well.” FracFocus data is operator-reported and is known to include data errors regarding water and fluid volumes. For information on how FracFocus data is prepared and quality-checked for use and analysis in the WSD, see Appendix A.

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 data set. Thus, the FracFocus data presented in this WSD for the years 2014–2023 may differ slightly from previous years’ WSD due to updates to historical FracFocus data made throughout 2024. See Appendix A for details regarding how FracFocus data were obtained, organized, and analyzed for use in this report.

1.3.3 Spill Data

NMOCD regulates oil and gas activity in New Mexico and enforces its rules and the state’s oil and gas statutes. In addition, NMOCD manages well production data, permits new wells, and ensures that abandoned wells are properly plugged, and that the land is responsibly restored.

In each field office or district section of this report, 2024 spill data from the NMOCD database (NMOCD 2025a) 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. Contaminants may also migrate through subsurface pathways, such as groundwater flow, eventually discharging into surface waterbodies via springs. In the NMOCD database, many attributes of spill incidents are tracked, including the location, spill material, volume, and amount recovered, and information on whether the spill reached a watercourse.

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 NMOCD database. Appendix A contains specific details on how NMOCD spill data are obtained, organized, and analyzed for use in this report.

1.4 UPDATING THE REPORT

As new data become available in New Mexico, it will be necessary to update water use (water use by category data from the USGS and FracFocus), spill data (data from the NMOCD), 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.

CHAPTER 2. STATE OF NEW MEXICO

This chapter contains an analysis and summary of the available water use and water quality data for New Mexico that support the evaluation of water resource impacts from oil and gas leasing and development (as described in Chapter 1). Water use estimates for all categories of consumptive water use (e.g., public drinking water supply, irrigation, thermoelectric power) are presented in Section 2.1. Additionally, Section 2.1 contains the summarized FracFocus water use data so water use from hydraulic fracturing can be compared with statewide water use. Section 2.2 contains a summary of the chemicals used in hydraulic fracturing that are disclosed to FracFocus.

Oil and gas leasing and development in New Mexico occurs mostly in the San Juan Basin and the Permian Basin. New Mexico ranks second in the United States in the production of crude oil and fourth in the marketed production of natural gas. The U.S. Energy Information Administration (EIA) reported that New Mexico produced 744,639 thousand barrels of oil and 3,596,959 thousand cubic feet (Mcf) of natural gas in 2024 (EIA 2025).

The BLM field offices that intersect these oil-producing areas of the San Juan Basin are the FFO and RPFO (Figure 2-1). The San Juan Basin, a circular geologic formation that covers northwestern New Mexico and southwestern Colorado, is the second-largest gas-producing basin in the nation and supports about 23,500 active oil and gas wells (Rextag 2025). Most of the hydrocarbons that have formed in the San Juan Basin are a result of stratigraphic traps within the geologic structure (BLM 2003a).

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 (EIA 2020). Of the approximately 20 million acres in the total PDO planning area boundary, about 2.4 million acres have already been leased for oil and gas development (Haque 2024).

The Las Cruces District Office (Permian Basin), Taos Field Office (San Juan Basin), and Socorro Field Office were omitted from this report due to their lack of or small areas of overlap with the basins and the paucity of oil and gas leasing within those areas.

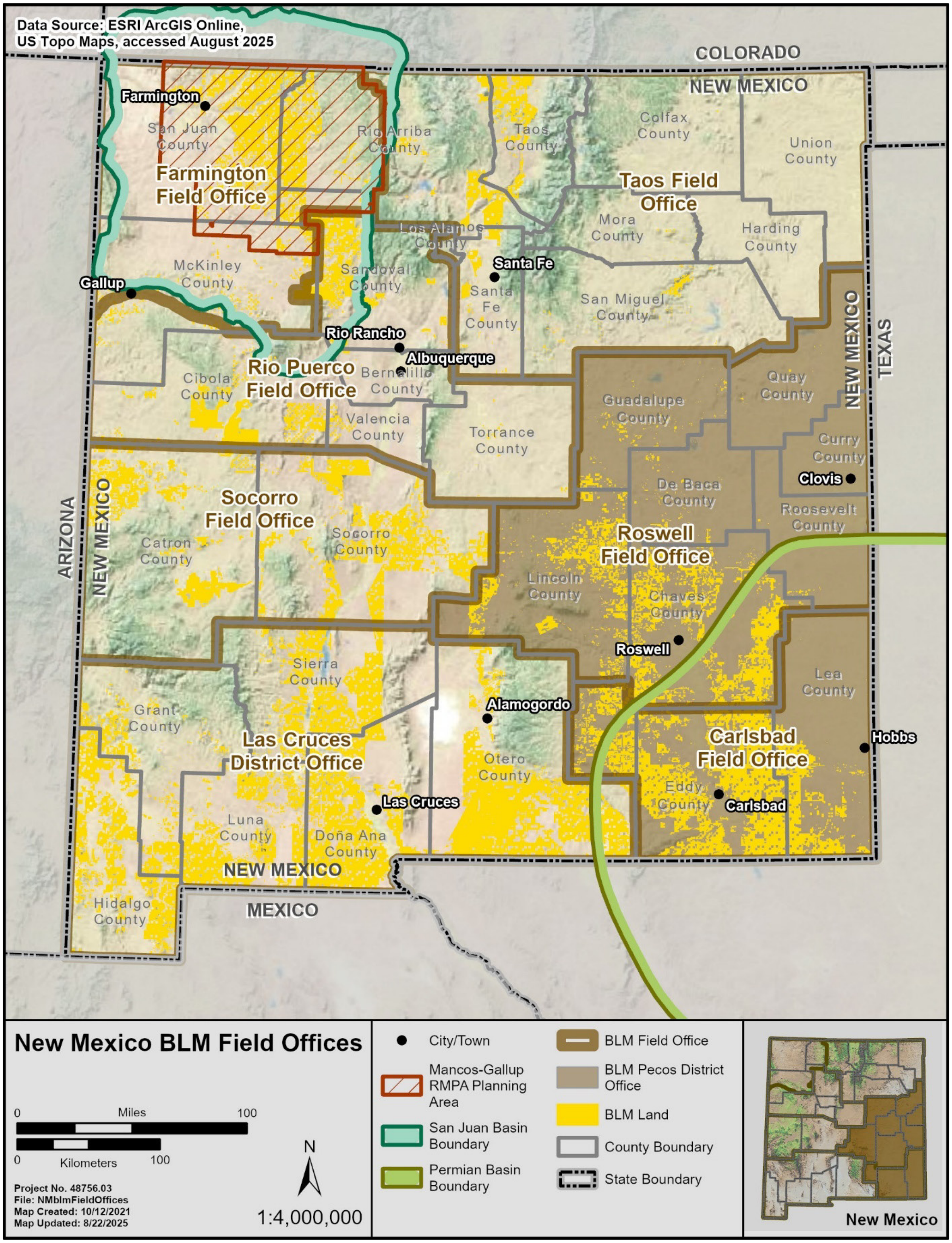

Figure 2-1. New Mexico BLM field offices and basin boundaries.

2.1 WATER QUANTITY

In 2015, the combined fresh and saline water withdrawals for all water use categories across New Mexico totaled 3,249,667 acre-feet (AF) (Table 2-1) (Dieter et al. 2018). Irrigation withdrawals accounted for the greatest water use within New Mexico at 82% (2,660,424 AF) in 2015. Public water supply and mining accounted for 9% and 5% of total water use (293,467 and 163,901 AF), respectively. Although total water withdrawals in the state were evenly divided between surface water and groundwater, the thermoelectric power and irrigation sectors relied predominantly on surface water, accounting for 81% and 56% of their total water use, respectively. In contrast, the other sectors primarily used groundwater. It is important to consider the impacts of groundwater well pumping on surface water availability, especially since New Mexico uses surface water for over half of its water use needs (Dieter et al. 2018). Groundwater pumping impacts the storage capacity of an aquifer, which can alter groundwater discharge zones that are connected to the aquifer from which water is being withdrawn (Barlow and Leake 2012). Altering aquifer storage capacity via groundwater pumping has the potential to change the local hydraulic gradient, which can impact connected discharge zones that feed surface water systems (Barlow and Leake 2012).

Total annual water use associated with the hydraulic fracturing of oil and gas wells throughout New Mexico increased in all but 2 years from 2014–2024 (all but 2020 and 2023), and totals ranged from 4,032 AF in 2014 to 113,910 AF in 2024 (Table 2-2). In the same time frame (2014–2024), average water usage per well increased from 6.0 AF in 2014 to 61.0 AF in 2024 (Table 2-2) (FracFocus 2025). The 10-year average (2015–2024) water use was 38.92 AF per well, while the 3-year average (2022–2024) totaled 55.5 AF per well. Water use for federal wells (as a percentage of water use for all wells) varies and ranged from a low of 12% in 2016 to a high of 52.0% in 2021. From 2014 through 2024, cumulative water usage within New Mexico totaled 508,315 AF, with federal wells comprising 40% (203,047 AF). From 2014 through 2024, 11,891 total wells (including all ownership/management jurisdictions) were reported to FracFocus, with an average of 1,081 wells per year between 2014 and 2024 (FracFocus 2025). In depth water quantity and water use information specific to field and district office jurisdictions can be found in subsequent chapters. Chapter 3 provides information related to water quantity conditions for the PDO, while Chapters 4 and 5 provide additional water quantity information for the FFO and RPFO, respectively.

FracFocus reports on water use directly associated with hydraulic fracturing jobs only, which represents the majority of water use per well across New Mexico (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 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).

Table 2-1. State of New Mexico 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	6,109	0	6,109	<1%	20,929	0	20,929	1%	27,039	1%	0	0%	27,039	1%
Domestic	0	–	0	0%	27,621	–	27,621	1%	27,621	1%	–	–	27,621	1%
Industrial	0	0	0	0%	3,811	0	3,811	<1%	3,811	<1%	0	0%	3,811	<1%
Irrigation	1,485,112	–	1,485,112	46%	1,175,312	–	1,175,312	36%	2,660,424	82%	–	–	2,660,424	82%
Livestock	2,522	–	2,522	0%	33,372	–	33,372	1%	35,894	1%	–	–	35,894	1%
Mining	19,550	0	19,550	1%	44,111	100,240	144,351	4%	63,662	2%	100,240	3%	163,901	5%
Public water supply	87,752	0	87,752	3%	205,715	0.00	205,715	6%	293,467	9%	0	0%	293,467	9%
Thermoelectric power	30,637	0	30,637	1%	6,872	0	6,872	<1%	37,509	1%	0	0%	37,509	1%
Total	**1,631,683**	**0**	**1,631,683**	**50%**	**1,517,744**	**100,240**	**1,617,984**	**50%**	**3,149,427**	**97%**	**100,240**	**3%**	**3,249,667**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 3,249,667 AF.

Table 2-2. Water Use by Oil and Gas Wells for Hydraulic Fracturing in New Mexico from 2014 through 2024

Year	Federal Water Use	Tribal Water Use	Non-Federal Water Use	Total Water Use	Federal Water Use (%)	Federal Cumulative Water Use	Total Cumulative Water Use	Average Water Use per Well*	Total No. of Wells	Total Non-HF Water Use	Total Water Use (HF plus non-HF)	Produced Water (bbl)
2014	1,435	–	2,597	4,032	36%	1,435	4,032	6.0	676	554.32	4,586	115,049
2015	1,931	–	4,480	6,411	30%	3,365	10,442	10.8	593	486.26	6,897	116,693
2016	866.9	–	6,086	6,953	12%	4,232	17,396	20.1	346	283.72	7,237	110,336
2017	3,391	39.0	11,486	14,877	23%	7,624	32,273	24.8	599	491.18	15,408	113,758
2018	9,382	89.1	22,942	32,324	29%	17,005	64,597	28.4	1,140	934.80	33,348	136,111
2019	11,079	20.2	33,013	44,092	25%	28,084	108,688	39.0	1,130	926.60	45,038	169,528
2020	16,475	–	25,524	41,999	39%	44,560	150,687	49.8	843	691.26	42,690	177,333
2021	34,762	118.8	32,234	66,995	52%	79,321	217,682	49.7	1,348	1105.36	68,219	209,481
2022	38,444	300.0	52,768	91,212	42%	117,765	308,894	52.2	1,748	1433.36	92,945	268,888
2023	38,960	1.2	46,550	85,510	46%	156,725	394,404	53.4	1,602	1313.64	86,825	300,272
2024	46,323	139.2	67,588	113,910	41%	203,047	508,315	61.0	1,866	1530.12	115,580	325,572
Total	**203,047**	**707.5**	**305,267**	**508,315**	**40%**	**–**	**–**	**35.9† (55.5)‡**	**11,891**	**9,750.62**	**518,773**	**2,043,023**

Source: FracFocus (2025). Data only for those wells that reported water usage to FracFocus are presented; produced water data are from NMOCD (2025d).

Note: All water use data are presented in AF. Produced water is not considered a type of water use but is produced as a byproduct of hydraulic fracturing and comes from naturally occurring water that exists in a formation that is being targeted for mineral extraction.

* Includes both federal and non-federal wells.

† 11-year average (2014–2024).

‡ 3-year average value (2022–2024).

bbl = barrels

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 that remains unrepresented throughout this report. 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 0.268 million gallons (Mgal) per well, equivalent to 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 New Mexico totaled 9,751 AF for 11,891 wells between the years 2014 and 2024 (see Table 2-2).

In New Mexico, total hydraulic fracturing, and non-hydraulic fracturing water use between the years 2014 and 2024 is estimated to be 518,773 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 New Mexico.

2.1.1 Produced Water

Public concern about water use from hydraulic fracturing is especially high in semiarid regions. Overall, there have been calls to increase the use of alternative water sources such as brackish water or recycling produced water, minimizing the strain on local freshwater resources (Kondash et al. 2018). The BLM encourages the use of recycled water in hydraulic fracturing techniques, and in 2019, New Mexico passed the Produced Water Act, which encourages oil and gas producers to reuse produced water for oil and gas extraction when possible rather than rely on freshwater sources. Recent studies indicate that the water used for hydraulic fracturing may be retained within the shale formation, with only a small fraction of the fresh water injected into the ground returning as flowback water (Kondash et al. 2018). Flowback fluid is a mixture of water, small amounts of chemicals, and proppants (granular solids that maintain fracture conductivity), that flow back through the wellhead directly after stimulation activities. Water returning to the surface is highly saline, difficult to treat, and often disposed of through deep injection wells (Kondash et al. 2018). Slickwater hydraulic fracturing, a technique that injects large volumes of water mixed with chemicals and sand at high pressure to fracture rock and release oil or gas, requires significantly more water than other methods due to its reliance on high fluid volumes to keep fractures open and extend them farther through low-permeability shale formations. Because slickwater fracs require much higher volumes of water per well, an increase in the average water use per well in hydraulic fracturing (see Table 2-2) indicates a rise in slickwater wells from 2014 to present. It is reasonable to assume with the increase in slickwater well construction that highly saline return water from the hydraulic fracturing process can be reused via water recycling methods. The NMED signed a memorandum of understanding (MOU) with New Mexico State University in September of 2019 to develop new technologies for treating produced water to inform future policies for produced water reuse (NMED 2019).

In September 2023, NMED began drafting the State's Ground and Surface Water Protection – Supplemental Requirements for Water Reuse (20.6.8 NMAC) regulations which focus on the restricted reuse of produced water. The proposed regulation would prohibit the discharge of both untreated and treated produced water to groundwater, including subsurface water in aquifers that are used for drinking water and other purposes. Specifically, produced water would not be permitted to be discharged to or disposed of on land, as such practices could result in leaching into aquifers from the surface and subsequent contamination of groundwater. In addition, the regulation would prohibit the discharge of produced water to surface waters, such as rivers, streams, lakes, wetlands, and arroyos. Furthermore, the regulation would establish requirements for the use of produced water in "demonstration projects" and "industrial projects." These requirements include explicit prohibitions on the discharge of produced water to ground and surface waters, as well as mandates that project operators develop spill prevention plans and assume financial responsibility for cleanup in the event of a spill, accident, or discharge. A draft version of the proposed NMAC 20.6.8 regulations can be found on the NMED website (NMED 2024a).

In 2024, New Mexico reported 325,572 AF of produced water by oil and gas wells for hydraulic fracturing to the New Mexico Energy, Minerals and Natural Resources Department-Oil Conservation Division (EMNRD-OCD) (see Table 2-2). Since 2014, New Mexico has seen a steady increase in produced water volumes.

2.2 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, most entries (58,532) did not include an ingredient name or Chemical Abstracts Service (CAS) number, 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 details on ingredient names or volumes are referred to as "unnamed" ingredients. Unnamed ingredients represented 15.80% of all FracFocus disclosures and 5.64% of the total hydraulic fracturing jobs (volume by percent mass) from 2014 through 2024. 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 2-3.

Not including unnamed ingredients, water is the most commonly disclosed ingredient in hydraulic fracturing operations, with 30,676 disclosures, representing 8.28% of all FracFocus disclosures and 31.44% of the total hydraulic fracturing jobs (chemical volume by percentage mass) from 2014 through 2024 (see Table 2-3). Crystalline silica (n = 11,043), methanol (n = 9,134) and hydrochloric acid (n = 7,440) represent the next most commonly reported chemicals constituents of hydraulic fracturing operations (see Table 2-3). In total, 370,503 unique chemical constituent disclosures in New Mexico were entered in the FracFocus database (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.

In depth water quality information specific to field and district office jurisdictions can be found in subsequent chapters. Chapter 3 provides information related to water quality conditions for the PDO, while Chapters 4 and 5 provide additional water quality information for the FFO and RPFO, respectively. Appendix A contains information on how FracFocus data are analyzed and summarized.

Table 2-3. Most Frequently Disclosed Ingredients Reported to FracFocus within New Mexico 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	58,532	5.64	15.80
Water	7732-18-5	30,676	31.44	8.28
Crystalline silica, quartz	14808-60-7	11,043	13.19	2.98
Methanol	67-56-1	9,134	0.01	2.47
Hydrochloric acid	7647-01-0	7,440	0.13	2.01
Glutaraldehyde	111-30-8	5,085	0.01	1.37
Ammonium chloride	12125-02-9	4,517	0.00	1.22
Distillates (petroleum), hydrotreated light	64742-47-8	4,263	0.03	1.15
Acetic acid	64-19-7	4,003	0.04	1.08
Ethanol	64-17-5	3,894	0.00	1.05
Sodium chloride	7647-14-5	3,563	0.06	0.96
Proprietary*	Proprietary	3,458	0.02	0.93
Propargyl alcohol	107-19-7	3,255	0.00	0.88
Ethylene glycol	107-21-1	3,125	0.04	0.84
Aluminum oxide	1,344-28-1	2,916	0.08	0.79
Ammonium persulfate	7,727-54-0	2,516	0.01	0.68
Guar gum	9,000-30-0	2,418	0.12	0.65
Sodium hydroxide	1,310-73-2	2,362	0.01	0.64
Ethoxylated alcohols	Varies	2,296	0.01	0.62
Alcohols, C12-16, ethoxylated	68439-45-2	2,273	0.00	0.61
Sodium perborate tetrahydrate	10486-00-7	2,116	0.02	0.57
Citric acid	77-92-9	2,106	0.00	0.57
Didecyl dimethyl ammonium chloride	7173-51-5	2,072	0.00	0.56
Surfactant	Varies	1,973	0.01	0.53
Isopropanol	67-63-0	1,891	0.01	0.51

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 detected 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 [2024] data dictionary).

‡ The total number of FracFocus ingredient disclosures between 2014 and 2024 in New Mexico is 370,503.

2.2.1 Spills

Spills associated with oil and gas development have the potential to impact both surface water and groundwater, either through direct release into waterways or indirectly via surface runoff, soil contamination, infiltration, and migration. These indirect pathways can eventually lead to the contamination of springs or other surface water sources. According to NMAC 19.15.29.10, major releases must be reported to NMOCD within 24 hours of the discovery of the release. A major release is defined in NMAC 19.15.29.7 as an unauthorized release of a volume, excluding gases, of 25 barrels or more. A major release also includes any unauthorized release that results in or is the result of a fire; may reach a watercourse; may endanger public health, property, or the environment; or may be detrimental to freshwater. Minor releases (less than 25 barrels and greater than five barrels) must be reported to NMOCD within 15 days (NMAC 19.15.29.10). All major and minor release reports (spills) are archived in the NMOCD spills database.

Spill data from NMOCD were retrieved from the NMOCD database and further reviewed and summarized (NMOCD 2025a) (see Appendix A for data methodology). In 2024, there were 919 liquid spills across the state associated with federal and non-federal oil and gas wells and facilities (Table 2-4) (NMOCD 2025a). The average percentage of the liquid spill volume lost (volume lost divided by volume released) varies by spill type, but the average spill volume for liquids lost (not recovered) was 59% in 2024 (see Table 2-4) (NMOCD 2025a). Gaseous spills (including flared natural gas, vented natural gas, and carbon dioxide) were not recoverable resulting in 100% loss. Complete spill loss for gaseous spills is expected to occur due to the ignition process of flaring excess natural gas liquids.

Table 2-4. Summary of 2024 Spills in New Mexico

Material	Spill Count	Volume Spilled	Volume Lost	Units	Average Spill Volume	Mean Percent Lost (%)	Waterways Affected	Groundwater Affected
Produced Water	559	83,233	41,234	bbl	149	60	3	1
Crude Oil	260	10,746	4,162	bbl	41	62	0	0
Condensate	63	811	664	bbl	13	90	4	0
Other (specify)	13	1,117	366	bbl	86	54	0	1
Drilling mud/fluid	1	95	20	bbl	95	21	0	0
Natural gas liquids	2	571	311	bbl	286	67	0	0
Glycol	5	39	36	bbl	8	97	0	0
Unknown	14	23,360	23,360	bbl	1,669	100	0	0
Brine water	2	209	205	bbl	105	82	0	0
Total Liquid Spills	**919**	**120,181**	**70,358**	**bbl**	**2,450**	**59**	**7**	**2**
Chemical (specify)	1	16	16	bbl	16	100	0	0
Natural gas flared	38,845	10,804,711	10,804,711	Mcf	278	100	0	6
Natural gas vented	896	595,916	595,916	Mcf	665	100	7	0
Carbon dioxide	178	48,749	48,749	Mcf	274	100	1	0

Material	Spill Count	Volume Spilled	Volume Lost	Units	Average Spill Volume	Mean Percent Lost (%)	Waterways Affected	Groundwater Affected
Total Gaseous Spills	**39,919**	**11,449,376**	**11,449,376**	**Mcf**	**1,217**	**100**	**8**	**6**

Source: NMOCD (2025a)

Units: bbl = barrels, Mcf= thousand cubic feet

Note: FracFocus does not differentiate between natural gas flaring/venting and a normal liquid spill that could occur during the hydraulic fracturing process; therefore, this table reflects two total value rows (one total value for conventional spills and one for natural gas flaring and venting). Natural gases that are vented and flared are done intentionally as part of the hydraulic fracturing process with no expected spill recovery.

The BLM works with NMOCD to remediate spills associated with federal oil and gas wells on BLM-managed lands or on private or state surface. Title 19, Chapter 15 of the NMAC pertains to oil and gas releases. According to NMAC 19.15.29.11, the responsible person shall complete Division-approved corrective action for releases that endanger public health or the environment in accordance with a remediation plan submitted to and approved by NMOCD or with an abatement plan submitted in accordance with NMAC 19.15.30. The remaining contaminants from unrecovered spills are remediated in accordance with federal and state standards. Such remediation consists of removing contaminated soil and replacing it with uncontaminated soil and performing corresponding chemical testing.

Statewide historical data presented by year in Table 2-5 indicate a substantial increase in reported gaseous spills since 2014, while the volume of liquid spills has remained relatively stable. This rise in gaseous spill reports is likely attributable to the implementation of mandatory quarterly gas reporting requirements for operators, which took effect in 2021 (New Mexico State Records Center and Archives 2021a, 2021b). Additionally, natural gas production has increased significantly (from 1,243,156,346 Mcf in 2014 to 3,528,055,124 Mcf in 2024) further contributing to the observed trend (NMOCD 2025a). Spill data specific to field and district offices is provided in subsequent chapters and sections. Spill data for the PDO can be found in Section 3.2.3.1, while spill data from the FFO and RPFO are available in Sections 4.2.3.1 and 5.2.3.1, respectively.

Table 2-5. Summary of Spills from All Wells in New Mexico between 2014 and 2024

Material Type	Spill Count by Year										
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Produced water	662	586	517	529	583	684	545	504	666	685	559
Crude oil	260	300	362	230	266	369	390	338	342	408	337
Natural gas liquids*	20	27	18	12	12	13	5	13	12	4	2
Condensate	63	98	93	43	31	30	33	21	32	47	27
Unknown (specify)	1	2	0	0	0	0	0	1	3	3	14
Other (specify)	22	18	14	14	35	34	21	31	49	20	13
Glycol	0	0	0	0	0	2	0	0	1	2	5
Diesel	1	1	0	1	3	0	0	1	3	1	0
Drilling mud/fluid	6	6	1	4	5	2	0	0	5	6	1
Brine water	3	3	6	3	3	4	3	3	5	1	2
Chemical (specify)	2	1	1	2	5	3	0	0	2	0	1
Acid	3	2	0	0	1	2	0	3	1	0	0
Lube oil	3	1	2	1	2	0	2	2	1	0	0
Gelled brine (frac fluid)	3	2	0	0	0	2	0	2	0	0	0

Material Type	Spill Count by Year										
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Sulfuric acid	0	0	0	0	1	0	0	0	0	0	0
Basic sediments and water	0	0	1	3	3	0	0	0	0	0	0
Hydrogen sulfide	0	0	0	0	0	0	0	0	0	1	0
Gasoline	4	1	0	0	0	0	0	0	0	0	0
Total Liquid Spills	***1,094***	***1,105***	***934***	***928***	***1,077***	***1,145***	***873***	***833***	***1,203***	***1,121***	***920***
Natural gas flared	1	0	0	0	0	0	10	14,191	37,755	49,829	38,845
Natural gas vented	0	0	0	0	0	0	2	729	1,571	1,553	896
Carbon dioxide	0	0	1	0	0	0	0	0	0	143	178
Methane	210	316	302	76	175	199	236	203	0	0	0
Total Gaseous Spills†	***211***	***316***	***303***	***76***	***175***	***199***	***248***	***15,123***	***39,326***	***51,525***	***39,919***

Source: NMOCD (2025a)

* Natural gas liquids material types include natural gas flared, natural gas liquid, and natural gas vented material.

† On May 25, 2021, NMOCD's new natural gas waste rules, NMAC 19.15.27 and 19.15.28, went into effect. These new rules resulted in a higher reporting number for natural gas liquid spills compared with previous years (New Mexico State Records Center and Archives 2021a, 2021b).

2.2.2 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 are a main component of aqueous film-forming foam (AFFF), which is used regularly in fire suppression and prevention activities performed at airports and military bases (Sunderland et al. 2018). AFFF 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). As of August 2022, the U.S. Environmental Protection Agency (EPA 2024a) has created a Comptox Chemicals Dashboard which houses a database identifying 14,735 chemicals that fit the PFAS criteria (EPA 2022a). The most common and widely studied PFAS include perfluorooctane sulfonate and perfluorooctanoic acid (EPA 2024a). PFAS are very persistent in both the environment and the human body due to their inability to readily break down (EPA 2024a). PFAS persistence has been linked to bioaccumulation in both the environment and human body, which may lead to adverse effects on human health (EPA 2024a).

In the years 2020–2021, the USGS partnered with the NMED to conduct a statewide assessment on PFAS to better understand PFAS contamination throughout the state (USGS 2024). The study analyzed PFAS presence in surface water and groundwater across New Mexico. Due to groundwater usage during the hydraulic fracturing process, only groundwater results will be considered in this section. Of the 117 groundwater sample locations across New Mexico, 27 sample locations (23% of sampling locations) were found to have one or more PFAS above the laboratory detection limit (USGS 2024). There were no PFAS sample locations that had concentrations exceeding the EPA's 70 nanogram/liter recommendation (USGS 2024). Additional information regarding PFAS data and data processing can be found in Appendix A.

2.2.2.1 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 process 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 of skimming oil spills from water during the remediation process (Gaines 2022).

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). Use of PFAS chemicals makes up a minimal amount (less than 1%) of chemical constituents disclosed to FracFocus for hydraulic fracturing in New Mexico (FracFocus 2025). In 2024, New Mexico had two reported ingredient instances of nonionic surfactants and 32 reported ingredient instances of poly-tetrafluoroethylene used in association with hydraulic fracturing. In total, 34 of the approximately 39,351 ingredient disclosures (0.09%) in 2024 were related to PFAS used in hydraulic fracturing processes in New Mexico. The majority of PFAS-contaminated water usage is strictly for well drilling, completion, stimulation, and oil spill mitigation. PFAS use in hydraulic fracturing is likely to occur in areas not associated with New Mexico's drinking water.

2.2.3 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 (TENORM). 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 2022b).

In New Mexico, the occurrence of NORM and TENORM in water resources is largely influenced by the state's geology and industrial legacy. Elevated concentrations are commonly linked to historical uranium mining and milling in areas such as the Grants Mineral Belt, as well as ongoing oil and gas production in regions like the San Juan Basin, where produced water may concentrate radionuclides including radium-226 and radium-228 (New Mexico Bureau of Geology and Mineral Resources n.d.; USGS 2015). Arid conditions and naturally mineralized formations contribute to radionuclide mobility, while sources such as abandoned mine sites, legacy waste piles, and inadequately controlled discharges of produced water have resulted in localized groundwater and surface water contamination (EPA 2000).

To manage these risks, the NMED implements water quality regulations consistent with EPA maximum contaminant levels for radionuclides in drinking water (EPA 2024b). These include 5 picocuries per liter for combined radium-226 and -228, 30 µg/L for uranium, and 15 picocuries per liter for gross alpha activity excluding radon and uranium (EPA 2022b). The NMED Drinking Water Bureau conducts system monitoring, while the Radiation Control Bureau oversees TENORM regulation under Title 20, Chapter 3 of the NMAC, which outlines standards for handling, monitoring, and disposal to protect public and environmental health.

2.3 DROUGHT AND WATER AVAILABILITY

To standardize drought reporting across federally managed lands, the BLM requested the use of ClimateEngine.org to calculate and categorize 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. 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
- Palmer Drought Severity Index
- Standardized Precipitation Index
- Palmer Hydrological Drought Index
- Soil Moisture Content

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 is used for evaluating drought severity across the field and district offices within New Mexico (PDO, FFO, RPFO). Due to specific data accessibility, the Farmington District Office (FDO), which comprises the FFO and Taos Field Office, has been used for drought evaluation of the FFO. The drought blend figures presented below combine the current, 3-month, and 1-year drought summaries to produce each blend figure.

New Mexico-specific drought data were compiled from the NMSO to ensure accurate statewide drought information. Climate Engine data at the highest level of analysis (entirety of the NMSO) include drought information from the entire jurisdiction of the NMSO (Texas, Oklahoma, and Kansas). As a result, it was not possible to generate a drought blend assessment tailored solely to New Mexico.

2.3.1 State of New Mexico

New Mexico has been subjected to a prolonged period of drought, which puts further strain on sources of water accessible via surface water diversion or groundwater pumping. According to the U.S Drought Monitoring tool, 1.9 million people in New Mexico are living in drought-affected areas in June 2025 (National Drought Mitigation Center [NDMC] 2025). In 2024, 85.5% of New Mexico experienced some level of drought severity (D0–D4), leaving most of the state subjected to long-term drought conditions (Table 2-6) (NDMC 2025). Figure 2-2 displays the change in drought conditions over the past 10 years, reflecting the change in the total drought percent area under each drought condition (D0–D4) (NDMC 2025).

Table 2-6. Average Annual Drought by Categories Across New Mexico from 2014 through 2024

Year	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)
2014	4.8	95.2	82.6	53.6	16.5	0.5
2015	42.3	57.7	32.2	9.5	0.6	0.0
2016	38.2	61.8	15.1	0.0	0.0	0.0
2017	74.0	26.0	4.6	0.0	0.0	0.0

Year	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)
2018	3.9	96.1	87.3	64.6	32.3	10.9
2019	49.5	50.5	29.1	12.4	3.4	1.0
2020	21.6	78.4	64.3	46.2	24.5	7.7
2021	3.2	96.8	91.0	78.4	50.1	26.5
2022	1.7	98.3	83.5	65.8	33.7	9.1
2023	21.5	78.5	57.5	36.9	14.2	1.9
2024	14.5	85.5	59.0	32.6	13.0	1.6

Note: Drought is categorized by mean percentage of the state experiencing increasing bracketed levels of drought. For example, in 2014, 95.2% of New Mexico experienced some level of drought (D0-D4); however, only 0.5% of the state experienced the highest level of drought (D4) during the same year.

Source: NDMC (2025)

With the unpredictability of monsoonal precipitation due to climate change, it cannot be reliably assumed that aquifers supplying water for hydraulic fracturing will consistently recharge via percolation from precipitation events. Extended drought conditions could result in decreased water availability at identified discharge zones. Consequently, surface water bodies hydrologically connected to these aquifers may experience reduced water levels due to the prolonged drought, impacting surface water availability across regions with significant hydraulic fracturing activity.

Moreover, increased groundwater withdrawals for oil and gas extraction for RFD in New Mexico could result in additional stress to aquifers. Hydrologically connected surface waters may exhibit altered flow regimes due to the increased groundwater extraction. Increased groundwater pumping due to the expansion of hydraulic fracturing, combined with regional drought, may reduce the water available for irrigation. Irrigation water supply is primarily sourced from surface water bodies and springs/seeps, which often depend on stable groundwater levels and climatic conditions for recharge.

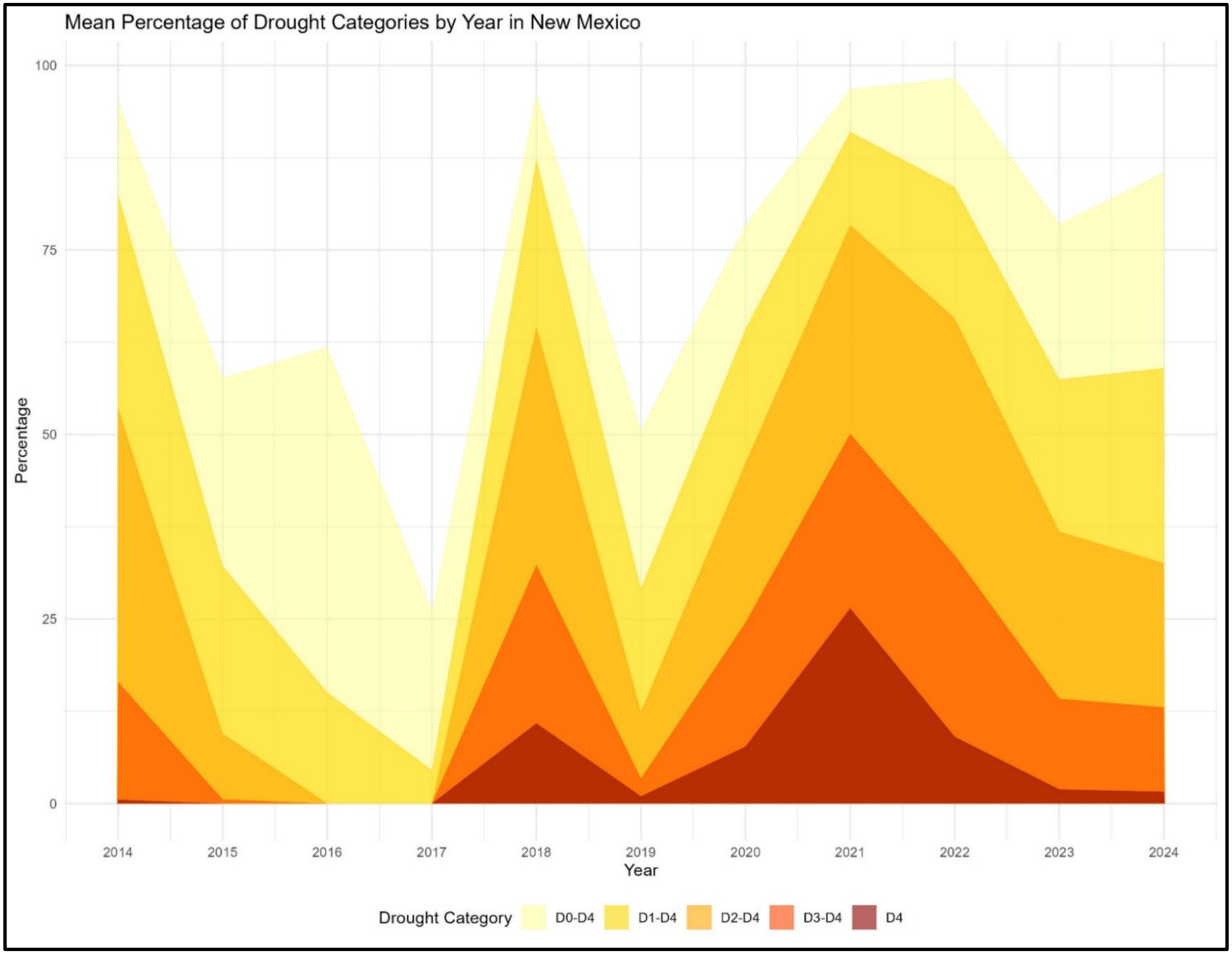

Figure 2-2. Drought conditions in New Mexico from 2014 through 2024.

Source: NDMC (2025)

D0 = Abnormally Dry, D1 = Moderate Drought, D2 = Severe Drought, D3 = Extreme Drought, D4 = Exceptional Drought.

2.3.2 Pecos District Office

On June 8, 2024, 78% of the total jurisdictional area of the PDO experienced drought conditions, including 17.1% of the area in severe drought and 16.0% in extreme drought conditions (Table 2-7). Drought conditions in the PDO show improvement 1 year later with 38% of the total area experiencing drought and 10.8% in severe and 8.1% in extreme drought on 5/30/2025. As of 5/30/2025, severe and extreme conditions are primarily concentrated in the south and southwest regions of the PDO. Figure 2-3 illustrates both long-term and short-term drought blend coverage from 5/30/2025.

Table 2-7. Drought Percent Area Across the Pecos District Office

Term	Time Period	No Drought	D0 (Abnormally Dry)	D1 (Moderate Drought)	D2 (Severe Drought)	D3 (Extreme Drought)	D4 (Exceptional Drought)
Long term	Current (5/30/2025)	62.0	6.4	12.6	10.8	8.1	0.1
	3 Month (3/1/2025)	48.1	5.1	15.2	12.2	17.8	1.6
	1 Year (6/8/2024)	22.0	13.8	31.1	17.1	16.0	0
Short term	Current (5/30/2025)	90.5	4.4	4.9	0.2	0	0
	3 Month (3/1/2025)	5.7	6.6	51.8	33.0	2.9	0
	1 Year (6/8/2024)	32.2	12.6	33.9	10.0	11.3	0

Source: Climateengine.org (2025)

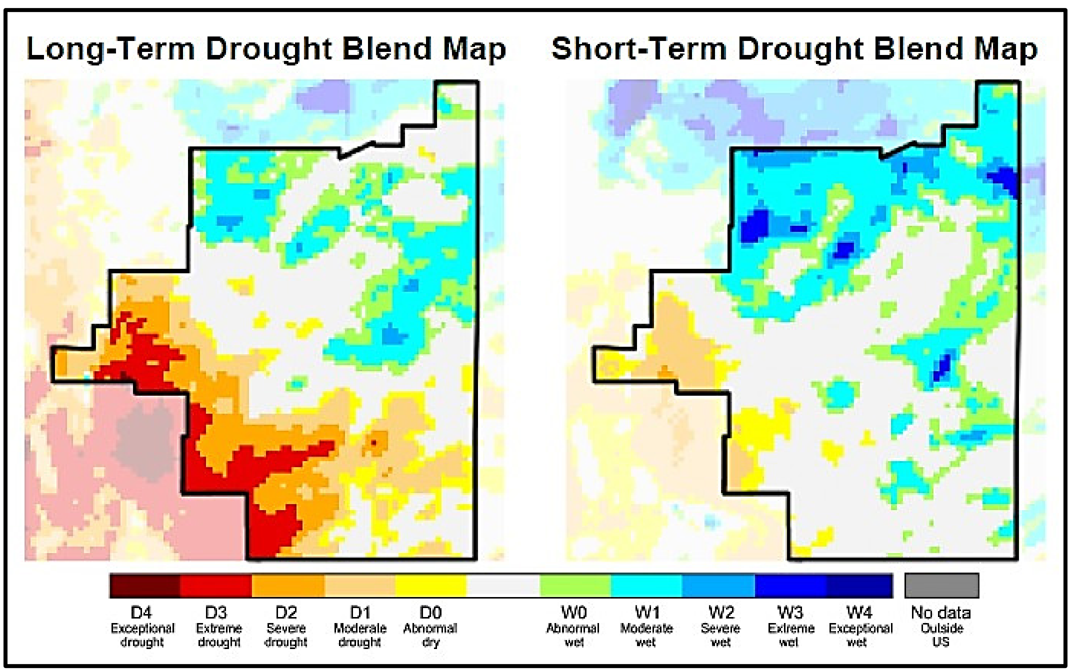

Figure 2-3. Drought blend summaries for the PDO.
Source: Climateengine.org (2025)

2.3.3 Farmington District Office

On June 8, 2024, 65.3% of the total jurisdictional area of the FDO experienced drought conditions, including 4.8% of the area in severe drought and 0.5% in extreme and exceptional drought conditions (Table 2-8). One year later, drought coverage in the FDO decreased to 49.6% of the total area, however areas of severe, extreme and exceptional condition increased to 11.0%, 3.1%, 0.3% respectively. Current drought conditions were concentrated in the central and western portions of the FDO shown in Figure 2-4, illustrating both long-term and short-term drought blend coverage.

Table 2-8. Drought Percent Area Across the Farmington District Office

Term	Time Period	No Drought	D0 (Abnormally Dry)	D1 (Moderate Drought)	D2 (Severe Drought)	D3 (Extreme Drought)	D4 (Exceptional Drought)
Long term	Current (5/30/2025)	50.4	8.4	26.8	11.0	3.1	0.3
	3 Month (3/1/2025)	49.5	8.7	32.7	7.4	1.5	0.2
	1 Year (6/8/2024)	34.7	20.1	39.9	4.8	0.3	0.2
Short term	Current (5/30/2025)	96.2	3.3	0.5	0.0	0.0	0.0
	3 Month (3/1/2025)	5.9	13.4	37.3	36.8	6.5	0.1
	1 Year (6/8/2024)	51.2	25.2	23.4	0.2	0.0	0.0

Source: Climateengine.org (2025)

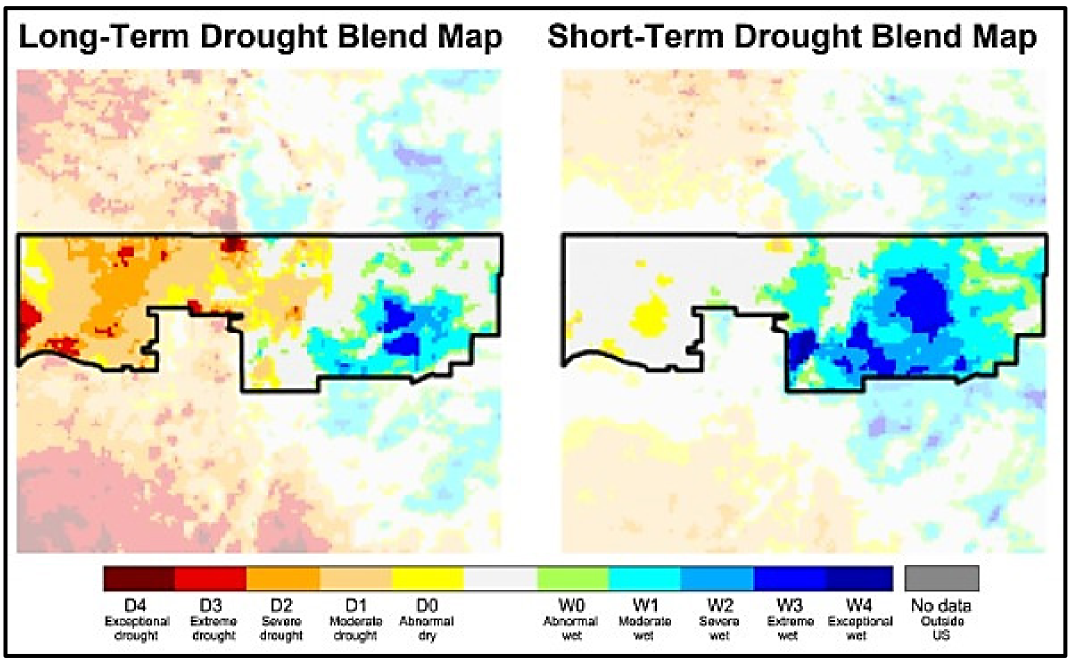

Figure 2-4. Drought blend summaries for the FDO.
Source: Climateengine.org (2025)

2.3.4 Rio Puerco Field Office

On June 8, 2024, 39.5% of the total jurisdictional area of the RPFO experienced drought conditions, with only 1.0% in severe drought and 0.0% in extreme and exceptional drought (Table 2-9). One year later, drought coverage in the RPFO increased to 81.9% of the total area, with 27.0% in severe and 5.4% in extreme drought. On 5/30/2025, drought conditions were concentrated in the central and western portions of the RPFO shown in Figure 2-5, illustrating both long-term and short-term drought blend coverage.

Table 2-9. Drought Percent Area Across the Rio Puerco Field Office

Term	Time Period	No Drought	D0 (Abnormally Dry)	D1 (Moderate Drought)	D2 (Severe Drought)	D3 (Extreme Drought)	D4 (Exceptional Drought)
Long term	Current (5/30/2025)	18.1	9.4	40.1	27.0	5.4	0.0
	3 Month (3/1/2025)	15.2	12.1	60.5	10.6	1.6	0.0
	1 Year (6/8/2024)	60.5	17.1	21.4	1.0	0.0	0.0
Short term	Current (5/30/2025)	90.3	7.8	1.9	0.0	0.0	0.0
	3 Month (3/1/2025)	0.0	0.0	18.1	69.0	12.9	0.0
	1 Year (6/8/2024)	88.5	7.3	4.2	0.0	0.0	0.0

Source: Climateengine.org (2025)

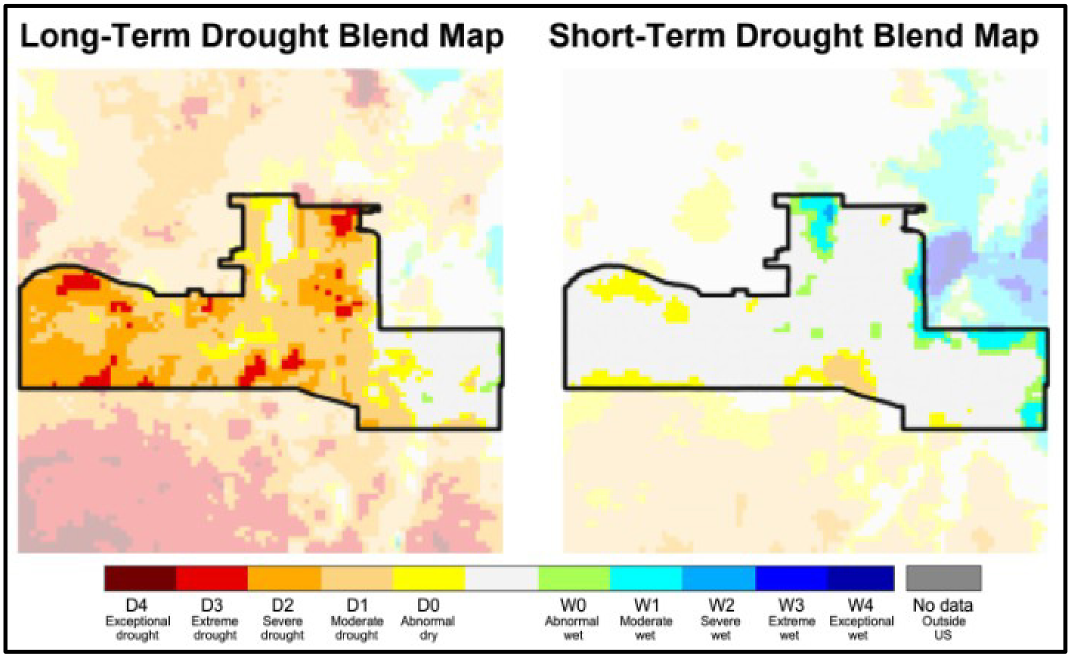

Figure 2-5. Drought blend summaries for the RPFO.

Source: Climateengine.org (2025)

2.4 STATE OF NEW MEXICO WATER PLANS

New Mexico's approach to water resources management is guided by a comprehensive strategy outlined in its three-part 2018 New Mexico State Water Plan (NMSWP) and a separate 50-year Water Action Plan, developed in 2021–2022. The 2018 NMSWP is divided into three key components; Part I of the 2018 plan outlines the state's highest priority water issues and the policies, goals, and strategies needed to address these issues and provides details regarding available resources (New Mexico Interstate Stream Commission [NMISC] 2018a). Part I of the 2018 NMSWP also highlights eight of the state's priority policy topics, including water infrastructure, data collection, drought, watershed management, water supply and demand, water conservation, water quality, and water planning (NMISC 2018a). Part II of the 2018 NMSWP integrates water resource data from regional plans completed in 2016–2017. Part II is a technical report that includes information about estimated water availability and associated uses, population projections, and stakeholder developed strategies to address these issues (NMISC 2018b). Part II does not directly address the impacts of climate change; however, prolonged drought estimates were considered (NMISC 2018b). Part III of the 2018 NMSWP details information about New Mexico water law decisions and events, as well as the circumstances that led to the structure of water resource management in New Mexico (NMISC 2018c). In accordance with the State Water Plan Act, New Mexico published a 5-year review of the 2018 NMSWP, evaluating the status of water planning relative to new climate projections and statutory requirements and prioritizing next steps for incorporating modern climate science into the state's water management planning (NMISC 2023). The review details successes and shortcomings of the 2018 plan elements across numerous categories from watershed management to water security and supply and discusses potential impacts of climate change within those categories using information from the 2022 Leap Ahead Report (Dunbar et al. 2022).

The 50-year Water Action Plan, developed by New Mexico in 2021–2022, provides a high-level view of the state's planned approach to water security and water quality management. Divided into 11 priority actions, the plan aims to protect water supply through water conservation, the establishment of new water sources, and watershed protection (NMISC 2022). The state plans to achieve its water conservation goals through public outreach and education, incentive programs to drive the adoption of efficient irrigation technology in agriculture, repairing existing infrastructure and developing a robust drinking water system, and prioritizing water infrastructure improvement projects (NMISC 2022). To establish new water sources, the state plans to establish reserve funds to be used to purchase community water supply, implement comprehensive rules for water reuse, and fully implement a reservoir monitoring system to support water supply management decisions (NMISC 2022). Lastly, the plan aims to reach its watershed protection goals through the cleanup of superfund sites in the state, a state surface water discharge permitting program, the overhaul and maintenance of wastewater treatment facilities and implementation of modern stormwater infrastructure, and the acceleration of watershed restoration projects (NMISC 2022).

2.5 INDUCED SEISMICITY

Induced seismicity refers to seismic events that are triggered by human activities rather than natural tectonic forces. A broad range of human activities have been attributed to induced seismicity, including but not limited to underground fluid injection (e.g., for wastewater and hydraulic fracturing) and oil and gas extraction (GWPC 2021). Between 2008 and 2015, seismic events increased in the mid-continental United States and studies pointed to a connection between increasing seismic events and the widespread disposal of wastewater into deep Class II[1] injection wells (GWPC 2021). Seismic events can occur when specific geologic conditions are present (e.g., sufficient pore pressure build-up near a pre-existing fault of concern) (GWPC 2021; Oklahoma Corporation Commission [OCC] 2022).

The risk for induced seismicity increases with high-volume injections into deep wells carried out through wastewater injections and enhanced oil recovery techniques. A combination of many factors is necessary to induce felt earthquakes: the injection rate and total volume injected, the presence of faults that are large enough to produce felt earthquakes, stresses that are large enough to produce earthquakes, and the presence of pathways for the fluid pressure to travel from the injection point to faults (Machette et al. 2000; USGS 2021). High injection rates of greater than 300,000 barrels (bbl) 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 2022; Weingarten et al. 2015).

Although hydraulic fracturing can also contribute to induced seismicity, seismic events triggered by hydraulic fracturing are relatively uncommon and generally have smaller magnitudes than injection-induced seismicity and are therefore considered to pose less risk (GWPC 2021; OCC 2018). 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). Several areas of heightened

[1] Class II wells dispose of fluid produced in conjunction with oil and gas drilling, completion, and production operations (GWPC 2021).

induced seismicity have been identified in New Mexico; most areas of concern occur in southeastern New Mexico, and one area occurs in northern New Mexico near the Colorado border (NMOCD 2021, 2025b). Since 2021, 35 earthquakes have been recorded within the areas of heightened induced seismicity in New Mexico; of these 5 were greater than 3.5 magnitude (NMOCD 2025b).

2.5.1 Pecos District Office

Within the Permian Basin, four areas of concern related to induced seismicity have been identified, one of which has been formally designated as a Seismic Response Area (SRA) (NMOCD 2021, 2025b & RRCT 2025):

- The first area, known as the County Line SRA, is approximately 35 miles southeast of Carlsbad, New Mexico, on the border of Eddy and Lea counties, New Mexico, and extending slightly into Texas. Within this area and its 10-mile radius in New Mexico, there are 5 active injection wells. Additionally, within 2.5 miles of the southernmost part of the County Line SRA (according to seismic events) in Texas, there are 9 injection wells..
- The second area is approximately 6 miles northeast of Jal, New Mexico, in Lea County, and extending slightly into Texas; containing 273 active injection wells within its 10-mile radius in New Mexico. Additionally, within 2.5 miles of the northeastern part of this SRA in Texas, there are 4 active injection wells.
- The third area is approximately 39 miles southwest of Lovington, New Mexico, in Lea County; with 3 active injection wells within its 10-mile radius.
- The fourth (Dagger Draw/McKittrick Seismic Response Area) spans approximately 3 to 41 miles south of Artesia and 5 to 24 miles west of Carlsbad, New Mexico, in Eddy County (also associated with an area known as the Dagger Draw Field); containing 37 active injection wells within its 10-mile radius.

New Mexico's Underground Injection Control (UIC) Program monitors and regulates the injection of fluids into the subsurface. The maximum allowable surface injection pressure is based on a 0.2 pound per square inch (psi)/foot gradient multiplied by the depth of the top perforation or top of the open-hole completion (GWPC 2020). New Mexico regulations set limits on maximum allowable surface injection pressures and require mechanical integrity testing of the boreholes, pressure monitoring, and reporting. All injection wells permitted by NMOCD are subject to limitations on surface injection pressure. Wells are required to be equipped with a pressure-limiting device that ensures that the maximum surface injection pressure is not exceeded (NMOCD 2004). Compliance officers from the NMOCD periodically inspect wells and surface facilities to ensure wells and related surface equipment are in good repair and meet regulations. See NMAC 19.15.26.1 through 19.15.26.15.

In November 2021, NMOCD issued a new seismic response protocol to address seismic activity related to Class II injection wells in New Mexico. The protocol includes requirements that are implemented either through voluntary actions by operators or by orders issued by NMOCD. The protocol directs operators to monitor seismic events and implement reduced injection rates if the seismic event has a magnitude of 2.5 or greater. The magnitude of reductions varies based on the earthquake magnitude and proximity of wells to these events (with 10 miles being the maximum distance for injection reductions to apply) (NMOCD 2021). Since 2021 there have been 27 instances of seismicity greater than magnitude 2.5 (NMOCD 2025b).

2.5.2 Farmington Field Office and Rio Puerco Field Office

Currently, there are no identified SRAs within either the FFO or the RPFO. The San Juan Basin, which is the primary geological feature in this region and is situated in the Four Corners area, is a sedimentary basin known for its low seismic activity. According to the USGS database, only 30 earthquakes of magnitude 2.5 or greater were recorded in the basin between 1966 and 2022 (McCormack et al. 2022). In 2018, the San Juan Basin was classified as having less than a 1% annual probability of experiencing minor-damage ground shaking (Petersen et al. 2018; USGS 2018). The region contains several faults, most notably the north-south-trending Nacimiento fault, which extends approximately 50 miles along the basin's eastern edge, and the smaller Gallina fault. Both faults are classified as normal faults with displacement rates of less than 0.2 millimeters per year. Normal faults in areas with low slip rates and minimal tectonic activity—such as the San Juan Basin—are often associated with lower seismic hazard (USGS 2025). Since 2021, no induced seismic events greater than magnitude 2.5 have been recorded in either the FFO or RPFO (NMOCD 2025b).

CHAPTER 3. PECOS DISTRICT OFFICE

The BLM Pecos District, which oversees the CFO and RFO, encompasses over 3.6 million surface acres and over 7.6 million federal mineral acres. The Pecos District includes the New Mexico portion of the Permian Basin, a sedimentary depositional basin (Figure 3-1). The Permian Basin is one of the leading oil and gas regions and has been producing these resources since the early 1900s.

The portion of the Pecos District that is underlain by the Permian Basin encompasses Eddy County, Lea County, and the majority of Chaves County (which is analogous to the New Mexico portion of the Permian Basin). While some drilling does occur in Roosevelt County, the vast majority of oil and gas activity in the Permian Basin takes place outside of it. Additionally, water use per well in Roosevelt County is significantly lower than in Chaves, Eddy, and Lea counties. Because the primary water sources expected to support future development are located in those three counties, Roosevelt County is excluded from further analysis in this document. The Pecos District tri-county area contains approximately 3.4 million acres of federal minerals. Some data from FracFocus and USGS water use are available at the county level only; thus, the term “Pecos tri-county area” may be used interchangeably with “Pecos District” (which denotes BLM administrative boundaries) in this report.

This chapter presents information on existing and projected water quantity and water quality data for the Pecos District, as summarized from information from the following sources:

- *Reasonable Foreseeable Development (RFD) Scenario for the BLM New Mexico Pecos District* (Engler and Cather 2012) and *Update to the Reasonable Foreseeable Development for the BLM Pecos District, SENM* (Engler and Cather 2014)
- *Reasonably Foreseeable Development (RFD) Scenario for Oil and Gas Activities, Carlsbad Field Office, Eddy County, Southeastern New Mexico* (Engler 2023)
- Data compiled from the USGS report *Estimated Use of Water in the United States in 2015* (Dieter et al. 2018)
- FracFocus, a national hydraulic fracturing chemical registry managed by the GWPC and IOGCC (FracFocus 2025)
- Draft Resource Management Plan and Environmental Impact Statement Carlsbad Field Office, Pecos District, New Mexico (BLM 2018)
- Roswell Approved Resource Management Plan and Record of Decision, Pecos District, New Mexico (BLM 1997)
- Sandia National Laboratories report *Water Resource Assessment in the New Mexico Permian Basin* (Lowry et al. 2018)
- Addendum to Water Resource Assessment in the New Mexico Permian Basin (Reardon et al. 2021)
- Spill data from the NMOCD database (NMOCD 2025a)
- Water use estimates from the USGS report *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)
- Data to Estimate Water Use Associated with Oil and Gas Development within the Bureau of Land Management Carlsbad Field Office area, New Mexico (Gonzalez-Salvat et al. 2023)
- Geodatabase of oil and gas pads and roads within the Bureau of Land Management's Carlsbad Field Office area, New Mexico (Villarreal et al. 2023)

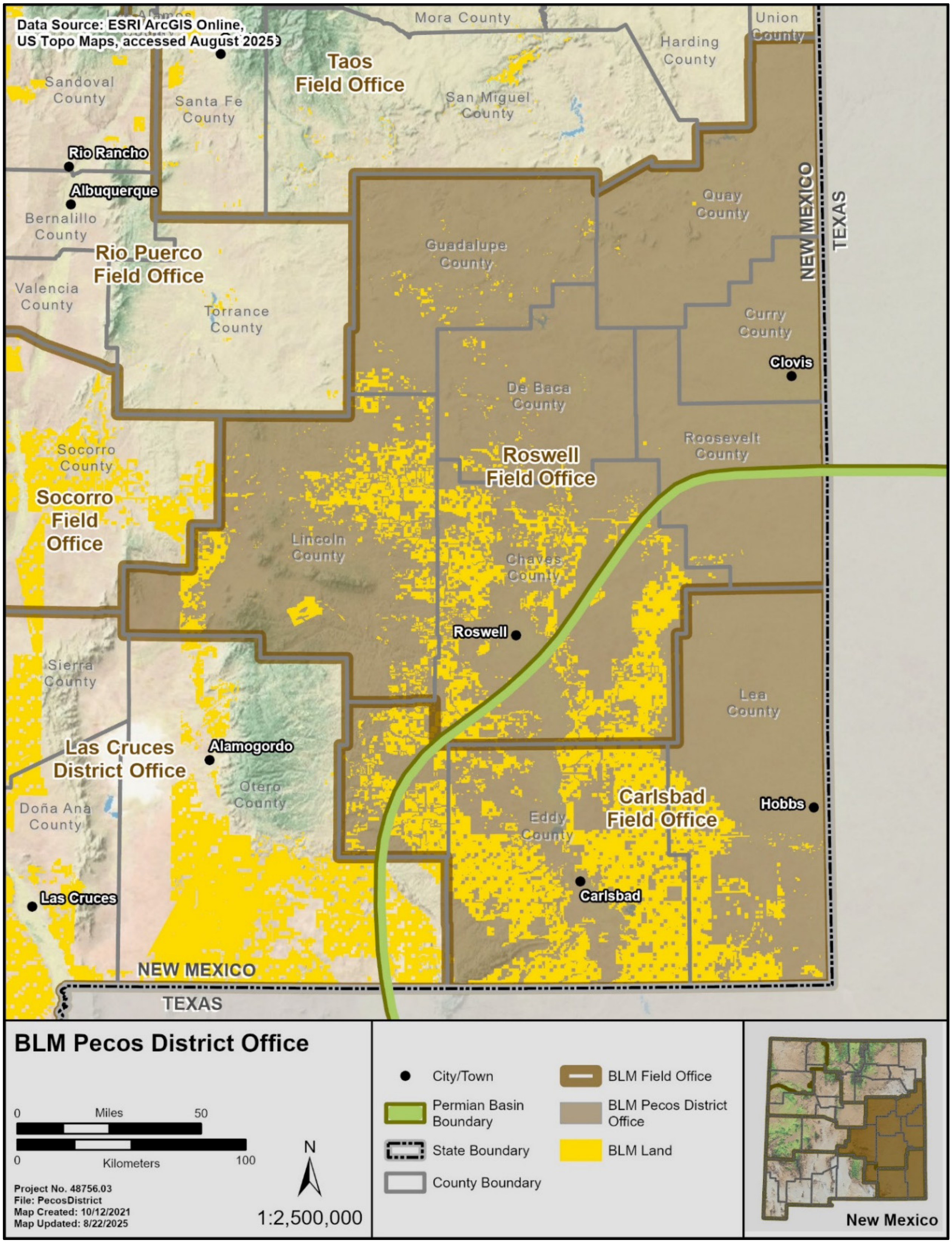

Figure 3-1. Map of BLM PDO boundaries.

3.1 WATER QUANTITY

3.1.1 Existing Surface Water and Groundwater Use

For the Pecos tri-county area, Dieter et al. (2018) list total water withdrawals across eight water use categories: aquaculture, domestic, industrial, irrigation, livestock, mining, public water supply, and thermoelectric power. Water usage data for Lea, Eddy, and Chaves counties are presented in Table 3-1, Table 3-2, and Table 3-3, respectively. Total water withdrawals in the Pecos tri-county area in 2015 were 619,375 AF (Table 3-4; Figure 3-2). Irrigation and mining activities consumed the greatest amount of water, accounting for 75% (466,784 AF) and 15% (94,758 AF), respectively, of all water withdrawals within the Pecos tri-county area. Approximately 88% of all water withdrawn within this region originated from groundwater. Of the total water withdrawals in the tri-county area, 17% were from saline sources.

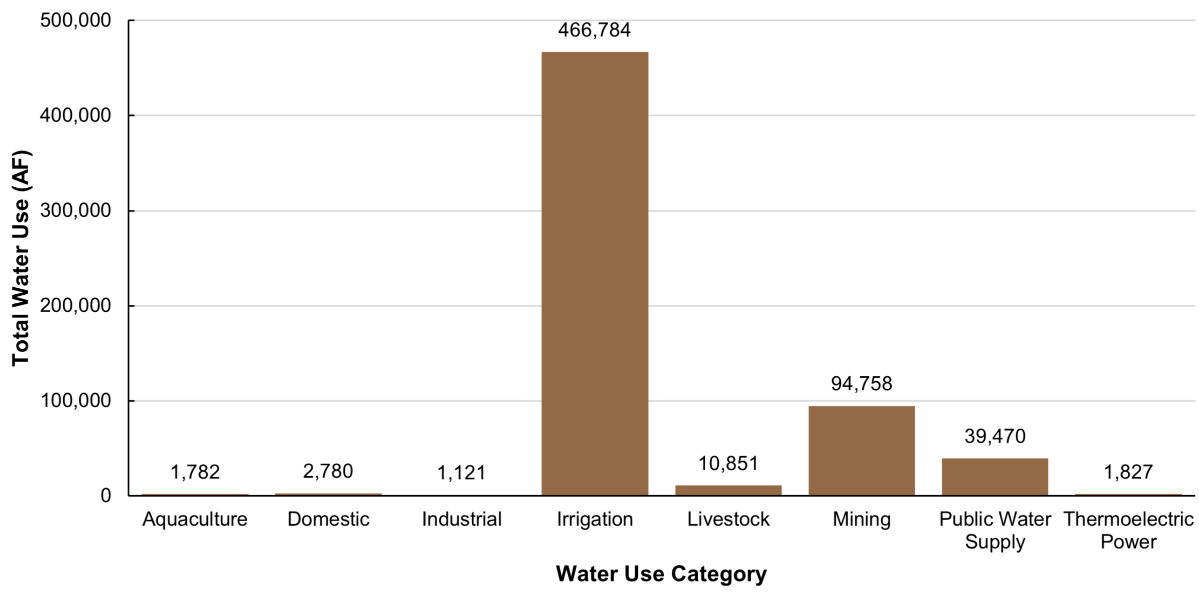

Figure 3-2. Pecos tri-county area (Chaves, Eddy, and Lea counties) water use by category in 2015 (Dieter et al. 2018).

Table 3-1. Lea 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%
Domestic	0	–	0	0	1,513	–	1,513	<1%	1,513	<1%	–	0%	1,513	<1%
Industrial	0	0	0	0	78	0	78	<1%	78	<1%	0	0%	78	<1%
Irrigation	0	–	0	0	166,099	–	166,099	63%	166,099	63%	–	0%	166,099	63%
Livestock	56	–	56	<1%	2,870	–	2,870	1%	2,926	1%	–	0%	2,926	1%
Mining	0	0	0	0	325	81,642	81,968	31%	325	<1%	81,642	31%	81,968	31%
Public water supply	0	0	0	0	11,423	0	11,423	4%	11,423	4%	0	0%	11,423	4%
Thermoelectric power	0	0	0	0	1,827	0	1,827	<1%	1,827	<1%	0	0%	1,827	<1%
County Totals	**56**	**0**	**56**	**<1%**	**184,135**	**81,642**	**265,778**	**100%**	**184,192**	69%	**81,642**	**31%**	**265,834**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 265,834 AF.

Table 3-2. Eddy 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%	258	–	258	<1%	258	<1%	–	0%	258	<1%
Industrial	0	0	0	0%	1,043	0	1,043	<1%	1,043	<1%	0	0%	1,043	<1%
Irrigation	64,054	–	64,054	35%	89,994	–	89,994	49%	154,048	84%	–	0%	154,048	84%
Livestock	34	–	34	<1%	1,289	–	1,289	<1%	1,323	<1%	–	0%	1,323	<1%
Mining	0	0	0	0%	975	10,145	11,120	6%	975	<1%	10,145	6%	11,120	6%
Public water supply	0	0	0	0%	15,077	0	15,077	8%	15,077	8%	0	0%	15,077	8%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
County Totals	**64,088**	**0**	**64,088**	**35%**	**108,636**	**10,145**	**118,781**	**65%**	**172,724**	**95%**	**10,145**	**6%**	**182,869**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 182,869 AF.

Table 3-3. Chaves 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%	1,782	0	1,782	1%	1,782	1%	0	0%	1,782	1%
Domestic	0	–	0	0%	1,009	–	1,009	<1%	1,009	<1%	–	0%	1,009	<1%
Industrial	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Irrigation	9,854	–	9,854	6%	136,784	–	136,784	80%	146,638	86%	–	0%	146,638	86%
Livestock	224	–	224	<1%	6,378	–	6,378	4%	6,603	4%	–	0%	6,603	4%
Mining	0	0	0	0%	78	1,592	1,670	<1%	78	<1%	1,592	<1%	1,670	<1%
Public water supply	0	0	0	0%	12,970	0	12,970	8%	12,970	8%	0	0%	12,970	8%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
County Totals	**10,078**	**0**	**10,078**	**6%**	**159,003**	**1,592**	**160,594**	**94%**	**169,080**	**99%**	**1,592**	**<1%**	**170,672**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 170,672 AF.

Table 3-4. Pecos Tri-county Area (Chaves, Eddy, and Lea counties) 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%	1,782	0	1,782	<1%	1,782	<1%	0	0%	1,782	<1%
Domestic	0	–	0	0%	2,780	–	2,780	<1%	2,780	<1%	–	0%	2,780	<1%
Industrial	0	0	0	0%	1,121	0	1,121	<1%	1,121	<1%	0	0%	1,121	<1%
Irrigation	73,908	–	73,908	12%	392,877	–	392,877	63%	466,784	75%	–	0%	466,784	75%
Livestock	314	–	314	<1%	10,537	–	10,537	2%	10,851	2%	–	0%	10,851	2%
Mining	0	0	0	0%	1,379	93,379	94,758	15%	1,379	<1%	93,379	15%	94,758	15%
Public water supply	0	0	0	0%	39,470	0	39,470	6%	39,470	6%	0	0%	39,470	6%
Thermoelectric power	0	0	0	0%	1,827	0	1,827	<1%	1,827	<1%	0	0%	1,827	<1%
County Totals	**74,222**	**0**	**74,222**	**12%**	**451,774**	**93,379**	**545,154**	**88%**	**525,996**	**85%**	**93,379**	**15%**	**619,375**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 619,375 AF.

3.1.2 Water Use Trends and Planned Actions

3.1.2.1 Past and Present Actions

The Pecos tri-county area total water usage in 2015 was 619,375 AF (see Table 3-4) and accounted for approximately 19% of total state withdrawals (Dieter et al. 2018). See Table 2-1 for statewide water use data. Water use in 2015 associated with mining, which includes oil and gas development, in the Pecos tri-county area was 94,758 AF (see Table 3-4) and represented approximately 58% of statewide mining water use (163,901 AF) and 15% of the Pecos District total water use (619,375 AF). Within the Pecos tri-county area, the largest amount of water is used for irrigation (see Figure 3-2), which represents 75% of all water use within the Pecos tri-county area (619,375 AF) and 14% of all water use within the state (3,249,667 AF).

Data from FracFocus were evaluated to provide objective information on the amount of water used by hydraulic fracturing activities in the Pecos tri-county area. Annual water use associated with direct hydraulic fracturing in federal wells has generally increased over time, ranging between 1,306.4 AF in 2014 and 45,075.9 AF in 2024 (FracFocus 2025) (Table 3-5). In 2024, federal oil and gas water usage accounted for 40% of all oil and gas water usage (45,076 AF) in the Pecos tri-county area (see Table 3-5). Non-federal oil and gas hydraulic fracturing used 66,922 AF of water, with a total combined usage between federal and non-federal wells of 111,997.80 AF in 2024. A full summary of water usage aggregated from FracFocus for the Pecos tri-county area can be found in Table 3-5. 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 3-5). 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, 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 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) 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.

Table 3-5. Water Use by Oil and Gas Wells for Hydraulic Fracturing in the Pecos Tri-County Area (Chaves, Eddy, and Lea counties) for 2014 through 2024

Year	Federal HF Water Use	Tribal HF Water Use	Non-Federal/ Tribal HF Water Use*	Total HF Water Use	Federal HF Water Use (%)	Federal HF Cumulative Water Use	Total HF Cumulative Water Use	Average HF Water Use per Well*	Total No. of Federal Wells	Total No. of Wells	Total Non-HF Water Use†	Total Water Use (HF plus non-HF)
2014	1,306.4	–	2,423	3,729.10	35%	1,306.4	3,729.10	7.0	147	532	436.24	4,165.34
2015	1,841.0	–	4,218	6,058.70	30%	3,147.4	9,787.80	12.1	148	499	409.18	6,467.88
2016	835.5	–	6,007	6,842.60	12%	3,982.9	16,630.40	22.2	56	308	252.56	7,095.16
2017	3,238.8	–	11,399	14,638.00	22%	3,982.9	31,268.40	27.3	142	537	440.34	15,078.34
2018	9,002.8	65.2	22,683	31,751.4	28%	12,985.7	63,019.80	31.8	285	998	818.36	32,569.76
2019	10,986.3	20.2	32,943	43,949.8	25%	12,985.7	106,969.60	42.6	245	1,032	846.24	44,796.04
2020	16,424.5	–	25,522	41,946.70	39%	12,985.7	148,916.30	50.3	310	834	683.88	42,630.58
2021	34,234.4	–	32,208	66,442.80	52%	12,985.7	215,359.10	51.0	625	1,303	1,068.46	67,511.26
2022	37,271.9	297.4	52,615	90,184.3	41%	12,985.7	305,543.40	55.6	652	1,622	1,330.04	91,514.34
2023	38,215.8	–	46,308	84,524.20	45%	12,985.7	390,067.60	56.5	623	1,496	1,226.72	85,750.92
2024	45,075.9	–	66,922	111,997.80	40%	12,985.7	502,065.40	65.2	628	1,718	1,408.76	113,406.56
Total	**198,433.30**	–	**303,249.30**	**502,065.40**	40%	**12,985.7**	**502,065.40**	**38.3 (59.1)‡**	**3,861**	**10,879**	**8,920.79**	**510,986.18**

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

† 11-year average (2014–2024).

‡ 3-year average (2022–2024).

Source: FracFocus (2025). Data are presented only for those wells reporting water usage to FracFocus.

Note: Water use data are in acre-feet/year unless otherwise indicated. See Appendix A for data methodology. Produced water is naturally occurring water that exists in a formation that is being targeted for mineral extraction and is produced as a byproduct.

–: no data available

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

- Direct – cementing (0.014 Mgal per well)
- Direct – drilling (0.143 Mgal per well)
- Indirect (0.111 Mgal per well)

Total non-hydraulic fracturing water use is approximately 0.268 Mgal per well, equivalent to 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. In 2024, 1,718 wells for both non-hydraulic and hydraulic fracturing used an estimated 113,406.56 AF (FracFocus 2025) (see Table 3-5). The total annual water use for all wells over the last 11 years was 510,986.18 AF.

Water use for hydraulic fracturing of all wells within the Pecos tri-county area increased from 3,729 to 111,998 AF from 2014 to 2024 (see Table 3.5), corresponding with an increase in average water use per well from 7.0 to 65.2 AF (FracFocus 2025). At the time of this report, data were not available to distinguish between the types of well stimulation techniques (e.g., nitrogen, recompletion, or slickwater). Additionally, there are very few well recompletions, with the majority of new wells being slickwater completions (Murray 2021). An increase in the amount of water used per well may be associated with changes in production stimulation techniques.

Cumulative water use is the amount of water cumulatively used each year by hydraulic fracturing and consists of the water use for any given year plus the water use for each previous year since 2014. See Appendix A for details on the combined water usage calculations. Combined water use estimates for federal and total (both federal and non-federal) water use associated with hydraulic fracturing in the Pecos tri-county area are shown in Table 3.5.

A water use study (hereinafter referred to as the Valder report) released by the USGS in 2021 (Valder et al. 2021) confirms the upward trend of water usage for oil and gas between the years 2010 and 2019 in the Permian Basin. This report modeled both direct and indirect water use for oil and gas development and operations across the Permian Basin between 2010 and 2019 (Valder et al. 2021). The Valder report characterized the mean water usage across the Permian Basin for total water usage and mean water usage per hydraulic fracturing well for both New Mexico and Texas oil and gas operations. The results modeled in this report were compared with other literature used to project water usage across the Permian Basin, further solidifying the increasing water usage trend across the Permian Basin. Hydraulic fracturing has shown an increase in water usage between the years 2010 and 2019. The average water use has steadily increased from 2010–2019 with the amount of water usage for oil and gas tripling between 2016 and 2019. From years 2010–2019, the Valder study shows a mean water usage of 15,449 AF for direct water use per year across all well sites across the Permian Basin.

The Valder et al. (2021) study estimates water usage associated with oil and gas development in the Permian Basin from years 2010–2019. The mean direct water use for oil and gas hydraulic fracturing, in AF as reported in the Valder report (Valder et al. 2021) varied greatly between the counties located in the Permian Basin. Between years 2010 and 2019, three counties, Chaves, Eddy, and Lea, in the Permian Basin registered more than 15,406 AF/year of direct water usage for oil and gas development (Valder et al. 2021). Lea County used 7,920 AF/year, Eddy County used 7,456 AF/year, and Chaves County used substantially less water with only 30.7 AF/year for direct oil and gas development (Valder et al. 2021). When compared to the 94,758 AF of water used for county-wide mining in 2015 provided by Dieter et al. (2018), direct hydraulic fracturing use accounts for 16.3% of total water use associated with mining within the Pecos District.

3.1.2.2 Water Use Associated with Reasonably Foreseeable Oil and Gas Development

The 2012 RFD scenario for the Pecos District was developed as a reasonable estimate of development associated with oil and gas production in the New Mexico portion of the Permian Basin from 2015 to 2035 and was updated in 2014 to provide better estimates based on new data. Planning factor assumptions used in the 2014 RFD include time frame, estimated well count, average water use, and proportion of horizontal wells drilled in the Bone Spring and Leonard Formations (Table 3-6). The revised RFD scenario for the Pecos District in 2014 (Engler and Cather 2014) projects approximately 800 new oil and gas wells per year (40% federal and 60% non-federal) over a 20-year period (2015–2035), for a total of 16,000 new wells. The 2014 revised RFD estimate of an average water use per well of 7.3 AF was based on a study of the Bone Spring Formation, where the majority of wells completed are horizontal, using data from 2013 (Engler and Cather 2014). The 2014 RFD is a comprehensive study of all existing plays and an analysis of recent activity, historical production, emerging plays for future potential, and completion trends. Since the initial revision to the RFD in 2014, there has been significant activity and development of slickwater wells throughout the area of the Pecos District underlain by the Permian Basin. During preparation of the draft CFO resource management plan (RMP)/environmental impact statement (EIS) (BLM 2018), the BLM updated estimated cumulative water use assuming an average of 31.2 AF per well (based on FracFocus data available at the time of the update) and development of 16,000 new wells projected in the revised 2018 estimates. This increased the estimated water use to a cumulative total of 24,960 AF of water in any given year across the CFO (Figure 3-3).

The new 2023 CFO RFD (Engler 2023) contains revised estimates for several plays in the Permian Basin, especially the Bone Spring and Leonard plays, and the projected oil and gas development activity for the next 20 years (2023–2043). The 2023 RFD included time frame, estimated well count, average water use, and proportion of horizontal and vertical wells across all plays in Eddy and Lea counties. These planning factors are used to estimate water usage within the region for the duration of the RFD. The 2023 RFD estimates water usage in only Eddy and Lea counties within the CFO; Chaves County has minimal oil and gas potential and therefore is not considered by the 2023 RFD. The 2023 CFO RFD projects a short-term increase in well development that tapers down across the duration of the 2023 RFD. The initial increase in well development in the beginning years is tied to the price of projected oil and gas commodities across the United States.

The total (federal and non-federal) cumulative projected well count of 19,600 wells (90% are expected to be horizontal wells) is a 22.5% increase compared with the 16,000 total wells predicted in the 2014 RFD. Of these 19,600 wells, at least 12,500 wells in CFO planning area alone would be federal (Engler 2023). Total well development per year on both federal and non-federal land is expected to be 1,208 new wells (770 federal) in the beginning of the forecast period (2023–2025) and is expected to decline to approximately 769 wells (490 federal) at the end of the 20-year 2023 RFD scenario, for an approximate average of 1,012 new wells per year. The 2023 RFD average total wells per year across all lands of 1,012 wells is 26.5% higher than the 800 total wells per year that was forecasted in the revised 2014 RFD (see Table 3-6).

The CFO RFD does not account for future well development in the RFO portion of the PDO planning area (which encompasses portions of Chaves and Roosevelt counties); therefore, well projections for the RFO planning area were extracted from the PDO RFD (Engler and Cather 2012, 2014). The PDO RFD projects that 800 oil and gas wells would be completed within the PDO each year for the 20-year scenario (2015–2035), for a total of approximately 16,000 new wells (federal and non-federal), most of which are expected to be horizontally drilled. Based on the review of cumulative production volumes through 2010 (see Summary Table 1 [page 49] in Engler and Cather [2012]), most of the production has occurred in Eddy and Lea counties, and development in Chaves and Roosevelt counties represents approximately 4%

of the cumulative production volumes for the PDO planning area. Assuming that this proportion of development in Chaves and Roosevelt counties relative to the larger PDO planning area would remain relatively stable into the future, the number of projected wells from the PDO RFD that are likely to occur within Chaves and Roosevelt counties would be approximately 640. When combined, the total number of projected wells for the PDO planning area is 20,240 (including 19,600 wells in CFO and 640 wells in RFO). PDO RFD projections over a 20-year time period show well development with an average of 1,012 wells per year (of which at least 625 would be federal).

Table 3-6. Planning Factors Used to Estimate Water Use Associated with the RFD in the Pecos District

Factor	2014 PDO RFD (Engler and Cather 2012, 2014)	Revised Estimate (2018)	2023 RFD
Time frame	2015–2035	No change	2023–2043
Number of wells	16,000 (approximately 800 per year)[†]	No change	20,240 (approximately 1,012 per year)[†]
Average water use, horizontal well	7.3 AF	31.2 AF[‡]	60 AF
Average water use, vertical well	–	1.53 AF[§] and assumed 100% horizontal wells for the RFD	60 AF[¶]
Number of wells needed for resource development in emerging plays*	Four wells per section per play (horizontal wells)	No change	11 wells per section per play (horizontal wells)
Percentage of horizontal wells in Bone Spring Formation	82% horizontal	No change	90%[#]
Percentage of horizontal wells in Leonard Formation	14% horizontal	No change	

Note: – = No data available.

*Resource development in emerging plays refers to the development of unconventional resource regions within the Woodford shale in southeastern New Mexico (Engler and Cather 2012).

[†]Of the 16,000 wells projected in the PDO RFD (Engler and Cather 2012, 2014), 4% (or approximately 640) are likely to occur within the RFO portion of the PDO. Therefore, 2023 RFD projections for PDO (20,240 wells total) include19,600 wells for the CFO (as projected in the 2023 CFO RFD [Engler 2023]) and an additional 640 wells for the RFO (as projected in the PDO RFD [Engler and Cather 2012, 2014]).

[‡] The water use estimate of 31.2 AF per well reflects water use per well as reported to FracFocus data at the time the CFO draft RMP/EIS was released (BLM 2018).

[§]BLM calculation developed during preparation of the CFO draft RMP/EIS (BLM 2018).

[¶]The 2023 RFD (Engler 2023) does not provide a separate water use estimate for vertical wells; only one average water use estimate is provided for all wells, which reflects an increasing trend in horizontal wells for the CFO.

[#]The 2023 RFD (Engler 2023) does not provide separate horizontal well projections for both Bone Spring and Leonard Formations. The number presented is the percent of total well development projected to be horizontal for the CFO.

Water use is expected to follow well completion trends projected by the 2023 CFO RFD, which will potentially see an increase in total water usage for the first 2 years before tapering down from 2025 through 2043. Development of the RFD scenario is estimated to require approximately 60 AF per well (Engler 2023). Development of the 20,240 federal and non-federal wells projected in the RFDs would require 1,214,400 AF of water over the 20-year development period, or, on average, 60,720 AF of water annually. Of the 20,240 predicted wells, approximately 12,500 in the CFO planning area alone are expected to be on federally managed lands over the duration of the 20-year planning estimate. With consideration of the revised water use estimates (60 AF/well), development of the 12,500 BLM surface wells projected in the CFO RFD would require 750,000 AF of water, or, on average, 37,500 AF of water annually.

Based on the analysis presented in the CFO's 2023 RFD (Engler 2023), there has been an increasing trend in water use for well completions since 2011, which is largely due to increasing lateral lengths (approximately 1.5 to 2 miles) of horizontal wells. Using the most recent data, the RFD estimates average water use at 60 AF per well. This value is consistent with the increasing trend seen in the FracFocus data and is considered a reasonable estimate of water use associated with future oil and gas development in the PDO.

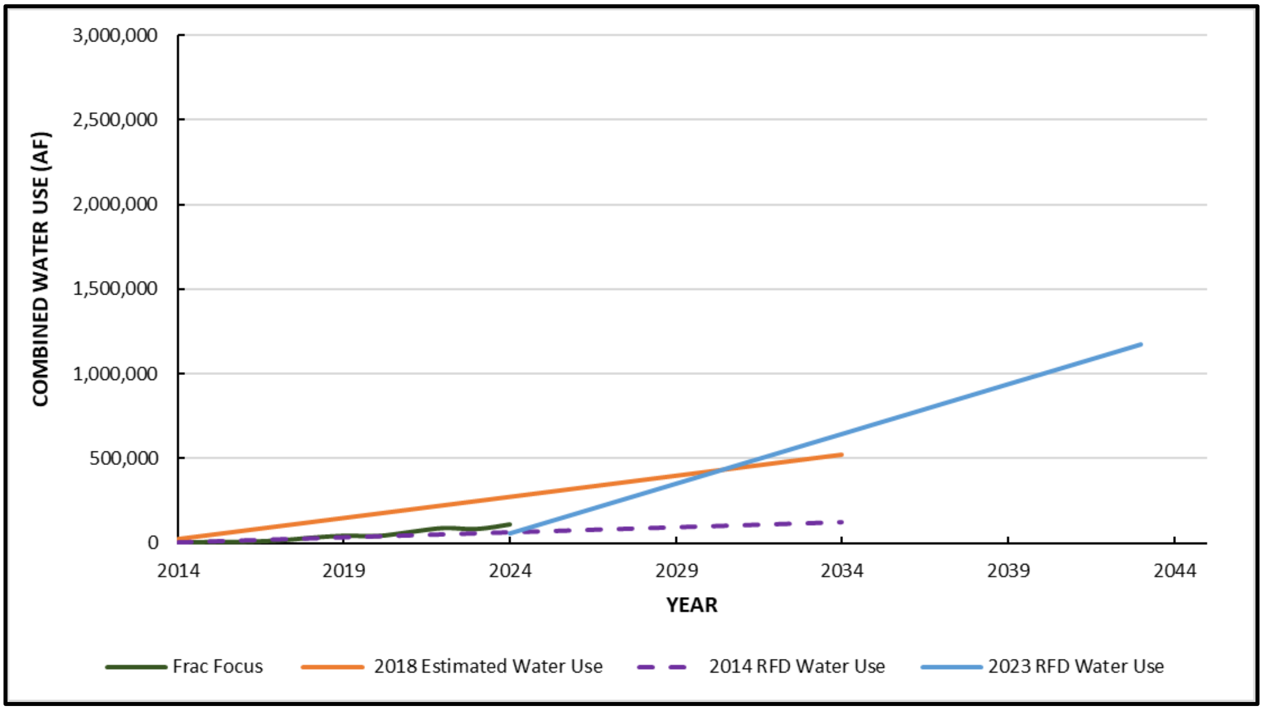

Figure 3-3. Cumulative water use associated with reasonably foreseeable oil and gas development in the New Mexico portion of the Permian Basin (Chaves, Eddy, and Lea counties) from 2014 through 2024 with projections through 2043.

Note: RFD water use planning factors of 7.3 AF/well and 5,840 AF/year come from the 2014 RFD (Engler and Cather 2014). Planning factors estimates of 31.2 AF/well and 24,960 AF/year are taken from the updated 2018 estimates. The 2018 water use planning factors are based on analysis of FracFocus data at the time the CFO draft RMP/EIS (BLM 2018) was released in 2018. The FracFocus data presented are actual total cumulative water use estimates between 2014 and 2024 (FracFocus 2025). RFD water use planning factors of 60 AF/well and 58,800 AF/year come from the 2023 RFD.

Since 2014, there has been a total of 10,879 wells, with 2024 having the highest number of wells. The total cumulative water use from 2014 to 2024 across all well types is approximately 510,986 AF. Between the years 2022 and 2024, the average annual water use per well for hydraulic fracturing operations was 59.1 AF (see Table 3-5). The water use reported to FracFocus over the previous 11 years (FracFocus 2025) indicates that the revised planning factors associated with the 2023 RFD (60 AF per well and 145,004 AF/year) are currently much more than the projected water use trends outlined in the 2014 and 2018 RFDs (see Figure 3-3).

3.1.2.3 Other Development

The BLM has not identified any additional reasonably foreseeable future actions (RFFAs) that would substantially contribute to water use impacts within the Pecos District beyond existing water use trends (BLM 2018). Some water use would be required during construction and operation of transmission lines and pipelines as part of RFD in the area; however, water use varies greatly by project, and these uses are not quantified in this analysis.

3.1.2.4 Water Use Associated with Planned Actions

The total water use associated with development of all RFFAs in the Pecos tri-county area is the same as the total water use estimate associated with reasonably foreseeable oil and gas development. This is because 1) no RFFAs related to mining apart from oil and gas development would contribute significantly to water use impacts from planned actions within the Pecos District (BLM 2018); and 2) water use estimates for other development such as construction and development of transmission lines and pipelines vary greatly by project, and specific water use estimates for these projects are not included in this analysis.

Development of all RFFAs within the RFD scenario using the revised water use planning factors in Table 3-6 would require approximately 37,500 AF of water in any given year. This is about 6% of Pecos tri-county area 2015 total water withdrawals (619,375 AF), which already include past and present actions. Irrigation would remain by far the largest water use (currently 75% of all water use within the Pecos District and 82% of all water use within the state).

3.1.3 Potential Sources of Water for Project Development

The Pecos District contains a variety of surface waters, including springs, seeps, lakes, playas, rivers, and ephemeral drainages (Table 3-7; Figure 3-4), that interact with the groundwater system as locations of recharge or discharge. Waters from spring developments, reservoirs or streams, and stream diversions within the Pecos tri-county area are used primarily for irrigation, livestock, and wildlife. Surface water is not used for domestic water supply in the Pecos tri-county area (Dieter et al. 2018). Diversions on BLM-managed land support crop irrigation and stock water needs on private lands.

Because approximately 88% of all water use and 100% of all mining water use (including oil and gas) in the Pecos District is currently from groundwater, it is reasonable to assume that water used for development of the RFD would be groundwater. Water used for oil and gas drilling and completion would be purchased legally from those who hold water rights in or around the Permian Basin.
The transaction would be handled by NMOCD as well as the New Mexico Office of the State Engineer (NMOSE). Potential sources of groundwater for use in oil and gas development in the Pecos District are outlined in Table 3-7.

Table 3-7. Potential Sources of Groundwater in the Pecos Tri-county Area (Chaves, Eddy, and Lea counties)

Aquifer Name	Description
Pecos Valley Alluvium	Surficial deposits along the Pecos River. Recharged by precipitation and hydrologically losing sections of the Pecos River and its tributaries. Hydraulically connected with the Pecos River. Typical total dissolved solids (TDS) range of <200 to 10,000 milligrams per liter (mg/L).
Dockum Formation (includes Dewey Lake and Santa Rosa)	Redbed sandstones. Inconsistent water source. Recharge occurs closer to the surface from precipitation. Typical TDS range of <5,000 to >10,000 mg/L.
Rustler Formation (includes Culebra and Magenta)	Dolomite, fractured and dissolution zones. Local recharge is driven by precipitation. Typical TDS ranges from <1,000 to 4,600 mg/L.
Capitan Reef	Limestone, Karstic formation. Low salinity west of the Pecos River, brackish toward the east. TDS ranges from 300 to >5,000 mg/L. Recharge in the west occurs mainly in the vicinity of the Guadalupe Mountains. Recharge in the east occurs in the vicinity of the Glass Mountains (in Texas). The New Mexico portion of the eastern part of the Capitan Reef is recharging at a high rate.

Note: Data are adapted from Lowry et al. (2018).

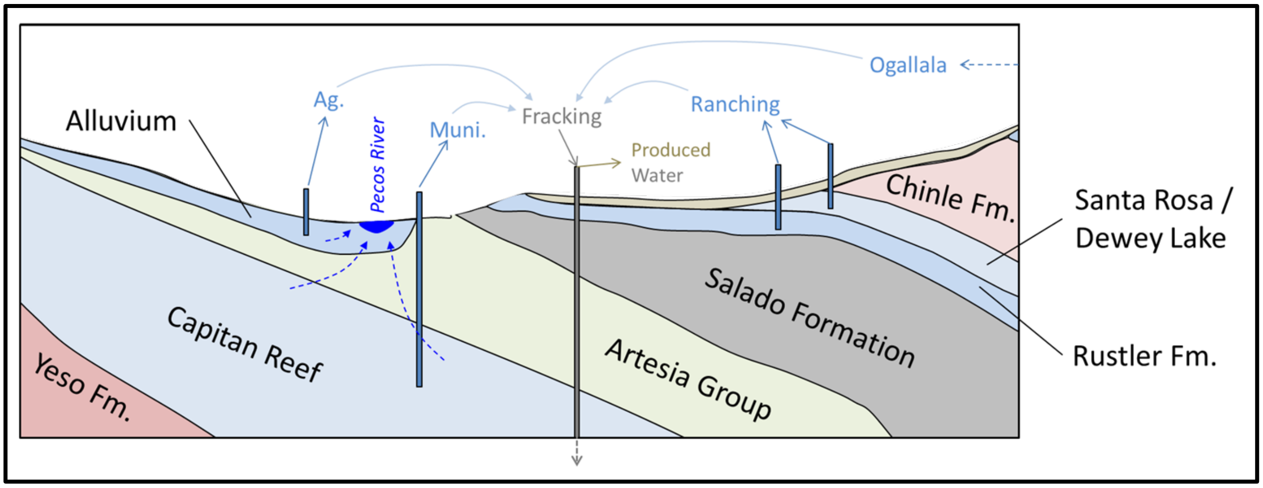

Figure 3-4. Idealized geologic cross section of potential water sources in the Pecos District (Lowry et al. 2018, modified from Summers 1972).

The Water Resource Assessment in the New Mexico Permian Basin (Lowry et al. 2018) is a study conducted by Sandia National Laboratories of four high-potential areas (HPAs) for oil and gas development within Eddy and Lea counties. The HPAs were associated with the BLM-managed mineral estate in the Alto Platform, Bone Spring, and Delaware Mountain Group plays.

The study established a water level and chemistry baseline to aid the BLM in understanding the regional water supply dynamics under different management, policy, and growth scenarios, as well as to preemptively identify risks to water sustainability. The addendum to Water Resource Assessment in the New Mexico Permian Basin (Reardon et al. 2021) expands upon the 2018 report, discussing water level and quality in the HPAs.

Most of the water wells that were sampled in each HPA appeared to have a mixture of source waters, and establishing definitive signatures for each aquifer was not possible. However, evidence shows that the main water source for water wells in the North HPA (which includes Loco Hills and areas along the Pecos River) are from the Dewey Lake and Santa Rosa aquifers (the Dewey Lake/Santa Rosa Formation) or another perched source in the host Dockum Formation. For the Center North HPA (which encompasses a region known as Burton Flats), the main sources are from the Dewey Lake/Santa Rosa Formation and the Rustler Formation. For the South HPA (located near Malaga and Loving), the main water sources are the Dewey Lake/Santa Rosa Formation. The East HPA, which primarily represents the Ogallala Aquifer, was excluded from the study because only a small percentage of the land is managed by the BLM (Lowry et al. 2018). The study also sampled wells that access water from the Capitan Reef, located near Carlsbad. Water quality in the Capitan Reef aquifer showed frequent exceedances of New Mexico Water Quality Control Commission (NMWQCC) standards, particularly for salinity-related parameters (total dissolved solids [TDS], chloride, sulfate) as well as iron and manganese. Generally, the water quality in the Capitan Reef is relatively fresh in the immediate vicinity of its recharge area in the Guadalupe Mountains and becomes brackish as it moves eastward and south into Texas (NMOSE 2016). Overall, this indicates that while the aquifer is an important groundwater source, its chemistry reflects significant mineralization and may require treatment before use (Lowry et al. 2018).

Select wells were monitored throughout the study using continuous and manual water level measurements (Reardon et al. 2021). Water levels in the two sampling water wells located in the North HPA (the Rustler Formation) fluctuated slightly over the monitoring period and had an overall decreasing trend. Based on available data, it is unclear if the drop in water level was a result of well operation or natural fluctuation in groundwater level. Water levels from five additional wells in the Center North HPA were also examined as part of the study. Additionally, three wells completed in the Rustler Formation showed variable water level fluctuations. One showed low water level changes suggestive of barometric effects and seasonal change; the second well showed water levels typical of nearby pumping; and a third well showed an overall decrease in water level due to unknown causes (Reardon et al. 2021). Two wells completed in the Dewey Lake/Santa Rosa Formation show increasing water levels due to recharge of the aquifer.

Of the 13 wells monitored in the South HPA:

- Eight are completed in the Rustler Formation, and three wells were monitored continuously as part of the study. Two wells have monitoring data indicating a steady declining trend due to livestock watering and prospecting of a natural resource. One well exhibited erratic water levels consistent with pumping cycles associated with small community water supply wells.
- Four wells are completed in the Dewey Lake/Santa Rosa Formation, and three are within 0.5 mile of one another. All three wells show the same general declining trend indicative of pumping in 2017 followed by recovery. The wells are listed for commercial use, and reports of nearby pumping in 2017 explain the general overall decrease. The fourth well is permitted for livestock watering, and water levels show decreasing trends consistent with pumping, although pumping ceased at this well in 2018 and water levels are rebounding.
- The final well in the South HPA is drilled to an unknown formation, although based on water levels, it is assumed to be completed in the Dewey Lake/Santa Rosa Formation. It is located in close proximity to the three wells listed for commercial use in the Dewey Lake/Santa Rosa Formation and exhibits the same general pattern in water levels over the same monitoring period.
- The Capitan Reef aquifer is one of the primary sources of water used to enhance oil recovery in Eddy County and is also a primary source of domestic water supply in that county. Four wells drilled in the Capitan Reef aquifer were monitored. Two wells show a steady decline, with daily fluctuations indicative of nearby pumping. Two wells on the east side of the Capitan Reef aquifer show steadily increasing water levels and recovery, which could be due to natural recharge that could potentially be enhanced by injection wells.

3.1.4 Water Use Mitigation Measures

Public concern about water use from hydraulic fracturing is especially high in semiarid regions. Overall, there have been calls to increase the use of alternative water sources such as brackish water or to recycle produced water, minimizing the strain on local freshwater resources (Kondash et al. 2018). The BLM encourages the use of recycled water in hydraulic fracturing techniques, and in 2019, New Mexico passed the Produced Water Act, which encourages oil and gas producers to reuse produced water for oil and gas extraction when possible rather than rely on freshwater sources. Recent studies indicate that the water used for hydraulic fracturing may be retained within the shale formation, with only a small fraction of the fresh water injected into the ground returning as flowback water (Kondash et al. 2018). Water returning to the surface is highly saline, difficult to treat, and often disposed of through deep injection wells (Kondash et al. 2018). Because slickwater fracs require much higher volumes of water per well, an increase in the average water use per well in hydraulic fracturing (see Table 3-5) indicates a rise in slickwater wells from 2014 to present. It is reasonable to assume with the increase in slickwater well construction that highly saline return water from the hydraulic fracturing process can be reused via water recycling methods. The NMED signed an MOU with New Mexico State University in 2022 to develop new technologies for treating produced water to inform future policies for produced water reuse (NMED 2019).

In September 2023, NMED began drafting the State's Ground and Surface Water Protection – Supplemental Requirements for Water Reuse (20.6.8 NMAC) regulations which focus on the restricted reuse of produced water. The proposed regulation would prohibit the discharge of both untreated and treated produced water to groundwater, including subsurface water in aquifers that are used for drinking water and other purposes. Specifically, produced water would not be permitted to be discharged to or disposed of on land, as such practices could result in leaching into aquifers from the surface and subsequent contamination of groundwater. In addition, the regulation would prohibit the discharge of produced water to surface waters, such as rivers, streams, lakes, wetlands, and arroyos. Furthermore, the regulation would establish requirements for the use of produced water in "demonstration projects" and "industrial projects." These requirements include explicit prohibitions on the discharge of produced water to ground and surface waters, as well as mandates that project operators develop spill prevention plans and assume financial responsibility for cleanup in the event of a spill, accident, or discharge. A draft version of the proposed NMAC 20.6.8 regulations can be found on the NMED website (NMED 2024a).

3.2 WATER QUALITY

3.2.1 Groundwater

Groundwater quality in Eddy and Lea counties and in the Lower Pecos Valley varies considerably depending on the aquifer and location (Lowry et al. 2018). In general, groundwater on the west side of the Pecos River is fresher than that east of the Pecos River. East of the Pecos River, salinity is higher and can reach concentrations of 35,000 milligrams per liter (mg/L). Shallow groundwater quality can be very good in the alluvial aquifers but of poor quality in deeper geologic formations due to the presence of salt, gypsum, and other evaporite deposits. Groundwater tends to be mineralized or "hard" west of the Ogallala Aquifer (Lowry et al. 2018). TDS typically range from 200 to 10,000 mg/L depending on aquifer material (see Table 3-7).

Overall, 30 wells in the South HPA, 11 wells in the Center North HPA, and 19 wells in the North HPA were selected for water quality analysis. The predominant water types for each of the HPAs and the Capitan Reef are listed below.

1. North HPA: calcium and magnesium dominant
2. Center North HPA: sodium and calcium dominant
3. South HPA: sodium and calcium dominant
4. Waste Isolation Pilot Plant: sodium and chloride dominant
5. Capitan Reef: sodium dominant

Water quality data collected at wells in the HPAs in 2018 (Lowry et al. 2018) and 2020 (Reardon et al. 2021) were also compared with the New Mexico Water Quality Control Commission (NMWQCC) human health, domestic water supply, and irrigation use standards for groundwater with a TDS concentration of 10,000 mg/L or less (NMAC 20.6.2.3103). All wells in the Center North and South HPAs reported exceedances of sulfate in 2020. Most wells in the Center North and South HPAs reported exceedances of TDS and chloride. One well in the South HPA reported an exceedance of fluoride. Two wells in the South HPA reported exceedances of the NMWQCC pH standards. Table 3-8 lists the sampled water quality parameters by HPA compared with the NMWQCC standards for drinking water (Lowry et al. 2018; Reardon et al. 2021).

Table 3-8. Sampled Water Quality Parameters Compared with NMWQCC Drinking Water Standards

Parameter	NMWQCC Standard	North HPA*	Central North HPA*	South HPA and Waste Isolation Pilot Plant*	Capitan Reef†
pH (pH units)	6–9	7.64	7.51–7.61	7.25–**9.29**	8.08–8.86
Specific conductance (µmhos/cm)	–	1,000	7,700–95,000	860–21,000	2,770–174,500
TDS	1,000	773	**3,800–51,800**	395–**11,100**	1,951–141,875
Calcium (Ca^{2+})	–	130	580–680	3–970	1.4–5,902
Magnesium (Mg^{2+})	–	45	95–1,700	5–360	82.26–1,420
Sodium (Na^{+})	–	21	440–14,000	110–2,000	225–46,700
Potassium (K^{+})	–	1.6	26–550	4–28	6.58–3,352
Chloride (Cl^{-})	250	18	**820–28,000**	32–**3,800**	388.80–82,602.1
Alkalinity ($CaCO_3$)	–	166.7	93–200	146–292	18.53–250.10
Bicarbonate (HCO_3^{-})	–	166.7	93–200	146–247	18.74–249.27
Carbonate (CO_3^{2-})	–	<2.0	<2.0	7–110	0–0.83
Sulfate (SO_4^{2-})	600	360	**8,800-16,000**	**900–2,800**	0–1,975.67
Fluoride (F^{-})	1.6	0.67	0–1.5	<1**–2**	0.09–0.52
Nitrate/Nitrite (NO_3/NO_2)	10	<RL	<RL	1.8–8.2	0.05–7.60
Silver (Ag)	0.05	–	–	–	0
Aluminum (Al)	5	–	0.18	0–4.06	–
Arsenic (As)	0.1	0.02–0.06	0.03–0.32	0–0.29	0.10
Barium (Ba)	1	0.01–0.13	0.01–0.03	0–0.1	0.02–0.25
Bromide (Br)	–	0–7.8	0.28–12.00	0–1,400	0.3–12.73
Cadmium (Cd)	0.01	–	–	–	–
Copper (Cu)	1	0.02	0.03	0.06–0.37	–
Iron (Fe)	1	3.34	0.04	0.01–1.62	3.41
Lithium (Li)	–	0.14–1.70	0.140–1.695	0.05–0.85	0.04–4.49
Manganese (Mn)	0.2	0–0.06	0–0.20	0–0.06	0–7.61
Nickel (Ni)	0.2	–	0–0.02	0–0.01	0.01
Lead (Pb)	0.05	0.04	–	0.02–0.06	–
Silicon (Si)	–	2.67–18.38	1.9–23.4	4.91–47.0	0–7.10
Strontium (Sr^{2+})	–	0.63 – 8.47	2.73–13.75	0.05–32.0	2.52–104.8
Vanadium (V)	–	–	0.01–0.03	0–0.1	–

Sources: Lowry et al. (2018); Reardon et al. (2021)

Note: Units are mg/L unless otherwise noted.

µmhos/cm = micromhos per centimeter

RL = reporting limit.

Bold = exceeds NMWQCC standard for groundwater <10,000 mg/L.

– = not applicable or not detected

* Values from 2020 samples, Reardon et al. (2021:Table 3). Range not reported for North HPA values because only one well was sampled.

† Values from Lowry et al. (2018:Table 16) because updated water quality values were not available in Reardon et al. (2021).

At the time of drafting this WSD, Sandia National Laboratories released a water resource assessment of the Permian Basin for 2023 (Kirkes et al. 2024). The 2024 Sandi`a report provides an in-depth look at water quality, geochemistry, and water level changes in the Permian Basin. In addition to reanalyzing water quality data, the 2024 Sandia report added new monitoring wells to each HPA. The BLM CFO is also currently working on a hydrologic assessment related to oil and gas development in the CFO area in support of their future RMP update. The hydrologic study will assess the water resources of BLM land in the New Mexico portion of the Permian Basin. More specifically, the objectives of the report are to quantify the amount of water available in the basin; characterize baseline water quality of both groundwater and surface water; and creating a hydrogeologic framework. Additionally, the CFO is conducting a hydrology study on the Black River. This study started in October 2024 and is expected to be completed by October 2027. The study will focus on sampling the Black River and shallow groundwater. The 2024 Sandia report will be used in conjunction with the CFO hydrology studies to update upcoming New Mexico WSDs to provide current water quality and geochemical characteristics for the PDO.

3.2.2 Surface Water

In New Mexico, the NMED administers CWA Sections 303(d), 305(b), and 314 related to surface water quality assessment and reporting. The NMED defines surface water quality beneficial uses and water quality standards to evaluate if these uses are being attained. Water quality standards are composed of designated uses for surface waters of the state and associated water quality criteria to protect those uses. The NMED prepares an Integrated Report (IR) every 2 years, where waterbodies not attaining their designated beneficial uses are reported. The IR also contains information on surface water quality and water pollution control programs in New Mexico (NMED 2024b). The BLM does not have authority to make use attainment evaluations based on water chemistry data.

Designated uses in the Pecos District consist of industrial water supply, irrigation storage, livestock watering, recreation, warm water fishery, and wildlife habitat. Water quality in streams flowing on BLM-managed lands is influenced by both natural water quality with regard to salinity content and the intensity of human and industrial activities in the watershed. For example, water quality may be vastly different in a remote mountain spring creek than in waters with natural brine discharge or where there are human impacts due to urban, farming, ranching, or industrial activities. Stream and river conditions vary widely, from completely undisturbed river and vegetative communities in the mountainous highlands to deep, erodible soil banks at lower elevations where livestock, recreationists, and other public users have access to streambanks and riverbanks. Another cause of water quality concerns, especially salinity, can occur through surface and groundwater interaction.

The major perennial waterbody in the Pecos District is the Pecos River, which is segmented into smaller reaches for assessment purposes in the IR. The most common pollutants listed across segments of the Pecos River in the Pecos District are *Escherichia coli* (*E. coli*), dichlorodiphenyltrichloroethane (DDT), and polychlorinated biphenyls (PCBs), the latter in fish consumption advisories (NMED 2024b). Other impairments in the region include temperature abnormalities, nutrients, and dissolved oxygen (NMED 2024b).

3.2.3 Potential Sources of Surface Water or Groundwater Contamination

3.2.3.1 Spills

In 2024, 820 liquid spills were associated with federal and non-federal oil and gas wells and facilities in the Pecos tri-county area (Table 3-9) (NMOCD 2025a). Produced water and crude oil made up 62.4% and

30.1% of total liquid spills, respectively (see Table 3-9). The percent loss varies by spill type, with the lost volumes of spilled liquids ranging from 21% to 100%. Gaseous spills are not recoverable due to their rapid dispersion into the atmosphere or potential for ignition. Consequently, no gaseous spills were recovered in 2024. In 2024, two produced water spills were reported as having affected a surface waterway. In addition, two spills were reported to have impacted groundwater—one involving produced water and the other involving an unspecified material. Gaseous spills accounted for one surface water impact (carbon dioxide) and six groundwater impacts (flared natural gas) in Chaves, Eddy, and Lea counties (NMOCD 2025a).

Table 3-9. Summary of 2024 Spills from All Wells in the Pecos Tri-county Area (Chaves, Eddy, and Lea counties)

Material Type*	Spill Count	Percentage of Total Spill Count (%)	Volume Spilled	Volume Lost	Unit	Average Volume Spilled	Percent Lost (%)	Waterways Affected	Groundwater Affected
Crude oil	247	30.1	10,067	3,883	bbl	40.76	62	0	0
Produced water	512	62.4	80,258	39,485	bbl	156.75	58	2	1
Other (specify)	10	1.2	942	216	bbl	94.2	44	0	1
Condensate	29	3.5	509	362	bbl	17.55	79	0	0
Brine water	2	0.2	209	205	bbl	104.5	82	0	0
Unknown	14	1.7	23,360	23,360	bbl	1,668.57	100	0	0
Glycol	2	0.2	26	23	bbl	13	92	0	0
Drilling mud/fluid	1	0.1	95	20	bbl	95	21	0	0
Natural gas liquids	2	0.2	571	311	bbl	285.5	67	0	0
Chemical (specify)	1	0.1	16	16	bbl	16	100	0	0
Total Liquid Spills	***820***	**100.0**	***116,053***	***67,881***	**bbl**	***249.18***	***70***	***2***	***2***
Natural gas flared	38,561	97.8	10,733,876	10,733,876	Mcf	278.36	100	0	6
Natural gas vented	699	1.8	558,132	558,132	Mcf	798.47	100	0	0
Carbon dioxide	177	0.4	48,569	48,569	Mcf	274.40	100	1	0
Total Gaseous Spills	***39,437***	**100.0**	***11,340,577***	***11,340,577***	**Mcf**	***450.41***	**100**	***1***	***6***

Source: NMOCD (2025a)

Note: FracFocus does not differentiate between natural gas flaring/venting and a normal liquid spill that could occur during the hydraulic fracturing process; therefore, this table reflects two total value rows (one total value for conventional spills and one for natural gas flaring and venting). Natural gases that are vented and flared are done so intentionally as part of the hydraulic fracturing process with no expected spill recovery.
* No spills of gelled brine (frac fluid) or sulfuric acid were documented in 2024.

Table 3-10 presents historical spill data from 2014 to 2024. The large increase in natural gas spills in the years 2021 to the present is attributed to NMOCD's new natural gas waste rules, NMAC 19.15.27 and 19.15.28, requiring more stringent recording of spills—which resulted in a much greater number of spills being recorded than in previous years. Operators can retroactively add spill data based on updated spill recording laws and regulations.

The BLM works with NMOCD to remediate spills associated with federal oil and gas wells on BLM-managed lands or private or state surface. Title 19, Chapter 15 of the NMAC pertains to oil and gas releases. According to NMAC 19.15.29.11, the responsible person shall complete NMOCD-approved corrective action for releases that endanger public health or the environment in accordance with a remediation plan submitted to and approved by NMOCD or with an abatement plan submitted in accordance with NMAC 19.15.30. The remaining contaminants from unrecovered spills are remediated in accordance with federal and state standards. Some remediation consists of removing contaminated soil and replacing it with uncontaminated soil and performing corresponding chemical testing.

Table 3-10. Summary of Spills from All Wells in the Pecos Tri-county Area (Chaves, Eddy, and Lea counties) between 2014 and 2024

Material Type	Spill Count by Year										
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Produced water	577	551	465	493	549	627	499	469	624	641	512
Crude oil	307	399	331	329	378	347	253	212	340	285	247
Condensate	7	23	20	12	13	12	16	21	60	58	29
Other (specify)	11	6	11	8	25	25	17	28	46	20	10
Drilling mud/fluid	6	3	1	4	5	2	0	0	5	6	1
Natural gas liquids*	8	11	14	9	6	7	5	13	12	3	2
Diesel	1	1	0	1	3	0	0	1	3	1	0
Glycol	0	0	0	0	0	0	0	0	1	1	2
Unknown	1	2	0	0	0	0	0	0	2	2	14
Brine water	3	3	6	3	3	4	3	3	5	1	2
Chemical (specify)	0	1	1	1	5	3	0	0	2	0	1
Acid	3	2	0	0	1	2	0	3	1	0	0
Lube oil	1	0	0	0	0	0	0	2	1	0	0
Gelled brine (frac fluid)	3	2	0	0	0	2	0	2	0	0	0
Sulfuric acid	0	0	0	0	1	0	0	0	0	0	0
Basic sediments and water	0	0	1	3	3	0	0	0	0	0	0
Gasoline	4	1	0	0	0	0	0	0	0	0	0
Total Liquid Spills	***932***	***1,005***	***850***	***863***	***992***	***1,031***	***793***	***754***	***1,102***	***1,018***	***820***
Natural gas flared	1	0	0	0	0	0	10	14,040	36,962	49,406	38,561
Natural gas vented	0	0	0	0	0	0	2	699	1,477	1,482	699
Carbon dioxide	0	0	0	0	0	0	0	0	0	140	177
Methane	94	237	263	49	153	171	210	190	0	0	0
Hydrogen sulfide	0	0	0	0	0	0	0	0	0	1	0
Total Gaseous Spills†	***95***	***237***	***263***	***49***	***153***	***171***	***222***	***14,929***	***38,439***	***51,029***	***39,437***

Source: NMOCD (2024b)

* Natural gas liquids material types include natural gas flared, natural gas liquid, and natural gas vented material.

† On May 25, 2021, NMOCD's new natural gas waste rules, NMAC 19.15.27 and 19.15.28, went into effect. These new rules resulted in a higher reporting number for natural gas liquid spills compared with previous years (Center for Western Priorities 2022).

According to FracFocus, from 2014 through 2024, most entries (53,142) within the New Mexico portion of the Permian Basin were unnamed (i.e., did not include an ingredient name or CAS number, but were still entered into the FracFocus registry as unnamed ingredients used for some purpose during the hydraulic fracturing process). Unnamed ingredients represented 16.09% of all FracFocus disclosures and 4.49% of the total hydraulic fracturing jobs (volume by percent mass) within the New Mexico portion of the Permian Basin from 2014 to 2024. 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 3-11.

Not including unnamed ingredients, water is the most commonly disclosed ingredient in hydraulic fracturing operations within the New Mexico portion of the Permian Basin with 28,045 disclosures, representing 8.49% of all FracFocus disclosures and 32.29% of the total hydraulic fracturing jobs (chemical volume by percentage mass) from 2014 through 2024. Crystalline silica (9,916 disclosures) represents the next most commonly reported chemical constituent of hydraulic fracturing operations (see Table 3-11) (FracFocus 2025).

Table 3-11. Most Frequently Disclosed Ingredients in Wells within the Pecos Tri-county Area (Chaves, Eddy, and Lea counties) from 2014 through 2024

Ingredient Name	CAS Registry Number	Number of Disclosures	Percentage of Hydraulic Fracturing Job†	Percentage of Total Number of FracFocus Disclosures‡
Unnamed	N/A	53,142	4.49%	16.09%
Water	7732-18-5	28,045	32.29%	8.49%
Crystalline silica (quartz)	14808-60-7	9,916	12.61%	3.00%
Methanol	67-56-1	7,980	0.01%	2.42%
Hydrochloric acid	7647-01-0	7,006	0.12%	2.12%
Glutaraldehyde	111-30-8	4,938	0.01%	1.50%
Ammonium chloride	12125-02-9	4,492	0.00%	1.36%
Distillates (petroleum), hydrotreated light	64742-47-8	4,046	0.03%	1.23%
Acetic acid	64-19-7	3,761	0.04%	1.14%
Ethanol	64-17-5	3,315	0.00%	1.00%
Proprietary*	Proprietary	3,275	0.02%	0.99%
Aluminum oxide	1344-14-5	2,911	0.08%	0.88%
Sodium chloride	7647-17-5	2,819	0.06%	0.85%
Ethylene glycol	107-21-1	2,817	0.05%	0.85%
Propargyl alcohol	107-19-7	2,671	0.00%	0.81%
Ammonium persulfate	7727-54-0	2,197	0.01%	0.67%
Alcohols, C12-16, ethoxylated	68551-12-2	2,187	0.00%	0.66%
Ethoxylated alcohols	68002-97-1	2,146	0.01%	0.65%
Sodium hydroxide	1310-73-2	2,111	0.01%	0.64%
Citric acid	77-92-9	2,025	0.00%	0.61%
Guar gum	9000-30-0	1,974	0.11%	0.60%
Sodium perborate tetrahydrate	10486-00-7	1,911	0.02%	0.58%
Surfactant	24938-91-8	1,910	0.01%	0.58%
Didecyl dimethyl ammonium chloride	7173-51-5	1,877	0.00%	0.57%

Ingredient Name	CAS Registry Number	Number of Disclosures	Percentage of Hydraulic Fracturing Job†	Percentage of Total Number of FracFocus Disclosures‡
Ethoxylated alcohol	68131-39-5	1,831	0.01%	0.55%
Polylactide resin	9051-89-2	1,609	0.00%	0.49%
Isopropanol	67-63-0	1,595	0.00%	0.48%
Mineral oil	8012-95-1	1,552	0.03%	0.47%

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 number of disclosures and ingredients presented in this table are to be used for general information only.

Table includes only the top 25 most frequently detected 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 [2024] data dictionary).

‡ The total number of FracFocus ingredient disclosures in the Pecos tri-county area from 2014 to 2024 is 330,253.

3.2.3.2 Drilling and Completion Activities

When wells are drilled, they usually pass through usable groundwater aquifers currently or potentially supplying stock, residential, and/or irrigation water. If proper cementing and casing programs are not followed, there may be a loss of well integrity resulting in increased risk of groundwater contamination, surface spills, or loss of fluids in the drilling and completion process that could result in large volumes of highly concentrated chemicals reaching groundwater resources. If contamination of usable water aquifers (TDS less than 10,000 parts per million [ppm]) from any source occurs, changes in groundwater quality could impact springs and water wells that are sourced from the affected aquifers.

The BLM and NMOCD have casing, cementing, and inspection requirements in place to limit the potential for groundwater reservoirs and shallow aquifers to be impacted by hydraulic fracturing or the migration of hydrocarbons during oil and gas drilling and production activities. The BLM requires operators to comply with the regulations at 43 Code of Federal Regulations (C.F.R.) § 3162. In addition, these regulations require oil and gas development to comply with the orders of the Authorized Officer. The regulations at 43 C.F.R. § 3162.3-3 and 43 C.F.R. § 3170 provide regulatory requirements for hydraulic fracturing, including casing specifications, monitoring and recording, and management of recovered fluids. New Mexico also has regulations for drilling, casing and cementing, completion, and plugging to protect freshwater zones (NMAC 19.15.16). Complying with the aforementioned regulations requires producers and regulators to verify the integrity of casing and cementing jobs. Casing specifications are designed and submitted to the BLM in a drilling plan as a component of an Application for Permit to Drill (APD). The BLM petroleum engineer independently reviews the drilling plan and based on site-specific geologic and hydrologic information, ensures that proper drilling, casing, and cementing procedures are incorporated in the plan to protect usable groundwater. The aforementioned regulations and review practices surrounding proper casing and cementing procedures isolate usable water zones from drilling, completion/hydraulic fracturing fluids, and fluids from other mineral-bearing zones, including hydrocarbon-bearing zones. Conditions of approval (COAs) may be attached to the APD, if necessary, to ensure groundwater protection. These may include requirements for closed loop drilling systems, spill prevention plans, leak detection plans, and appropriate equipment (leak detection and automatic shutoff system) in sensitive groundwater recharge areas. Casing and cementing operations are witnessed by certified BLM petroleum engineering technicians (PETs). At the end of the well's economic life, the operator is required to submit a plugging plan to the BLM for approval. A BLM petroleum engineer will review the plan prior to commencement of plugging operations. The BLM PETs witness plugging operations to ensure the planned procedures are properly followed. The BLM's review, approval, and inspections ensure the permanent isolation of usable groundwater from hydrocarbon-bearing zones.

In summary, the BLM, NMED, and NMOCD have put in place numerous requirements for oil and gas producers so that drilling fluids, hydraulic fracturing fluids, and produced water and hydrocarbons remain within the well bore and do not enter groundwater or any other formations. These include BLM regulations covered under 43 C.FR § 3160; 43 C.F.R. § 3162.3-3; 43 C.F.R. § 3162.3-5; 43 C.F.R. § 3170; Notice to Lessees (NTL) and Operators of Onshore Federal and Indian Oil and Gas Leases-3A (NTL-3A); NMOCD regulations under NMAC 19.15.26; and the state's primacy agreement under the Safe Drinking Water Act (42 United States Code § 300f et seq.). With these requirements in place, including the use of casing and cementing measures, contamination of groundwater resources from development of the lease parcels is highly unlikely. In addition, the BLM has authority under standard terms and conditions to require additional measures to protect water quality if site-specific circumstances require them. Site-specific mitigation tools would be developed as appropriate for the individual circumstances, including groundwater-quality monitoring studies. The regulations at 43 C.F.R. § 3162.5-2(d) give the BLM the authority to require an operator to monitor water resources to ensure that the isolation procedures used to protect water and other resources are effective.

CHAPTER 4. FARMINGTON FIELD OFFICE

The FFO administers approximately 4.2 million total acres of all federal mineral ownership types in San Juan, Rio Arriba, Sandoval, and McKinley counties (Figure 4-1). Portions of the FFO are within the San Juan Basin, an oil and gas basin in northwestern New Mexico and southwestern Colorado (BLM 2003a). Currently, federal oil and gas minerals cover approximately 2.1 million acres, of which approximately 1.8 million acres are currently leased and approximately 300,000 acres are currently unleased (Engler 2025).

The BLM FFO published an updated RFD scenario in 2025 which includes projections of potential future oil and gas development activity for the next 30 years (starting in 2025) (Engler 2025). The FFO RFD focuses on the area with significant recent oil and gas activity known as the Mancos/Gallup play, more specifically the Mancos shale basin-centered gas subplay near the Colorado border and the Mancos/Gallup oil subplay along the southern perimeter of the San Juan Basin, which are further discussed in Section 4.1.2.3 (see Figure 4-1).

This chapter presents information on existing and projected water quantity and water quality data for the FFO as summarized from information gathered from the following sources:

- 2003 Farmington Resource Management Plan with Record of Decision (BLM 2003a)
- 2018 RFD (Crocker and Glover 2018)
- 2025 RFD (Engler 2025)
- Data compiled from the USGS report *Estimated Use of Water in the United States in 2015* (Dieter et al. 2018)
- FracFocus, a national hydraulic fracturing chemical registry managed by the GWPC and IOGCC (FracFocus 2025)
- Spill data and recompletion activities from the NMOCD database (NMOCD 2025a)

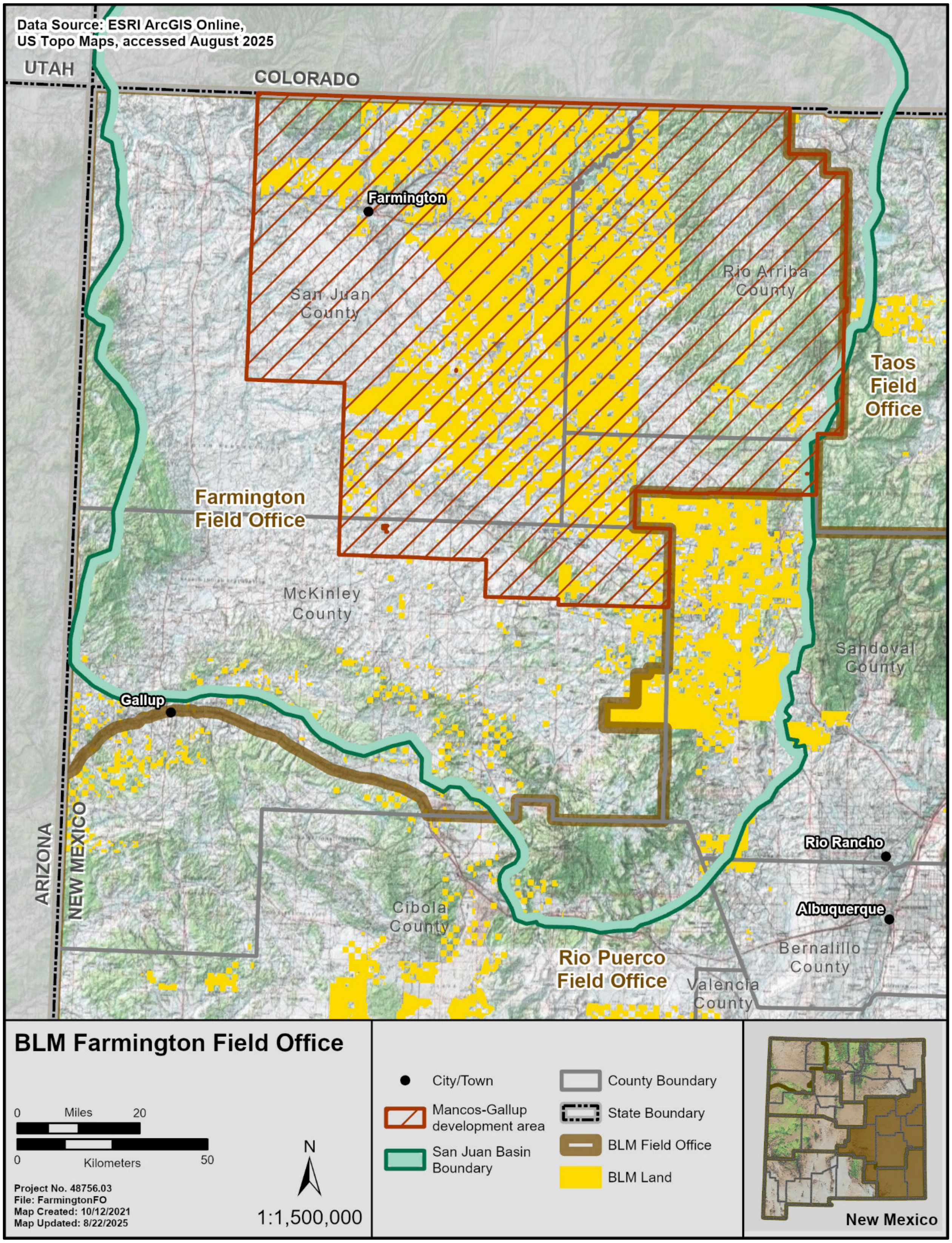

Figure 4-1. BLM FFO and Mancos-Gallup planning area boundaries.

4.1 WATER QUANTITY

4.1.1 Existing Surface Water and Groundwater Use

4.1.1.1 Farmington Field Office (McKinley, Rio Arriba, Sandoval, and San Juan counties)

Dieter et al. (2018) list total water withdrawals across eight water use categories: aquaculture, domestic, industrial, irrigation, livestock, mining (which includes oil and gas development), public water supply, and thermoelectric power (Table 4-1 through Table 4-4; Figure 4-2). Water withdrawal totals for each of these industries are summarized by surface water and groundwater, which are further divided into fresh water and saline water for each category. Total water withdrawals were 13,217 AF, 118,120 AF, 71,576 AF, and 283,748 AF for McKinley, Rio Arriba, Sandoval, and San Juan counties, respectively (see Table 4-1 through Table 4-4), for a combined total of approximately 486,660 AF (Table 4-5). This is 14.7% of total water withdrawals within New Mexico in 2015 (see Table 2-1). The largest use of water within the FFO area was irrigation, comprising 79.07% (384,817 AF) of total water use.

Water use associated with mining (11,658 AF) comprises 2% of total water withdrawal within the FFO area; over half of all mining-related water withdrawals in the FFO area occurred in San Juan County (6,356 AF, or 55% of the total mining water withdrawals in the FFO area). Water withdrawn for mining is sourced from both surface water (2,724 AF) and groundwater (8,934 AF). Surface water withdrawn for mining was entirely derived from fresh water resources, whereas groundwater extractions for mining were split between fresh and saline sources (3,677 AF and 5,257 AF, respectively). Within the FFO planning area, saline water withdrawals occur only from groundwater used for mining, while all other surface and groundwater withdrawals across each category come from fresh sources.

Table 4-1. McKinley 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%	3,195	–	3,195	24%	3,195	24%	–	0%	3,195	24%
Industrial	0	0	0	0%	34	0	34	<1%	34	<1%	0	0%	34	<1%
Irrigation	1,099	–	1,099	8%	0	–	0	0%	1,099	8%	–	0%	1,099	8%
Livestock	101	–	101	<1%	370	–	370	3%	471	4%	–	0%	471	4%
Mining	0	0	0	0%	1,625	684	2,309	17%	1,625	12%	684	5%	2,309	17%
Public water supply	0	0	0	0%	3,811	0	3,811	29%	3,811	29%	0	0%	3,811	29%
Thermoelectric power	0	0	0	0%	2,298	0	2,298	17%	2,298	17%	0	0%	2,298	17%
County Totals	**1,199**	**0**	**1,199**	**9%**	**11,333**	**684**	**12,017**	**91%**	**12,533**	**95%**	**684**	**5%**	**13,217**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 13,217 acre-feet.

Table 4-2. Rio Arriba 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%	3,554	0	3,554	3%	3,554	3%	0	0%	3,554	3%
Domestic	0	–	0	0%	1,345	–	1,345	1%	1,345	1%	–	0%	1,345	1%
Industrial	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Irrigation	107,874	–	107,874	91%	1,256	–	1,256	1%	109,129	92%	–	0%	109,129	92%
Livestock	168	–	168	<1%	191	–	191	<1%	359	<1%	–	0%	359	<1%
Mining	0	0	0	0%	437	1,244	1,682	1%	437	<1%	1,244	1%	1,682	1%
Public water supply	381	0	381	<1%	1,670	0	1,670	1%	2,051	2%	0	0%	2,051	2%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
County Totals	**108,423**	**0**	**108,423**	**92%**	**8,452**	**1,244**	**9,697**	**8%**	**116,875**	**99%**	**1,244**	**1%**	**118,120**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 118,120 acre-feet.

Table 4-3. Sandoval 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%	1,087	0	1,087	2%	1,087	2%	0	0%	1,087	2%
Domestic	0	–	0	0%	3,128	–	3,128	4%	3,128	4%	–	0%	3,128	4%
Industrial	0	0	0	0%	2,578	0	2,578	4%	2,578	4%	0	0%	2,578	4%
Irrigation	48,326	–	48,326	68%	2,320	–	2,320	3%	50,647	71%	–	0%	50,647	71%
Livestock	101	–	101	<1%	123	–	123	<1%	224	<1%	–	0%	224	<1%
Mining	0	0	0	0%	1,065	247	1,312	2%	1,065	1%	247	<1%	1,312	2%
Public water supply	135	0	135	<1%	12,466	0	12,466	17%	12,600	18%	0	0%	12,600	18%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
County Totals	**48,562**	**0**	**48,562**	**68%**	**22,768**	**247**	**23,014**	**32%**	**71,329**	**100%**	**247**	**<1%**	**71,576**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 71,576 acre-feet.

Table 4-4. San Juan 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%	1,312	–	1,312	<1%	1,312	<1%	–	0%	1,312	<1%
Industrial	0	0	0	0%	22	0	22	<1%	22	<1%	0	0%	22	<1%
Irrigation	223,942	–	223,942	79%	0	–	0	0%	223,942	79%	–	0%	223,942	79%
Livestock	67	–	67	<1%	303	–	303	<1%	370	<1%	–	0%	370	<1%
Mining	2,724	0	2,724	1%	549	3,083	3,632	1%	3,273	1%	3,083	1%	6,356	2%
Public water supply	21,097	0	21,097	7%	11	0	11	0%	21,108	7%	0	0%	21,108	7%
Thermoelectric power	30,637	0	30,637	11%	0	0	0	0%	30,637	11%	0	0%	30,637	11%
County Totals	**278,468**	**0**	**278,468**	**98%**	**2,197**	**3,083**	**5,280**	**2%**	**280,665**	**99%**	**3,083**	**1%**	**283,748**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 283,748 acre-feet.

Table 4-5. Water Use by Category in 2015 within the FFO Area (McKinley, Rio Arriba, Sandoval, and San Juan counties)

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%	4,641	0	4,641	<1%	4,641	<1%	0	0%	4,641	<1%
Domestic	0	–	0	0%	8,979	–	8,979	2%	8,979	2%	–	0%	8,979	2%
Industrial	0	0	0	0%	2,634	0	2,634	<1%	2,634	<1%	0	0%	2,634	<1%
Irrigation	381,241	–	381,241	78%	3,576	–	3,576	<1%	384,817	79%	–	0%	384,817	79%
Livestock	437	–	437	<1%	986	–	986	<1%	1,424	<1%	–	0%	1,424	<1%
Mining	2,724	0	2,724	<1%	3,677	5,257	8,934	2%	6,401	1%	5,257	1%	11,658	2%
Public water supply	21,613	0	21,613	4%	17,958	0	17,958	4%	39,571	8%	0	0%	39,571	8%
Thermoelectric power	30,637	0	30,637	6%	2,298	0	2,298	<1%	32,935	7%	0	0%	32,935	7%
Basin Totals	**436,652**	**0**	**436,652**	**90%**	**44,750**	**5,257**	**50,008**	**9%**	**481,402**	**99%**	**5,257**	**1%**	**486,660**	**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.

* Saline water withdrawals are not reported for domestic, irrigation, or livestock water use (Dieter et al. 2018).

† 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, which amounted to 486,660 acre-feet.

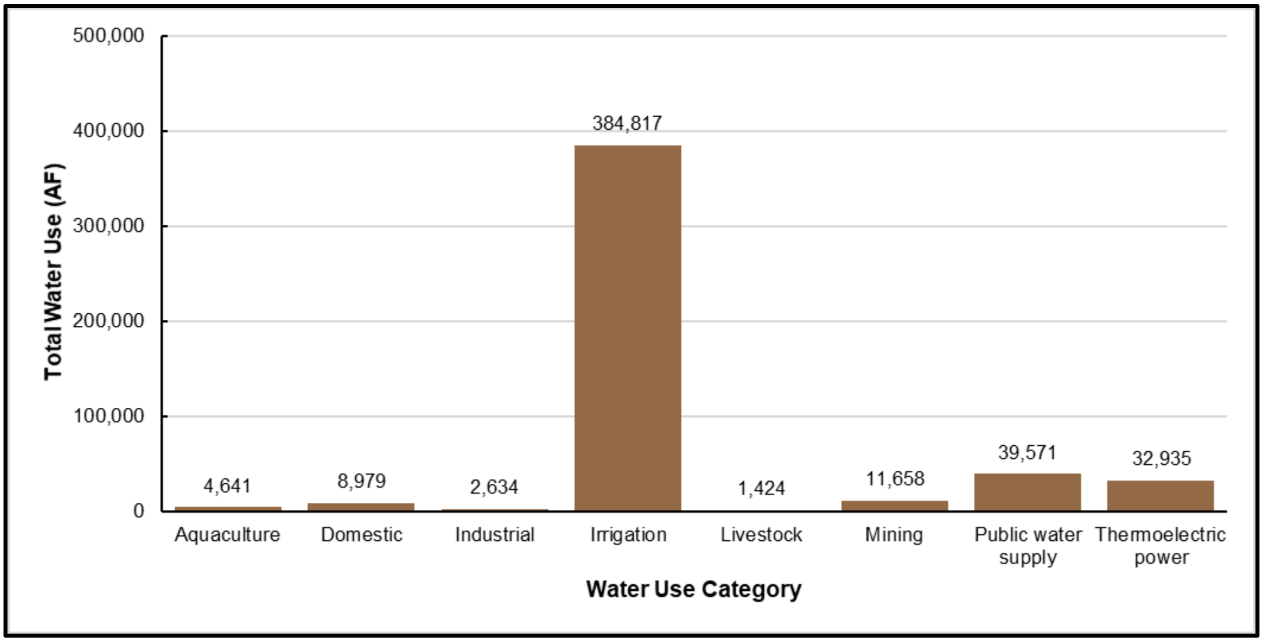

Figure 4-2. FFO (McKinley, Rio Arriba, Sandoval, and San Juan counties) water use by category in 2015 (Dieter et al. 2018).

4.1.2 Water Use Trends and Planned Actions

4.1.2.1 Past and Present Actions

As noted previously, total water usage in the four FFO counties in 2015 was approximately 486,660 AF and accounted for approximately 15% (3,249,667 AF) (see Table 2-1) of the total state water withdrawals (Dieter et al. 2018). The largest use of water within the FFO area is irrigation, comprising 79% of total water use within the FFO area and 14.4% of all irrigation-related use within the state (384,000 AF/state total irrigation water use [2,660,424 AF]). Mining (which includes oil and gas development) comprised 2% of the total water withdrawals within the FFO area and 7% of all mining-related water use in the state.

Data from FracFocus were evaluated to provide objective information on the amount of water used in hydraulic fracturing (see Appendix A). Operators are required by New Mexico to disclose chemistry and water use information to FracFocus. Annual water use in oil and gas wells within the four FFO counties has varied over the past 7 years. The number of wells completed increased from 106 in 2023 to 148 in 2024, and the total water use for all wells increased from 1,074 AF in 2023 to 2,173 AF in 2024. Average hydraulic fracturing water use per well increased from 9.3 AF in 2023 to 13.9 AF in 2024 (Table 4-6) (FracFocus 2025). Hydraulic fracturing on federal land consumed 1,246.7 AF of water in 2024, 61% of the 2024 total hydraulic fracturing water usage. Table 3-5 presents water use data from FracFocus associated with hydraulic fracturing jobs only, which represents the majority of water use per well within the FFO.

The combined water use estimates for federal and total (both federal and non-federal) water use associated with hydraulic fracturing in the FFO are shown in Table 4-6. With consideration of all water use by oil and gas wells for hydraulic fracturing from 2014 to 2024, the combined federal water use and total combined water use was 4,634.5 AF and 6,958.1 AF, respectively. The 11-year total combined water use is approximately 7,769.08 AF and the average AF per well in 2024 was approximately 13.9 AF. Based on the most recent 3 years of data (2022–2024), the 3-year average is 11.2 AF per well. This is due to the higher volume of non-hydraulic fracturing use wells, the likelihood that horizontal wells are being drilled to longer lengths in the intervening time, the continued use of hydraulic fracturing technologies in well drilling and completion, and operators transitioning from nitrogen fracturing methods to water-intensive slickwater fracturing. While slickwater fracturing is a more water-intensive process, most operators are targeting non-potable water sources for fracturing operations, though exact sources cannot be determined as FracFocus does not distinguish between water types used.

Cumulative water use is the amount of water cumulatively used each year by hydraulic fracturing and consists of the water use for any given year plus the water use for each previous year since 2014. See Appendix A for details on the combined water usage calculations. Combined water use estimates for federal and total (both federal and non-federal) water use associated with hydraulic fracturing in the FFO are shown in Table 4-6.

While the FracFocus database is an excellent tool for identifying well completions, FracFocus does not currently differentiate between wells that are new completions or recompletions of previously drilled wells. This data reporting discrepancy can skew water use statistics, as recompletions typically use less water than new completions. The FracFocus database alone does not provide all the required data on well completion method (vertical, slickwater, nitrogen) and requires additional data sources to accurately capture water use associated with each well completion method.

Table 4-6. Water Use by Oil and Gas Wells for Hydraulic Fracturing in the FFO (McKinley, Rio Arriba, Sandoval, and San Juan counties) from 2014 through 2024

Year	Federal HF Water Use	Tribal HF Water Use	Non-Federal/ Tribal HF Water Use*	Total HF Water Use	Federal HF Water Use (%)	Federal HF Cumulative Water Use	Total HF Cumulative Water Use	Average HF Water Use per Well*	Total No. of Federal Wells	Total No. of Wells	Total Non-HF Water Use†	Total Water Use (HF plus non-HF)
2014	164.6	–	154	318.7	52%	164.6	318.7	2.4	71	132	108.24	426.94
2015	87.3	–	255	342.5	25%	251.9	661.2	3.8	38	90	73.80	416.30
2016	42.9	–	68	110.7	39%	294.8	771.9	2.9	20	38	31.16	141.86
2017	131.1	39.0	108	278.4	47%	425.9	1,050.3	4.5	28	62	50.84	329.24
2018	375.3	23.9	258	657.6	57%	801.2	1,707.9	4.7	80	141	115.62	773.22
2019	92.7	–	69	161.9	57%	893.9	1,869.8	1.8	58	92	75.44	237.34
2020	51.0	–	–	51.0	100%	944.9	1,920.8	5.7	9	9	7.38	58.38
2021	527.1	118.8	25	671.1	79%	1,472.0	2,591.9	14.9	33	45	36.90	708.00
2022	1,171.8	2.6	153	1,327.2	88%	2,643.8	3,919.1	10.5	112	126	103.32	1,430.52
2023	744.0	1.2	242	987.1	75%	3,387.8	4,906.2	9.3	89	106	86.92	1,074.02
2024	1,246.7	139.2	666	2,051.9	61%	4,634.5	6,958.1	13.9	88	148	121.36	2,173.26
Total	**4,634.5**	324.7	**1,999**	**6,958.1**	**67%**	**4,634.5**	**6,958.1**	**6.8† (11.2‡)**	**626**	**989**	**810.98**	**7,769.08**

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

Source: FracFocus (2025)

Note: Data are presented only for those wells reporting water usage to FracFocus. See Appendix A for data analysis methodology. Produced water data are from NMOCD (2025d). Produced water is naturally occurring water that exists in a formation that is being targeted for mineral extraction and is produced as a byproduct. Water use data are in acre-feet unless otherwise indicated.

†11-year average (2014–2024).

‡ 3-year average value (2022–2024).

–: no data available

Water use can vary depending on the well completion method, so additional well information was compiled from BLM records and available data from NMOCD and aggregated with FracFocus data to provide a more detailed analysis of water use by well type (new completion versus recompletion and completion method) (Table 4-7). To determine the well completion type, data from FracFocus is obtained for wells in the desired county and during the desired year. The individual well reports provide the well American Petroleum Institute (API) number and water use. If the water quality information includes nitrogen and water use is ~2.5 AF, then it is a nitrogen well (BLM 2025).

Table 4-7. Water Use Statistics by Well Type for the FFO from 2014 through 2024

Year	Well Type	Number of Wells	Average Water Use per Well (AF)	Total Water Use (AF)
2014	Nitrogen	105	2.9	301.3
	Recompletion	22	0.7	15.6
	Slickwater	0	–	–
	Vertical	4	0.4	1.7
	Total	**131**	**2.4**	**318.6**
2015	Nitrogen	65	3.3	213.3
	Recompletion	7	0.3	2.1
	Slickwater	3	40.4	121.3
	Vertical	15	0.4	5.8
	Total	**90**	**3.8**	**342.5**
2016	Nitrogen	16	5.1	81.5
	Recompletion	23	0.2	5.9
	Slickwater	1	23.3	23.3
	Vertical	0	–	–
	Total	**40**	**2.7**	**110.7**
2017	Nitrogen	40	4.8	186.9
	Recompletion	11	0.3	3.4
	Slickwater	1	87.3	87.3
	Vertical	11	0.1	1.0
	Total	**63**	**4.4**	**278.6**
2018	Nitrogen	19	4.6	88.3
	Recompletion	107	0.2	25
	Slickwater	14	38.9	544.5
	Vertical	2	0.1	0.2
	Total	**142**	**4.6**	**658.0**
2019	Nitrogen	17	5.6	94.4
	Recompletion	74	0.2	17.2
	Slickwater	1	49.2	49.2
	Vertical	0	–	–
	Total	**92**	**1.7**	**160.8**

Year	Well Type	Number of Wells	Average Water Use per Well (AF)	Total Water Use (AF)
2020	Nitrogen	9	5.7	51.0
	Total	**9**	**5.7**	**51.0**
2021	Nitrogen	15	5.2	78.2
	Recompletion	16	0.3	4.5
	Slickwater	14	42.1	588.4
	Total	**45**	**14.9**	**671.1**
2022	Nitrogen	34	5.2	177
	Recompletion	53	0.2	12.8
	Slickwater	31	35.5	1,135.8
	Vertical	7	0.2	1.4
	Total	**125**	**10.3**	**1,327**
2023	Nitrogen	9	6.2	55.9
	Recompletion	78	0.3	22.8
	Slickwater	19	45.0	854.4
	Total	**106**	**17.2**	**933.1**
2024	Recompletion	88	0.4	32.8
	Slickwater	60	33.7	2,023.0
	Total	**148**	**34.1**	**2,055.8**
2014–2024	Nitrogen	329	4.0	1,327.8
	Recompletion	479	0.3	142.1
	Slickwater	144	37.7	5,427.2
	Vertical	39	0.3	10.1
	Total	**991**	**7.0**	**6,891.6**
	Total (without recompletions)	**512**	**13.2**	**6,765.1**

Note: Well data was sourced from FracFocus (2025) and aggregated with additional data from BLM records.

To determine whether a well is a slickwater well, BLM Form 3160-4 is downloaded from the NMOCD website using the well API number and the NMOCD Well File Search form (NMOCD 2025c). The BLM 3160-4 form has information on whether the well is new or recomplete. If the well is new, the water use is greater than 2.5 AF, and the chemical data does not include nitrogen, then the well is considered to be a slickwater well(BLM 2025). The chemical data for slickwater also includes a listing for guar gum.

From 2014 to 2024, recompletions of 479 previously existing wells used an average of 0.3 AF/well for a total of 142.1 AF of total water use over 11 years, while completions of 39 vertical wells used an average of 0.3 AF/well but accounted for 10.1 AF of total water use. Water use associated with new completions of nitrogen and slickwater wells used an average of 4.0 and 37.7 AF/well, respectively. Total water volume used for nitrogen wells from 2014 through 2024 equaled 1,327.8 AF, whereas slickwater wells used 5,427.2 AF of water over the same period. The total new well counts for 2014 through 2024 (excluding recompletion wells) equals 512, with 60 new wells developed in 2024. The average volume of water used per new well completed in 2024 (excluding recompletions) was 33.7 AF. Despite accounting for only 14.5% of well completions from 2014 through 2024, slickwater well development was responsible for approximately 78.7% of water used in well development during this time period, including water used in recompletions. Figure 4-3 indicates the proportion of wells by completion type from 2014 to 2024.

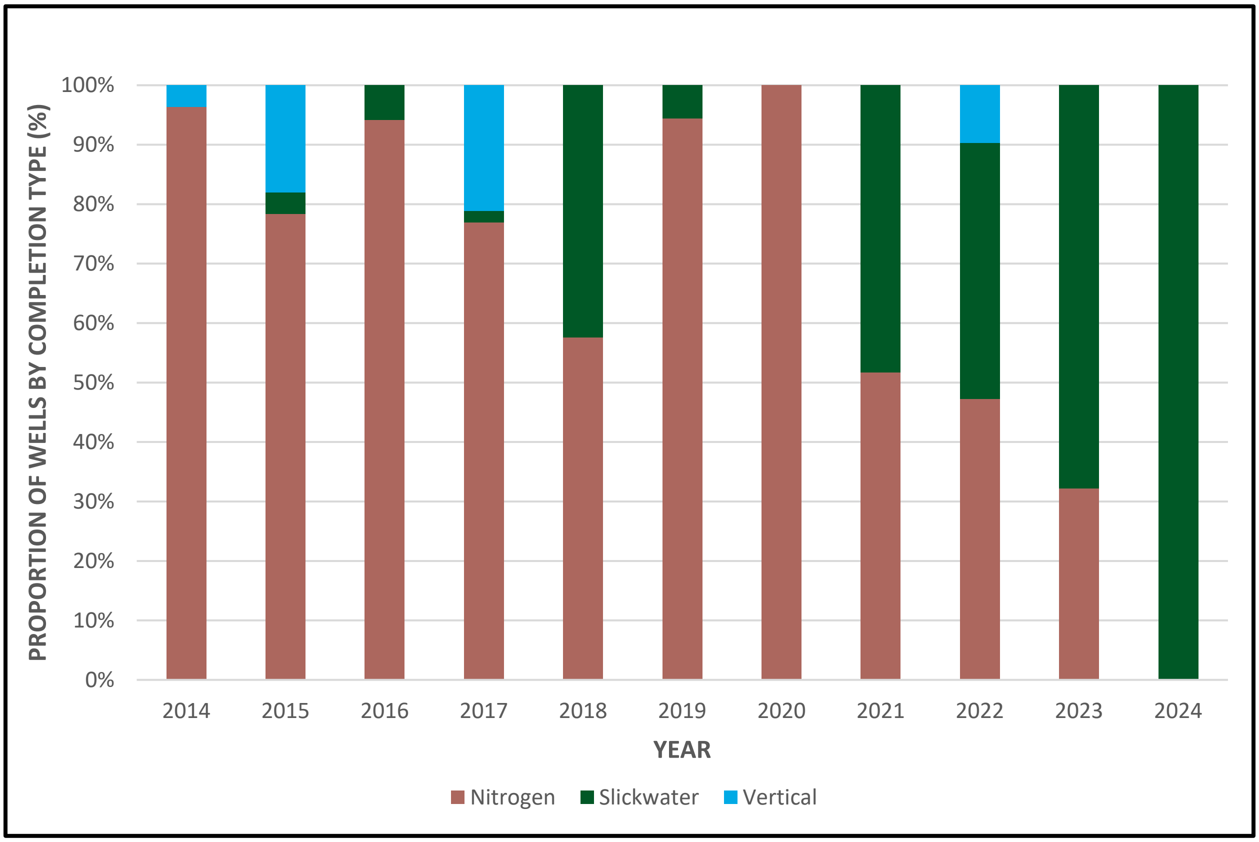

Figure 4-3. Proportion of oil and gas well stimulation techniques in the FFO from 2014 through 2024.

Note: Well data sourced from FracFocus (2025). Recompletion wells were not included in this chart as they are not a stimulation technology. The new well total for 2024, without recompletion wells, equals 60 wells. Associated percentages are based on this total.

4.1.2.2 Water Use Per Well Comparisons

As previously discussed, actual water use quantities reported from 2014 through 2024 for the FFO vary from an average of 6.8 AF per well (see Table 4-6) to 13.2 AF per well (see Table 4-7), depending on the data source used. For the FFO specifically, a summary of the average water use per well across data sources is summarized in Table 4-8. The 26.5 AF/well 3-year average is considered a reasonable estimate of water use associated with future oil and gas development in the FFO. This value is also the most conservative approach for assessing impacts from water use.

Table 4-8. Water Use per Well Comparisons

Data Source	Water Use (AF/well)	Notes
FracFocus 3-year average	11.2	Average water use per well between 2022 and 2024.
FracFocus 11-year average	6.8	Average water use per well between 2014 and 2024.
FracFocus 3-year average with corrected stimulation techniques (without recompletions)	26.5	Average water use per new well between 2022 and 2024

Data Source	Water Use (AF/well)	Notes
FracFocus 11-year average with corrected stimulation techniques (without recompletions)	13.2	Average water use per new well between 2014 and 2024.

4.1.2.3 Water Use Scenarios Associated with Reasonably Foreseeable Oil and Gas Development

4.1.2.3.1 2025 RFD WATER USE PROJECTIONS

The 2025 FFO RFD (Engler 2025) summarizes historical and recent oil and gas development trends in the Mancos-Gallup Formation Analysis Area. Vertical and directional wells were once the dominant forms of completion, but over the last decade horizontal wells have become increasingly common and are now the dominant well type. Generally, gas production has been declining since 1999 and most of the past major gas plays are currently depleted. Future development within past major gas plays (i.e., the Fruitland Coal, Pictured Cliffs, and Mesa Verde/Dakota) will be scarce and scattered throughout the basin and will also include maintenance of existing resources (recompletions, commingling of zones, etc.). The Mancos shale basin-centered gas subplay, located near the Colorado border, currently has the greatest development potential for gas. Oil production has been increasing since 2014 and the Mancos/Gallup oil subplay, located along the southern perimeter of the basin, currently has the greatest development potential for oil. Water production associated with oil and gas development peaked in 2011 and has been variable but generally on the decline since then; this declining trend is projected to continue into the future. Per-well water usage has increased since 2013 and varies greatly between subplays and their associated completion types. Wells from the Mancos shale basin-centered gas subplay generally consume more water compared to wells in the Mancos/Gallup oil subplay as they are often completed using slickwater stimulation techniques which require larger volumes of water.

The 2025 FFO RFD scenario outlines projections for well development in the two primary subplays: the Mancos shale basin-centered gas subplay and the Mancos/Gallup oil subplay. The RFD presents three different development scenarios: a reference case (also known as “most likely case”) which represents a continuation of recent activity; a high development case that relaxes external constraints to allow for more rapid development; and a low case scenario where limited resources combine with external controls to constrain development. Under the reference or most likely scenario, the RFD projects 300 wells in the Mancos shale basin-centered gas subplay over the course of 30 years (between 2025 and 2055) and assumes that the pace of development during this time would remain constant at 10 new wells per year. Under this same scenario the RFD projects 700 wells in the Mancos/Gallup oil subplay over the course of 20 years (between 2025 and 2045) and assumes that the pace of development during this time would remain constant at 35 new wells per year. When combined, the 2025 FFO RFD reference case projects 1,000 new oil and gas wells over the 30-year period from 2025 through 2055, or approximately 45 wells per year, with all wells projected to use horizontal drilling methods. Of the additional 1,000 (federal and non-federal) wells drilled within the analysis area by 2055, 680 would be federal (Engler 2025). Predicted well counts shown in Table 4-9 are the most likely or base case.

The 2025 RFD provided water use projections for each of the subplays, both on a per-well and cumulative basis; Table 4-9 provides per-well water use estimates for the projected wells in each subplay and the total projected water volumes for the RFD reference case. Figures 4-4 and 4-5 (which come directly from the 2025 RFD) show the cumulative water use (historic plus projected) for both subplays from 2010 to 2055. To improve the accuracy of future water use projections, the RFD analyzed historical water usage data according to well type, recognizing that water requirements differ substantially between vertical and horizontal wells. The RFD’s analysis began with FracFocus data, which provided detailed water volumes and well identification information. Eleven years of data, spanning 2013 to 2023, were reviewed to ensure a robust assessment of historic water use trends. The RFD cross-referenced this information with records from the NMOCD to verify well types and locations, and with Enverus data, a commercial energy database that aggregates drilling, production, and completion records, to identify trends specific to horizontal well development (Engler 2025; Enverus 2025).

The two Mancos/Gallup subplays have different water use trends due to distinct stimulation designs. The gas subplay has historically averaged 500 thousand barrels of liquid (Mbbls) (64.4 AF) of water per well, with most recent usage numbers closer to 700 Mbbls (90.2 AF). In contrast, the oil subplay has historically averaged 63 Mbbls (8.1 AF) per well but has been increasing over time with most recent usage numbers closer to 110 Mbbls (14.2 AF). The difference in per well usage arises because the oil subplay initially used energized fluid fracs with reduced water volumes due to the low reservoir pressure but has recently shifted to a non-energized slickwater frac design, which requires significantly more water. In contrast, the gas subplay has consistently used higher water volumes for stimulation (Engler 2025). The RFD applied the most recent per-well water use estimates for the oil and gas subplays (700 Mbbls and 110 Mbbls, respectively) to the future well projections in each subplay.

Based on the projected per-well water use estimates contained in the 2025 FFO RFD, the total water use required for hydraulic fracturing of the 1,000 wells is estimated at 36,992 AF, or about 1,233 AF per year on average (see Table 4-9).

Table 4-9. 2025 RFD Projected Water Use in the New Mexico Portion of the San Juan Basin (FFO)

Subplay	Mancos/Gallup Oil Subplay	Mancos Shale Basin-Centered Gas Subplay
Predicted water use per well during a hydraulic fracturing operation*	14.2 AF	90.2 AF
Projected number of wells*	700	300
Predicted water source	Recycled produced water or makeup water from Entrada formation (97% non-potable)	Freshwater from Navajo Reservoir
Total Projected RFD Water Use*	**9,926 AF†**	**27,066 AF†**

Source: 2025 FFO RFD (Engler 2025).

* Predicted number of wells and cumulative water use shown are for the most likely or base case only and account from 2025 to 2045 for the oil subplay and from 2025 to 2055 for the gas subplay.

† Total Projected Water use = Water use per well multiplied by number of anticipated wells.

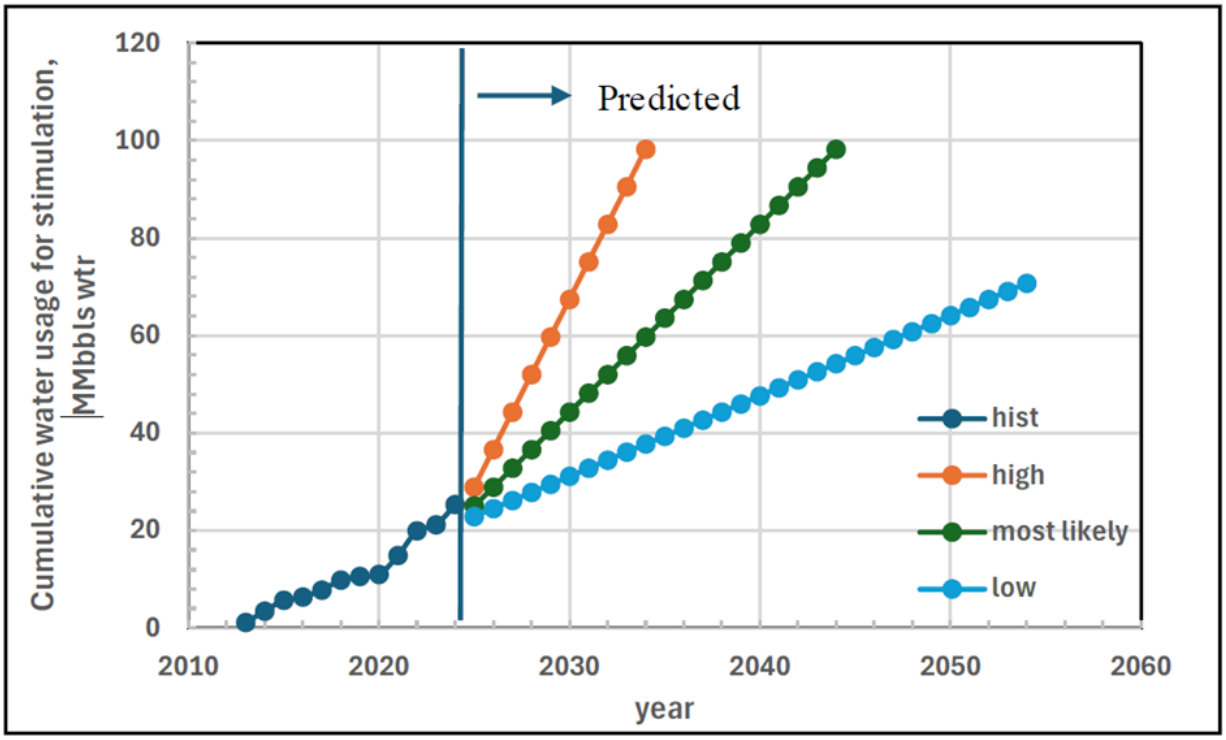

Figure 4-4. Cumulative water use in millions of barrels (multiply by 128.9 to get acre-feet) for stimulation for the three scenarios of additions of new wells in the Mancos/Gallup southern rim horizontal well oil subplay (Engler 2025).

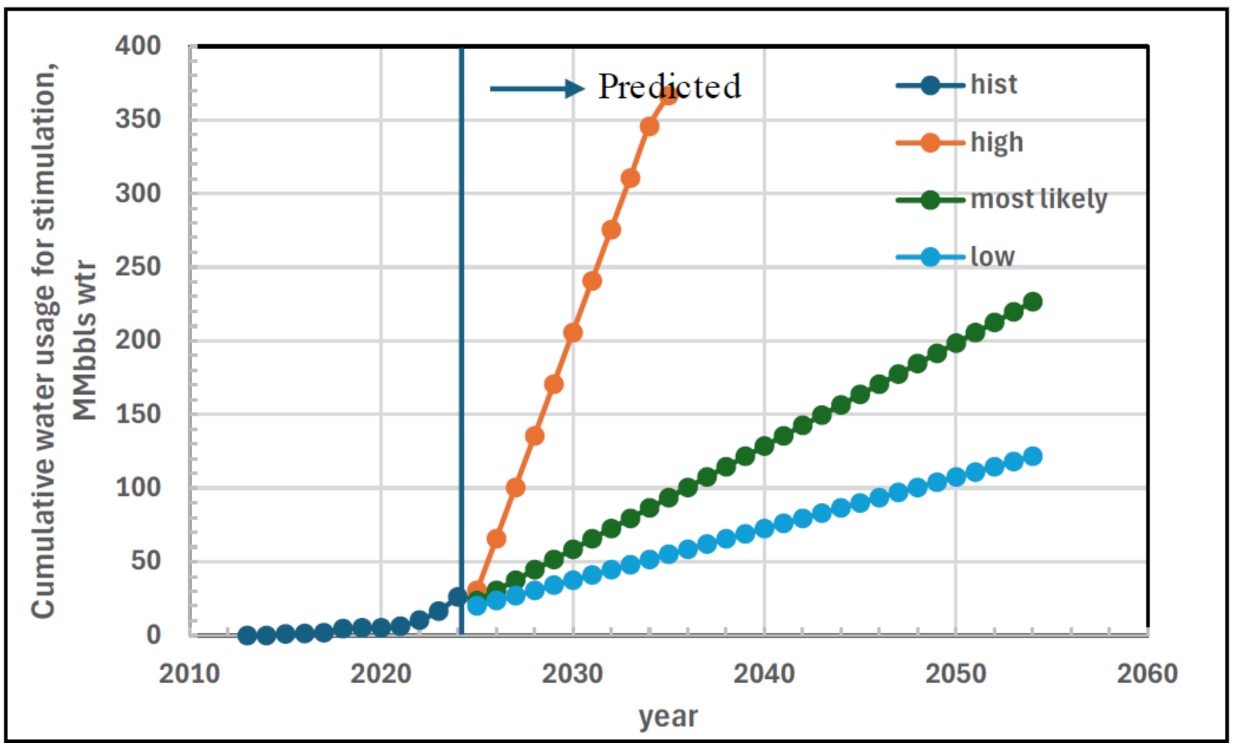

Figure 4-5. Cumulative water use in millions of barrels (multiply by 128.9 to get acre-feet) for stimulation for the three scenarios of new well additions in the Mancos Shale basin-centered horizontal well gas subplay (Engler 2025).

Compared to observed FracFocus water use trends over the past 11 years (see Table 4-8), the RFD water use projections for the oil subplay are within a similar range of the FracFocus 3- and 10-year averages but RFD water use projections for the gas subplay are much higher than the FracFocus 3- and 10-year averages.

4.1.3 Potential Sources of Water for Project Development

In the FFO, water used in hydraulic fracturing may originate from surface or groundwater sources. Principal surface water drainages in the analysis area are the San Juan River (which is impounded at Navajo Dam), the Animas River, and the La Plata River (Dieter et al. 2018). Another source of surface water in the area is the Navajo Reservoir, which has a total storage capacity of approximately 1.7 million acre-feet. Annual yield and releases are managed based on water rights, downstream demands, and compact obligations. Water allocations are coordinated through the Bureau of Reclamation and local water authorities, with significant portions dedicated to agricultural and tribal uses (NMISC 2016).

Table 4-10 lists the sub-aquifers within the Colorado Plateau aquifer system that serve as sources of groundwater in the FFO. Additionally, associated lithologies/formations and sources of recharge of each aquifer in this region are also provided in Table 4-10 below. Water yields in these areas vary, but most aquifers yield less than 20 gallons per minute (gpm) (BLM 2003b). Aquifers that are known to yield sufficient quantities of water are usually found within sandstone units of Jurassic, Cretaceous, and Tertiary age (BLM 2003b). Aquifers that have the potential to yield 100 gpm include the San Andres Glorieta system, the Entrada Sandstone, the Morrison Formation, the Gallup Sandstone, the Ojo Alamo Sandstone, the Nacimiento Formation, and the San Jose Formation, all of which are within the greater Uinta-Animas aquifer (BLM 2003b).

Table 4-10. Potential Sources of Groundwater in the FFO

Sub-Aquifer Name	Principal Lithologies/Formations	General Location (New Mexico focus)	Recharge Sources
Uinta-Animas aquifer	San Jose, Animas, Nacimiento Formations; Ojo Alamo Sandstone (San Juan Basin); also Uinta, Duchesne River, Wasatch, Green River Formations (elsewhere)	San Juan Basin	Higher altitude margins of basins (precipitation, stream infiltration)
Mesaverde aquifer	Mesaverde Group (sandstone, siltstone, shale, coal); inter-tongued with Mancos Shale and Lewis Shale	San Juan Basin	Upland areas (precipitation, surface water infiltration, Zuni Uplift, Chuska Mountains, North Sandoval County)
Dakota-Glen Canyon aquifer system	Dakota Sandstone, Morrison Formation, Entrada Sandstone, Glen Canyon Group (Navajo, Kayenta, Wingate Formations)	San Juan Basin, Four Corners area	Basin margins, uplifts (precipitation, stream infiltration)
Coconino-De Chelly aquifer	Coconino, De Chelly, Glorieta Sandstones; San Andres Limestone; Yeso, Cutler Formations	West-central New Mexico, Zuni Uplift, Defiance Uplift	Uplifts and slopes (precipitation), e.g., Zuni Uplift, Defiance Uplift, Mogollon Slope

Source: *Groundwater Atlas of the United States: Segment 2, Arizona, Colorado, New Mexico, Utah* (USGS 1995).

San Juan Basin oil and gas operators have included plans to use multiple hydraulic fracturing methods, including slickwater fracturing technology. The two general water types that may be used for slickwater stimulation are categorized as potable/fresh and non-potable. Any water that has TDS greater than 1,000 ppm has been defined as non-potable by New Mexico (72-12-25 New Mexico Statutes Annotated 1978). The BLM has determined that waters containing less than 10,000 ppm TDS to be protected in the casing rule of the BLM's 43 C.F.R. § 3170. Waters with higher TDS concentrations (non-potable water) are not subject to these protective regulations and are mainly diverted for mineral exploration purposes. The higher TDS levels that are acceptable for slickwater stimulation expand the possible water sources beyond those that are traditionally used (e.g., surface water or groundwater) into non-traditional sources of water (e.g., non-potable groundwater sources). Water contained in the Entrada Sandstone is highly saline (Kelley et al. 2014). As such, it is considered non-potable and has not been declared an administrative aquifer by NMOSE.

Other sources of non-potable water that can be used in stimulation are flowback fluid and produced water. Flowback fluid is a mixture of water, small amounts of chemicals, and proppants (granular solids that maintain fracture conductivity), that flow back through the wellhead directly after stimulation activities. Generally, 10% to 40% of the initial volume used for stimulation activities returns as flowback fluid; of this flowback fluid, 10% to 40% is non-potable water that may be used in future stimulation activities. Produced water is the outcome of a process involving naturally occurring water that exists in a formation. It is targeted for mineral extraction and is produced as a byproduct, thereby becoming produced water.

Water used for oil and gas drilling and completion would generally be obtained through the following methods:

- Leasing a valid water right through an NMOSE permit
- Buying/leasing water from a legal water provider (or from a private well owner at up to 3 AF)
- Purchasing water from a non-potable reclaimed water supplier

In addition to using surface water or groundwater, operators may also bring water to a well site via truck from many different sources. The transaction would be handled by NMOCD as well as NMOSE. All water use would be evaluated at the APD stage in site-specific NEPA analysis and subject to standard lease terms and conditions; all water used for well development and operations would be from an approved source.

Based on current oil and gas trends outlined in the most recent FFO RFD, the use of slickwater fracturing technology occurs in both Mancos Gallup oil and gas subplays. Although slickwater fracturing has historically been much more common in the Mancos Gallup gas subplay, it has recently become common in the Mancos Gallup oil subplay as well. In addition, the primary water source for the gas subplay is freshwater from Navajo Reservoir, whereas the primary water source for the oil subplay is non-potable water, which is either recycled water or makeup water from the deeper Entrada Sandstone Formation (Engler 2025).

4.1.4 Water Use Mitigation Measures

Public concern about water use from hydraulic fracturing is especially high in semiarid regions. Overall, there have been calls to increase the use of alternative water sources such as brackish water or recycling produced water, minimizing the strain on local freshwater resources (Kondash et al. 2018). The BLM encourages the use of recycled water in hydraulic fracturing techniques, and in 2019, New Mexico passed the Produced Water Act, which encourages oil and gas producers to reuse produced water when possible rather than rely on freshwater sources for oil and gas extraction. Recent studies indicate that the water used for hydraulic fracturing may be retained within the shale formation, with only a small fraction of the fresh water injected into the ground returning as flowback water; water returning to the surface is highly saline, difficult to treat, and often disposed through deep injection wells (Kondash et al. 2018). The NMED signed an updated MOU in 2022 with New Mexico State University to develop new technologies for treating produced water to inform future policies for produced water reuse.

In September 2023, NMED began drafting the State's Ground and Surface Water Protection – Supplemental Requirements for Water Reuse (20.6.8 NMAC) regulations which focus on the restricted reuse of produced water. The proposed regulation would prohibit the discharge of both untreated and treated produced water to groundwater, including subsurface water in aquifers that are used for drinking water and other purposes. Specifically, produced water would not be permitted to be discharged to or disposed of on land, as such practices could result in leaching into aquifers from the surface and subsequent contamination of groundwater. In addition, the regulation would prohibit the discharge of produced water to surface waters, such as rivers, streams, lakes, wetlands, and arroyos. Furthermore, the regulation would establish requirements for the use of produced water in "demonstration projects" and "industrial projects." These requirements include explicit prohibitions on the discharge of produced water to ground and surface waters, as well as mandates that project operators develop spill prevention plans and assume financial responsibility for cleanup in the event of a spill, accident, or discharge. A draft version of the proposed 20.6.8 NMAC regulations can be found on the NMED website (NMED 2024a).

As noted above, water-intensive stimulation methods such as nitrogen or slickwater fracturing can be accomplished using non-traditional water sources. The use of non-potable recycled or makeup water has become increasingly common in the Mancos Gallup oil subplay and accounts for over 97% of water used in hydraulic fracturing in this area (Engler 2025). NMOSE is the agency responsible for water withdrawal permitting actions. Its notice of intent process includes a model-based evaluation of the potential effects of proposed withdrawals and the identification of possible requirements for applicants to obtain water rights to offset any depletions identified in NMOSE's analyses prior to applicants commencing diversions.

4.2 WATER QUALITY

4.2.1 Groundwater

Results of the hydrologic assessment of oil and gas development of the Mancos Shale in the San Juan Basin (Kelley et al. 2014) indicate that groundwater quality in the San Juan Basin is variable (ranging from fresh to brackish) due to the complex stratigraphy and varying rock formations within the basin. Brackish and saline water is typically found in the center of the basin, and fresh groundwater is typically found along the basin margins. Deep saline water can migrate upward along cracks and fissures. Fresh water along the basin margins at depths greater than 3,500 feet indicate fast recharge rates influenced by geologic structures (Kelley et al. 2014).

The geologic formation where groundwater resides also influences groundwater salinity. Figure 4-6 displays a geologic cross section showing the distribution of saline aquifers within the San Juan Basin at the latitude of Aztec, New Mexico.

TDS concentration is a measure of all dissolved matter in a sample of water and is the primary indicator of groundwater quality, as higher TDS concentrations typically render water less suitable for drinking or agricultural purposes such as irrigation. In groundwater, TDS is influenced by the dissolution of natural materials such as rock, soil, and organic material. Anthropogenic activities also contribute to TDS concentrations in shallow, unconfined aquifers.

TDS concentration in the San Juan Basin is dependent on the stratigraphic location and geologic formation where the water resides. Fresh water (TDS <1,000 mg/L) is typically found at depths less than 2,500 feet below the ground surface, although exceptions to this generalization occur in deeper layers such as the Gallup Sandstone and Morrison Formation. Saline and brackish water is dominant in the center of the San Juan Basin at greater depths (Kelley et al. 2014).

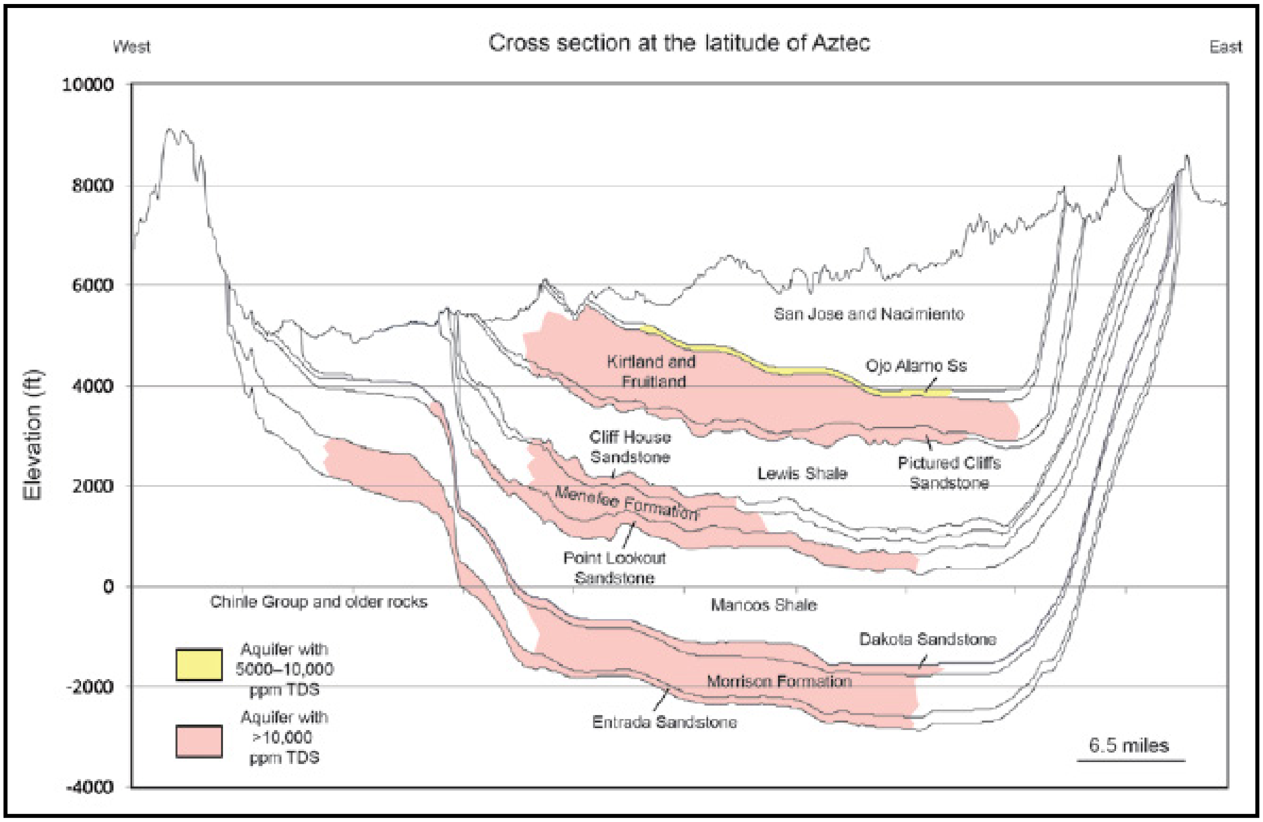

Figure 4-6. Geologic cross section showing the distribution of saline aquifers in the San Juan Basin (Kelley et al. 2014).

4.2.2 Surface Water

In New Mexico, the NMED administers CWA Sections 303(d), 305(b), and 314 related to surface water quality assessment and reporting. The NMED defines surface water quality beneficial uses and water quality standards to evaluate if these uses are being attained. Water quality standards are composed of designated uses for surface waters of the state and associated water quality criteria to protect those uses. The NMED prepares an IR every 2 years, where waterbodies not attaining their designated beneficial uses are reported. The IR also contains information on surface water quality and water pollution control programs in New Mexico (NMED 2024b). The BLM does not have authority to make use attainment evaluations based on water chemistry data.

Surface water is the principal water supply for various uses throughout the San Juan Basin planning region. The San Juan River, along with its main tributaries, the Animas River, Canon Largo, Chaco River, and La Plata River, serves as the primary source of surface water in this area. Water storage in the region is dominated by Navajo Reservoir, which has a capacity of approximately 1.7 million acre-feet and spans into Colorado. The San Juan River watershed itself is shared with the states of Colorado, Utah, and Arizona, but does not overlap with any other planning regions within New Mexico (NMISC 2016).

Specific pollutants identified in the San Juan Basin region include E. coli, temperature, sediment/turbidity, nutrients, biological indicators, phosphorus, selenium, dissolved oxygen, and mercury in fish tissue. A recent study completed in the region identifies additional sources of pollutants for specific reaches identified in the 303(d) list (NMED 2024b; NMISC 2016).

4.2.3 Potential Sources of Surface Water or Groundwater Contamination

4.2.3.1 Spills

The San Juan Basin has been a producing oil and natural gas field since the early to middle 1900s. There were 90 liquid and 474 gaseous spills in the New Mexico portion of the San Juan Basin in 2024 (Table 4-11). Additionally, Table 4-12 provides a more in-depth view of both liquid and gaseous spills in 2024.

Table 4-11. Summary of Spills by Year in the FFO (McKinley, Rio Arriba, Sandoval, and San Juan counties)

Material Type	Spill Count by Year										
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Produced water	71	34	48	34	31	45	35	28	32	35	39
Condensate	20	24	12	8	20	18	15	22	33	40	34
Crude oil	23	8	9	7	11	20	9	14	11	12	11
Glycol	0	0	0	0	0	2	0	0	0	1	3
Unknown	0	0	0	0	0	0	0	1	1	1	0
Natural gas (liquid)	12	16	4	2	6	5	0	0	0	1	0
Drilling mud/fluid	0	3	0	0	0	0	0	0	0	0	0
Lube oil	2	0	2	1	1	0	2	0	0	0	0
Other (specify)	3	0	3	3	3	9	10	3	1	6	11
Motor oil	0	0	0	0	1	0	0	0	0	0	0
Chemical (specify)	2	0	0	1	0	0	0	0	0	0	0
Total Liquid Spills	**141**	**91**	**76**	**56**	**80**	**99**	**64**	**68**	**80**	**90**	**90**
Natural gas (flared)	0	0	0	0	0	0	0	132	775	313	281
Natural gas (vented)	0	0	0	0	0	0	0	30	89	70	193
Natural gas (methane)	104	70	34	27	20	24	21	12	0	0	0
Total Gaseous Spills	**104**	**70**	**34**	**27**	**20**	**24**	**21**	**174**	**864**	**383**	**474**

Source: NMOCD (2025d)

Note: FracFocus does not differentiate between natural gas flaring/venting and a normal liquid spill that could occur during the hydraulic fracturing process; therefore, this table reflects two total value rows (one total value for conventional spills and one for natural gas flaring and venting). Natural gases that are vented and flared are done so intentionally as part of the hydraulic fracturing process with no expected spill recovery.

Table 4-12. Summary of 2024 Spills in the FFO (McKinley, Rio Arriba, Sandoval, and San Juan counties)

Material Type*	Spill Count	Volume Spilled	Volume Lost	Units	Average Volume Spilled	Percent Lost	Waterways Affected	Groundwater Affected
Produced water	39	2,842	1,638	bbl	72.87	87.49	1	0
Condensate	34	302	302	bbl	8.88	100	4	0
Crude oil	11	673	277	bbl	61.18	75.14	0	0
Produced water	35	1,692	1,224	bbl	48	77	0	0

Material Type*	Spill Count	Volume Spilled	Volume Lost	Units	Average Volume Spilled	Percent Lost	Waterways Affected	Groundwater Affected
Other (specify)	3	175.19	150.19	bbl	58.40	87.56	0	0
Glycol	3	12.59	15.59	bbl	4.20	100	0	0
Total Liquid Spills	**90**	**4004.79**	**2379.79**	**bbl**	**41.11**	**90.04**	**5**	**0**
Natural gas flared	281	68,985	68,985	Mcf	245.50	100	0	0
Natural gas vented	193	36,966	36,966	Mcf	191.53	100	7	0
Total Gaseous Spills	**474**	**105,951**	**105,951**	**Mcf**	**218.52**	**100**	**7**	**0**

Source: NMOCD (2025a, 2025d)

Note: FracFocus does not differentiate between natural gas flaring/venting and a normal liquid spill that could occur during the hydraulic fracturing process; therefore, this table reflects two total value rows (one total value for conventional spills and one for natural gas flaring and venting). Natural gases that are vented and flared are done so intentionally as part of the hydraulic fracturing process with no expected spill recovery.

* No spills of brine water, chemicals, drilling mud/fluid, gelled brine (frac fluid), lube oil, sulfuric acid, or natural gas (methane) were reported in 2025, as of May 2025.

In 2024, ability for spill recovery varied by spill type, but in general, for liquid spills about 90% of all spills were lost. Gaseous spills had a 100% loss rate in 2024 (due to the ignition process of flared and vented natural gas compounds). In 2024, 12 spill incidents were reported as having affected surface waterways. The BLM works with NMOCD to remediate spills associated with federal oil and gas wells, including spills from federal wells drilled on private or state land. According to NMAC 19.15.29.11, the responsible person shall complete NMOCD-approved corrective action for releases that endanger public health or the environment in accordance with a remediation plan submitted to and approved by NMOCD or with an abatement plan submitted in accordance with NMAC 19.15.30. The remaining contaminants from unrecovered spills are remediated in accordance with federal and state standards. Some remediation consists of removing contaminated soil and replacing it with uncontaminated soil and performing corresponding chemical testing.

According to FracFocus, from 2014 through 2024, most entries (5,285) within the San Juan Basin were unnamed (i.e., did not include an ingredient name or CAS number, but were still entered into the FracFocus registry as unnamed ingredients used for some purpose during the hydraulic fracturing process). Unnamed ingredients represented 13.42% of all FracFocus disclosures and 18.31% of the total hydraulic fracturing jobs (volume by percent mass) within the San Juan Basin from 2014 to 2024. 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 FFO wells from 2014 through 2024.

Not including unnamed ingredients, water is the most commonly disclosed ingredient in hydraulic fracturing operations within the San Juan Basin with 2,514 disclosures, representing 6.38% of all FracFocus disclosures and 23.08% of the total hydraulic fracturing jobs (chemical volume by percentage mass) from 2014 through 2024. Methanol (1,641 disclosures) and crystalline silica (1,109 disclosures) represent the next most commonly reported chemical constituents of hydraulic fracturing operations (Table 4-13) (FracFocus 2025).

Table 4-13. Most Frequently Disclosed Ingredients in Wells within the San Juan Basin (McKinley, Rio Arriba, Sandoval, and San Juan counties) 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	5,285	18.31	13.42
Water	7732-18-5	2,514	23.08	6.38
Methanol	67-56-1	1,641	0.01	4.17
Crystalline silica (quartz)	14808-60-7	1,109	18.11	2.82
Isopropyl alcohol	67-63-0	1,104	0.02	2.80
Sodium chloride	7647-14-5	730	0.03	1.85
Quaternary amine	Varies	584	0.00	1.48
Propargyl alcohol	107-19-7	583	0.00	1.48
Ethanol	64-17-5	564	0.01	1.43
Nitrogen	7447-40-7	506	22.93	1.28
Amine salts	64-19-7	488	0.00	1.24
Naphthalene	91-20-3	469	0.00	1.19
Heavy aromatic petroleum aphtha	64742-94-5	446	0.01	1.13
Guar gum	9000-30-0	430	0.14	1.09
Hydrochloric acid	7647-01-0	430	0.26	1.09
Inner salt of alkylamines	Varies	413	0.05	1.05
2-Butoxyethanol	111-76-2	410	0.01	1.04
Glycerin	56-81-5	410	0.01	1.04
Alcohols, C14-15, ethoxylated	68951-67-7	391	0.00	0.99
Ethylene glycol butyl ether	111-76-2	390	0.03	0.99
Formaldehyde	50-00-0	373	0.01	0.95
Poly(oxy-1,2-ethanediyl, alpha-(4-nonylphenyl)-omega-hydroxy-, branched	127087-87-0	358	0.00	0.91
1,2,4 trimethylbenzene	95-63-6	349	0.00	0.89
Ethylene glycol	107-21-1	308	0.01	0.78
Ammonium persulfate	7727-54-0	293	0.01	0.74
Hydroxyalkyl ammonium chloride	Varies	293	0.03	0.74
Hemicellulase enzyme	Varies	274	0.00	0.70
Oxylated phenolic resin	Varies	245	0.00	0.62
Acetic acid	64-19-7	241	0.01	0.61
Cured acrylic resin	varies	239	0.00	0.61

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 number of disclosures and ingredients presented in this table are to be used for general information only.

Table includes only the top 30 most frequently reported 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 total number of FracFocus ingredient disclosures in the FFO area from 2014 through 2024 is 39,385.

‡ The amount of the ingredient in the total hydraulic fracturing volume by percent mass (definition from FracFocus [2024] data dictionary).

4.2.3.2 Drilling and Completion Activities

When wells are drilled, they most likely pass through usable groundwater aquifers currently or potentially supplying stock, residential, and/or irrigation water. If proper cementing and casing programs are not followed, there may be a loss of well integrity, surface spills, or loss of fluids in the drilling and completion process that could result in large volumes of high concentrations of chemicals reaching groundwater resources. If contamination of usable water aquifers (TDS less than 10,000 ppm) from any source occurs, changes in groundwater quality could impact springs and water wells that are sourced from the affected aquifers.

The BLM and NMOCD have casing, cementing, and inspection requirements in place to limit the potential for groundwater reservoirs and shallow aquifers to be impacted by hydraulic fracturing or the migration of hydrocarbons during oil and gas drilling and production activities. The BLM requires operators to comply with the regulations at 43 C.F.R. § 3160. In addition, these regulations require oil and gas development to comply with directives in the Onshore Oil and Gas Orders and the orders of the Authorized Officer. Regulatory requirements for hydraulic fracturing, including casing specifications, monitoring and recording, and management of recovered fluids are located in 43 C.F.R. § 3170 and 43 C.F.R. § 3162.3-3. New Mexico also has regulations for drilling, casing and cementing, completion, and plugging to protect freshwater zones (NMAC 19.15.16). Complying with the aforementioned regulations requires producers and regulators to verify the integrity of casing and cementing jobs. Casing specifications are designed and submitted to the BLM in a drilling plan as a component of an APD. The BLM petroleum engineer independently reviews the drilling plan and, based on site-specific geologic and hydrologic information, ensures that proper drilling, casing, and cementing procedures are incorporated in the plan to protect usable groundwater. The aforementioned regulations and review practices surrounding proper casing and cementing procedures isolate usable water zones from drilling, completion/hydraulic fracturing fluids, and fluids from other mineral-bearing zones, including hydrocarbon-bearing zones. COAs may be attached to the APD, if necessary, to ensure groundwater protection. These may include requirements for closed loop drilling systems, spill prevention plans, leak detection plans, and appropriate equipment (leak detection and automatic shutoff system) in sensitive groundwater recharge areas. Casing and cementing operations are witnessed by certified BLM PETs. At the end of the well's economic life, the operator is required to submit a plugging plan to the BLM for approval. A BLM petroleum engineer will review the plan prior to commencement of the plugging operations. The BLM PETs witness plugging operations to ensure the planned procedures are properly followed. The BLM's review, approval, and inspections ensure the permanent isolation of usable groundwater from hydrocarbon-bearing zones.

In summary, the BLM, the NMED, and NMOCD have put in place numerous requirements for oil and gas producers so that drilling fluids, hydraulic fracturing fluids, and produced water and hydrocarbons remain within the well bore and do not enter groundwater or any other formations. These include BLM regulations covered under 43 C.F.R. § 3160; 43 C.F.R. § 3170; 43 C.F.R. § 3162.3-3; 43 C.F.R. § 3162.3-5; NTL-3A; NMOCD regulations under NMAC 19.15.26; and the state's primacy agreement under the Safe Drinking Water Act. With these requirements in place, including the use of casing and cementing measures, contamination of groundwater resources from development of the lease parcels is highly unlikely. In addition, the BLM has authority under standard terms and conditions to require additional measures to protect water quality if site-specific circumstances require them. Site-specific mitigation tools would be developed as appropriate for the individual circumstances, including groundwater-quality monitoring studies. The regulations at 43 C.F.R. § 3162.5-2(d) give the BLM the authority to require an operator to monitor water resources to ensure that the isolation procedures used to protect water and other resources are effective.

CHAPTER 5. RIO PUERCO FIELD OFFICE

The RPFO area covers approximately 8,620,838 acres and includes Bernalillo, Cibola, Torrance, and Valencia counties; most of Sandoval County; and small parts of McKinley and Santa Fe counties (Figure 5-1). To date, most of the drilling in the RPFO area has occurred in the northeastern corner of Sandoval County, which is in the San Juan Basin (FracFocus 2025). Additionally, the 2019 RFD predicts that future oil and gas development will occur in the San Juan Basin (Crocker et al. 2019).

This chapter outlines existing and projected (reasonably foreseeable) water quantity and water quality conditions for the RPFO area. The analysis is based on information gathered from the following sources:

- The RFD for the RPFO (Crocker et al. 2019)
- 2015 consumptive water use data from the USGS report *Estimated Use of Water in the United States in 2015* (Dieter et al. 2018)
- FracFocus, a national hydraulic fracturing chemical registry managed by the GWPC and IOGCC (FracFocus 2025)
- Spill data from the NMOCD database (NMOCD 2025a)
- Personal communication with the BLM on well completion type data

5.1 WATER QUANTITY

5.1.1 Existing Surface Water and Groundwater Use

The water use of counties within the RPFO area varies greatly and is dependent on the predominant industry within a given county. In 2015, public water supply and domestic water withdrawals comprised the greatest proportion of water use in McKinley County (53%; 7,006 AF) (Table 5-1; Figure 5-2). Valencia and Bernalillo counties represent the largest water users within the RPFO. Bernalillo County (which contains Albuquerque) consumed 155,382 AF of water in 2015, with public water supply (69%; 106,820 AF) and irrigation (30%; 46,544 AF) representing 99% of water withdrawals (Table 5-2). Valencia County is directly south of Bernalillo County and withdrew 156,794 AF of water in 2015 (Table 5-2), whereas all other counties within the RPFO withdrew less than 75,000 AF of water in 2015. Irrigation used the greatest proportion of water in Sandoval (71%; 50,647 AF), Valencia (93%; 146,246 AF), Torrance (94%; 45,849 AF), Santa Fe (62%; 24,314 AF), and Cibola (50%; 5,448 AF) counties (Table 5-3 through Table 5-7, respectively). Water withdrawals associated with mining (which includes oil and gas development), ranged from 112 to 2,309 AF (in Torrance and McKinley counties, respectively). The proportion of surface water and groundwater use varied by county and was also industry specific. Water withdrawals for all RPFO counties totaled 495,874 AF (Table 5-8), with surface water and groundwater comprising 60% and 40%, respectively. Mining activities consumed 5,953 AF, which made up 1% of water extractions in 2015 (see Figure 5-2). Irrigation, at 320,146 AF (65% of total withdrawals), was the sector that consumed the greatest amount of water within the RPFO area (see Figure 5-2). Irrigation, at 320,146 AF, made up approximately 10% of all water extractions within the state (3,249,667 AF).

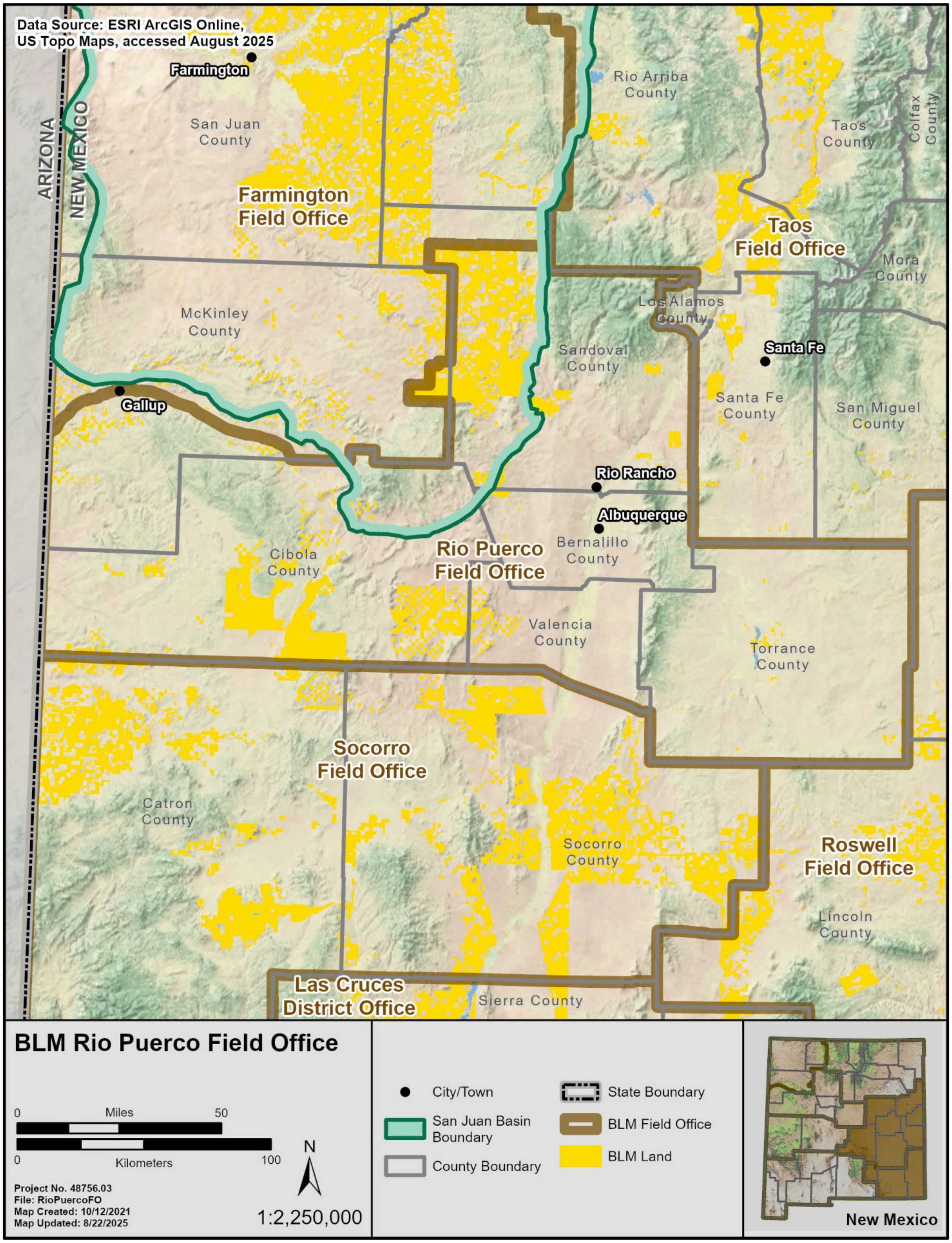

Figure 5-1. Map of BLM RPFO boundaries.

Table 5-1. McKinley 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%	3,195	–	3,195	24%	3,195	24%	–	0%	3,195	24%
Industrial	0	0	0	0%	34	0	34	<1%	34	<1%	0	0%	34	<1%
Irrigation	1,099	–	1,099	8%	0	–	0	0%	1,099	8%	–	0%	1,099	8%
Livestock	101	–	101	<1%	370	–	370	3%	471	4%	–	0%	471	4%
Mining	0	0	0	0%	1,625	684	2,309	17%	1,625	12%	684	5%	2,309	17%
Public water supply	0	0	0	0%	3,811	0	3,811	29%	3,811	29%	0	0%	3,811	29%
Thermoelectric power	0	0	0	0%	2,298	0	2,298	17%	2,298	17%	0	0%	2,298	17%
County Totals	**1,199**	**0**	**1,199**	**9%**	**11,333**	**684**	**12,017**	**91%**	**12,533**	**95%**	**684**	**5%**	**13,217**	**100%**

Source: Dieter et al. (2018)

Note: Water use data are presented in acre-feet 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, which amounted to 13,217 acre-feet.

Table 5-2. Bernalillo 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%	22	0	22	<1%	22	<1%	0	0%	22	<1%
Domestic	0	–	0	0%	1,312	–	1,312	<1%	1,312	<1%	–	0%	1,312	<1%
Industrial	0	0	0	0%	56	0	56	<1%	56	<1%	0	0%	56	<1%
Irrigation	38,843	–	38,843	25%	7,701	–	7,701	5%	46,544	30%	–	0%	46,544	30%
Livestock	11	–	11	<1%	191	–	191	<1%	202	<1%	–	0%	202	<1%
Mining	0	0	0	0%	135	0	135	<1%	135	<1%	0	0%	135	<1%
Public water supply	52,743	0	52,743	34%	54,077	0	54,077	35%	106,820	69%	0	0%	106,820	69%
Thermoelectric power	0	0	0	0%	291	0	291	<1%	291	<1%	0	0%	291	<1%
County Totals	**91,597**	**0**	**91,597**	**59%**	**63,785**	**0**	**63,785**	**41%**	**155,382**	**100%**	**0**	**0%**	**155,382**	**100%**

Source: Dieter et al. (2018)

Note: Water use data are presented in acre-feet 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, which amounted to 155,382 acre-feet.

Table 5-3. Sandoval 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%	1,087	0	1,087	2%	1,087	2%	0	0%	1,087	2%
Domestic	0	–	0	0%	3,128	–	3,128	4%	3,128	4%	–	0%	3,128	4%
Industrial	0	0	0	0%	2,578	0	2,578	4%	2,578	4%	0	0%	2,578	4%
Irrigation	48,326	–	48,326	68%	2,320	–	2,320	3%	50,647	71%	–	0%	50,647	71%
Livestock	101	–	101	<1%	123	–	123	<1%	224	<1%	–	0%	224	<1%
Mining	0	0	0	0%	1,065	247	1,312	2%	1,065	1%	247	<1%	1,312	2%
Public water supply	135	0	135	<1%	12,466	0	12,466	17%	12,600	18%	0	0%	12,600	18%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
County Totals	**48,562**	**0**	**48,562**	**68%**	**22,768**	**247**	**23,014**	**32%**	**71,329**	**100%**	**247**	**<1%**	**71,576**	**100%**

Source: Dieter et al. (2018)

Note: Water use data are presented in acre-feet 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, which amounted to 71,576 acre-feet.

Table 5-4. Valencia 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%	3,554	–	3,554	2%	3,554	2%	–	0%	3,554	2%
Industrial	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Irrigation	136,157	–	136,157	87%	10,089	–	10,089	6%	146,246	93%	–	0%	146,246	93%
Livestock	34	–	34	<1%	986	–	986	<1%	1,020	<1%	–	0%	1,020	<1%
Mining	0	0	0	0%	437	0	437	<1%	437	<1%	0	0%	437	<1%
Public water supply	0	0	0	0%	5,538	0	5,538	4%	5,538	4%	0	0%	5,538	4%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
County Totals	**136,190**	**0**	**136,190**	**87%**	**20,604**	**0**	**20,604**	**13%**	**156,794**	**100%**	**0**	**0%**	**156,794**	**100%**

Source: Dieter et al. (2018)

Note: Water use data are presented in acre-feet 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, which amounted to 156,794 acre-feet.

Table 5-5. Torrance 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%	437	–	437	<1%	437	<1%	–	0%	437	<1%
Industrial	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Irrigation	0	–	0	<1%	45,849	–	45,849	94%	45,849	94%	–	0%	45,849	94%
Livestock	45	–	45	0%	605	–	605	1%	650	1%	–	0%	650	1%
Mining	0	0	0	0%	112	0	112	<1%	112	<1%	0	0%	112	<1%
Public water supply	0	0	0	0%	1,973	0	1,973	4%	1,973	4%	0	0%	1,973	4%
Thermoelectric power	0	0	0	<1%	0	0	0	0%	0	0%	0	0%	0	0%
County Totals	**45**	**0**	**45**	**<1%**	**48,976**	**0**	**48,976**	**100%**	**49,021**	**100%**	**0**	**0%**	**49,021**	**100%**

Source: Dieter et al. (2018)

Note: Water use data are presented in acre-feet 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, which amounted to 49,021 acre-feet.

Table 5-6. Santa Fe 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%	2,522	–	2,522	6%	2,522	100%	–	0%	2,522	6%
Industrial	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Irrigation	11,378	–	11,378	29%	12,936	–	12,936	33%	24,314	100%	–	0%	24,314	62%
Livestock	56	–	56	<1%	67	–	67	<1%	123	100%	–	0%	123	<1%
Mining	0	0	0	0%	224	0	224	<1%	224	100%	0	0%	224	<1%
Public water supply	4,663	0	4,663	12%	7,186	0	7,186	18%	11,849	100%	0	0%	11,849	30%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
County Totals	**16,098**	**0**	**16,098**	**41%**	**22,936**	**0**	**22,936**	**59%**	**39,033**	**100%**	**0**	**0%**	**39,033**	**100%**

Source: Dieter et al. (2018)

Note: Water use data are presented in acre-feet 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, which amounted to 39,033 acre-feet.

Table 5-7. Cibola 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%	1,143	–	1,143	100%	1,143	11%	–	0%	1,143	11%
Industrial	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
Irrigation	1,592	–	1,592	15%	3,856	–	3,856	71%	5,448	50%	–	0%	5,448	50%
Livestock	34	–	34	<1%	135	–	135	80%	168	2%	–	0%	168	2%
Mining	0	0	0	0%	67	1,356	1,424	100%	67	<1%	1,356	13%	1,424	13%
Public water supply	0	0	0	0%	2,668	0	2,668	100%	2,668	25%	0	0%	2,668	25%
Thermoelectric power	0	0	0	0%	0	0	0	0%	0	0%	0	0%	0	0%
County Totals	**1,625**	**0**	**1,625**	**15%**	**7,869**	**1,356**	**9,226**	**85%**	**9,495**	**88%**	**1,356**	**13%**	**10,851**	**100%**

Source: Dieter et al. (2018)

Note: Water use data are presented in acre-feet 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, which amounted to 10,851 acre-feet.

Table 5-8. RPFO Counties 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%	1,110	0	1,110	<1%	1,110	<1%	0	0%	1,110	<1%
Domestic	0	–	0	0%	15,290	–	15,290	3%	15,290	3%	–	0%	15,290	3%
Industrial	0	0	0	0%	2,668	0	2,668	<1%	2,668	<1%	0	0%	2,668	<1%
Irrigation	237,394	–	237,394	48%	82,752	–	82,752	17%	320,146	65%	–	0%	320,146	65%
Livestock	381	–	381	<1%	2,477	–	2,477	<1%	2,859	<1%	–	0%	2,859	<1%
Mining	0	0	0	0%	3,666	2,287	5,953	1%	3,666	<1%	2,287	<1%	5,953	1%
Public water supply	57,541	0	57,541	12%	87,718	0	87,718	18%	145,259	29%	0	0%	145,259	29%
Thermoelectric power	0	0	0	0%	2,590	0	2,590	<1%	2,590	<1%	0	0%	2,590	<1%
County Totals	**295,316**	**0**	**295,316**	**60%**	**198,271**	**2,287**	**200,558**	**40%**	**493,588**	**100%**	**2,287**	**<1%**	**495,874**	**100%**

Source: Dieter et al. (2018)

Note: Water use data are presented in acre-feet 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, which amounted to 495,874 acre-feet.

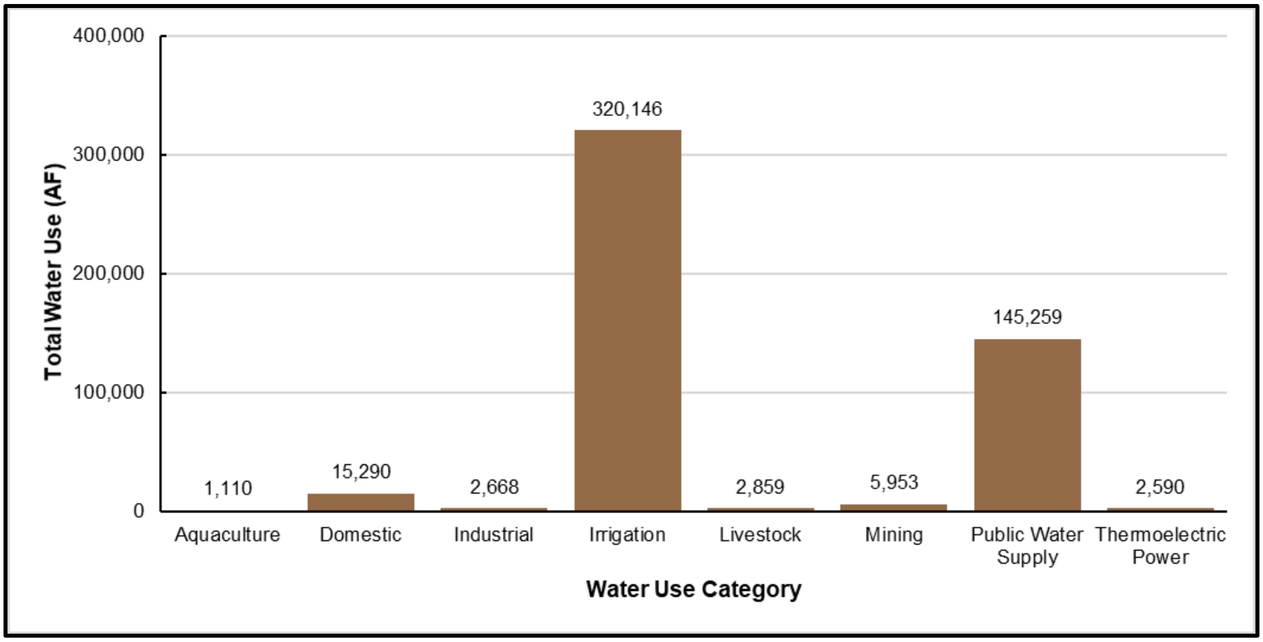

Figure 5-2. RPFO (Bernalillo, Cibola, Torrance, Valencia, Sandoval, McKinley, and Santa Fe counties) water use by category in 2015 (Dieter et al. 2018).

5.1.2 Water Use Associated with Reasonably Foreseeable Oil and Gas Development

In 2019, a new RFD was published (Crocker et al. 2019) that updates the estimates for the number of oil and gas wells that could reasonably be developed within the boundaries of the RPFO. Although the RPFO area encompasses several counties, the only county with consistent oil and gas well development is Sandoval County, with 12 wells. As such, oil and gas development scenarios and discussion in this chapter assume that all development will occur in the portion of Sandoval County within the RPFO area.

The 2019 RFD (Crocker et al. 2019) forecasts development of 200 oil and gas wells (federal and non-federal) over a 20-year period from 2020 to 2039. Of the 200 projected wells, 160 are expected to be vertical and 40 are expected to be horizontal. Annual well counts are expected to increase from seven to 13 per year from 2020 to 2039.

The 2019 RFD was also used to forecast estimates of the quantity of water that would be required for hydraulic fracturing of the forecasted wells. These water use estimates assume that 100% of wells will be hydraulically fractured and do not account for reuse or recycling of hydraulic fracturing fluid. These are conservative water use estimates, as the 2019 RFD suggests that most wells would be vertical wells, which typically require less water to drill than horizontal wells. The quantity of water used during hydraulic fracturing is expected to increase from 8.34 to 22.49 AF/year from 2020 to 2039, with an estimated total water use of 308 AF over the 20-year period. The water use projections assume that one vertical well will require 0.32 AF and one horizontal well with a 1-mile lateral will require 6.44 AF (Crocker et al. 2019).

Water used for development of the estimated 200 wells in the 2019 RFD scenario is assumed to come primarily from groundwater sources, based on previous oil and gas development in the area and USGS county water use data (see Table 5-3). Projected well developments within Sandoval County were estimated at 23.4% of the 2015 mining water use and 0.43% of the 2015 total water consumption, based on dividing the projected 308 AF over the 20-year period by the 2015 mining and total water use volumes reported in Table 5-3. Due to the split of Sandoval County between the FFO and RPFO and the lack of historical water use data, it is difficult to accurately predict the water use of oil and gas development throughout the county over the next 20 years.

5.1.3 Water Use Trends and Planned Actions

5.1.3.1 Past and Present Actions

Although there are well completions reported in the BLM Automated Fluid Minerals Support System, since 2014 there have been no completed oil and gas wells (federal or non-federal) reported to FracFocus within the administrative boundaries of the RPFO (FracFocus 2025). Although there has been consistent development within Sandoval County, the completed oil and gas wells reported in FracFocus are within the FFO area. As such, there are no data available from FracFocus for water use by oil and gas wells within RPFO boundaries, and statistical analysis and forecasting are not possible. With the RPFO's proximity and relationships with the FFO, well reporting estimates for the FFO can be used as reference for the RPFO.

5.1.3.2 Water Use Associated with Reasonably Foreseeable Oil and Gas Development

The 2019 RFD (Crocker et al. 2019) predicted an initial development of seven wells and a water use of 8.34 AF in 2020, which is predicted to increase to 13 wells and a water use of 22.49 AF by 2039, resulting in a 20-year average water use of 15.4 AF/year and a total cumulative water use of 308 AF (Figure 5-3). The projected well developments would be an estimated 23.4% of water used in mining and 0.43% of the total water consumption in 2015 within the RPFO area. In contrast, no water usage associated with hydraulic fracturing has been reported to FracFocus for the RPFO during the 4 years in which FracFocus reporting overlaps with predictions from the 2019 RFD (see Figure 5-3). Despite this, water usage in neighboring Sandoval County is rapidly increasing due to hydraulic fracturing, indicating that oil and gas development in the RPFO may also increase, as predicted by the 2019 RFD. Consequently, cumulative water usage is likely to increase (see Figure 5-3).

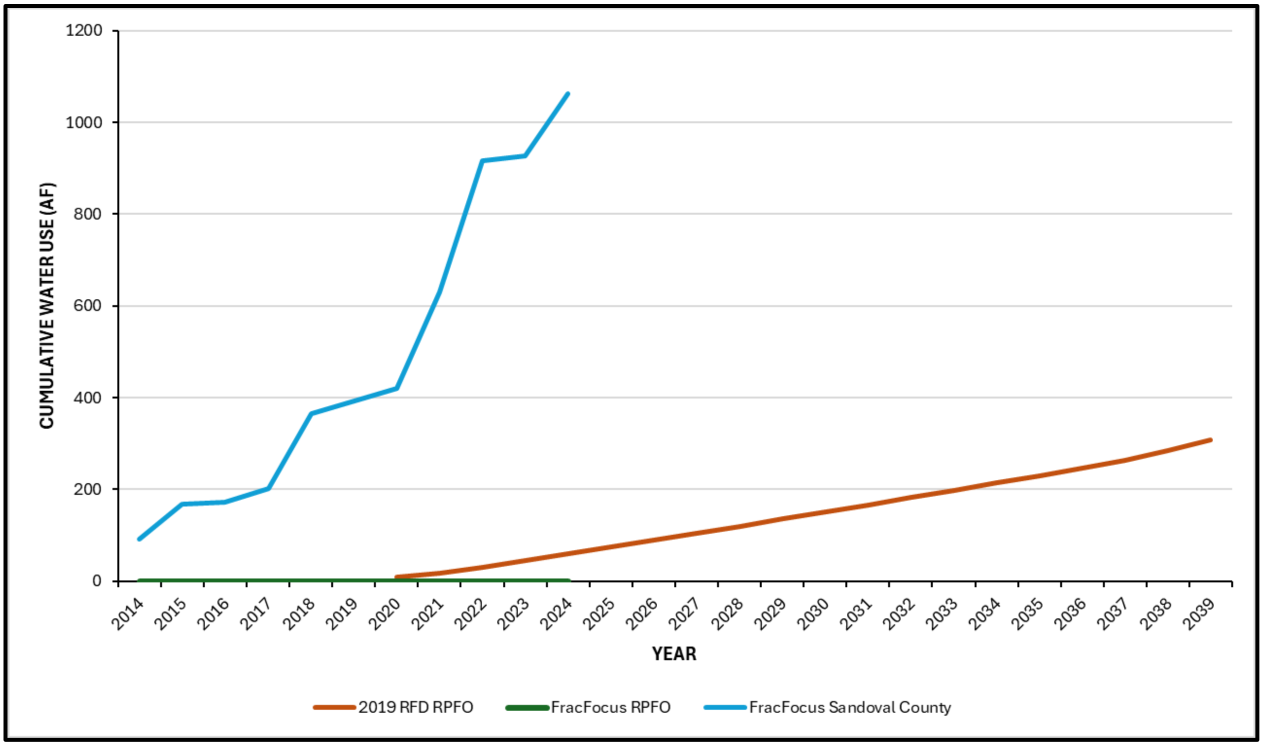

Figure 5-3. Cumulative water use associated with reasonably foreseeable oil and gas development in the RPFO from 2020 through 2039, and FracFocus water reporting for RPFO and Sandoval County from 2014 through 2024.

Water use estimates from the neighboring FFO area may also provide some insight regarding water use by oil and gas wells developed in the RPFO area in the future. From 2014 to 2024, 70 wells (federal and non-federal) in the portion of Sandoval County in the FFO area reported data to the BLM (Section 4.1.2 discusses the water use associated with reasonably foreseeable oil and gas development in the FFO area). In 2024, 11 wells were reported to use slickwater stimulation; however, no wells were reported to use nitrogen and carbon dioxide as a stimulation technique (Table 5-9). Nitrogen and carbon dioxide stimulation methods can be used to reduce water usage during a hydraulic fracturing operation, aiding in the recovery of stimulation fluids (Rogala et al. 2013). The relative distribution of stimulation technologies within a year varies greatly in the FFO area, which makes it difficult to predict total water usage. As such, the values provided in the 2019 RFD should be used for water use projections.

Table 5-9. Descriptive Statistics of Water Use of Oil and Gas Wells in the FFO Portion of Sandoval County for Two Stimulation Techniques in 2024

Stimulation Technique	Number of Wells
Nitrogen and carbon dioxide	0
Slickwater	11

Source: FracFocus (2025)

Note: Wells hydraulically fractured with water were identified as wells that did not use nitrogen or slickwater stimulation. Data are only presented for wells that reported chemical compositions to FracFocus (2025).

5.1.4 Potential Sources of Water for Project Development

The RPFO contains many types of surface waterbodies, including springs, seeps, lakes, rivers, streams, and ephemeral drainages and draws. However, waters from spring developments, reservoirs, streams, and stream diversions within the RPFO planning area are used primarily for irrigation, livestock, and wildlife. Diversions of surface water on BLM-managed lands support private land crop irrigation and stock water needs.

Because most water used in mining activities in the counties that compose the RPFO is currently from groundwater (see Table 5-8), it is reasonable to assume that a large portion of the water used for hydraulic fracturing under the 2019 RFD scenario would likely be groundwater. Groundwater is a more readily available source of water than surface water due to the ephemeral nature of many surface water features in the San Juan Basin.

Information about the aquifers underlying the RPFO comes primarily from *Hydrologic Assessment of Oil and Gas Development of the Mancos Shale in the San Juan Basin* (Kelley et al. 2014) and *Farmington Proposed Resource Management Plan and Final Environmental Impact Statement* (BLM 2003b).
The geologic setting of the region is highly stratified and complex. Geologic processes have created both continuous and discontinuous sandstone aquifers. There are 12 major confined aquifers in the San Juan Basin: San Jose Formation, Nacimiento Formation, Morrison Formation, Ojo Alamo Sandstone, Pictured Cliffs Sandstone, Cliff House Sandstone, Menefee Formation, Kirtland Shale/Fruitland Formation, Point Lookout Sandstone, Gallup Sandstone, Dakota Sandstone, and Entrada Sandstone (Kelley et al. 2014). Most of the groundwater in the San Juan Basin is developed in Cenozoic to Mesozoic sandstones that are separated by low-permeability shale to mudstone intervals (Kelley et al. 2014). Table 5-10 lists the general description of the major formations in the San Juan Basin.

Cenozoic (younger) aquifers in the San Juan Basin, such as the Ojo Alamo Sandstone, the Nacimiento Formation, and the San Juan Formation, have potential to produce water at a rate of 100 gpm (BLM 2003b). Other aquifers in the San Juan Basin are known to yield water at a rate of less than 20 gpm (BLM 2003b). According to Kelley et al. (2014:55), "of the aquifers investigated in this study, the 'true' Gallup Sandstone contains the least amount of water and the San Jose/Nacimiento aquifer contains the most."

In the southern portion of the San Juan Basin, water for hydraulic fracturing of oil wells comes from sources that tap the Nacimiento Formation and the Ojo Alamo Sandstone. Kelley et al. (2014) state, "water level monitoring by the U.S. Geological Survey during the 1980s reveals that long term use of a well drilled into these aquifers will cause water levels to drop, potentially affecting neighboring wells."

Water used for oil and gas drilling and completion would be purchased legally from those who hold water rights in or around the San Juan Basin. The transaction would be handled by NMOCD and NMOSE. Water used for oil and gas drilling and completion would generally be obtained through the following methods:

- Leasing a valid water right through an NMOSE permit
- Buying/leasing water from a legal water provider (or from a private well owner at up to 3 AF)
- Purchasing water from a non-potable reclaimed water supplier

It is difficult to predict the actual source of water that would be used for development of the RPFO RFD (or the development of any specific lease sales) because in addition to using surface water or groundwater, operators may also bring water to a well site via truck from many different sources.
All water uses would be evaluated at the APD stage in site-specific NEPA analysis and subject to

standard lease terms and conditions; however, it is important to note that sources of water for lease development are also not always known at the APD stage.

Table 5-10. General Description of the Major Rock Units in the San Juan Basin

Geologic Age	Formation	Rock Type (major rock listed first)	Resource
Cenozoic	San Jose Formation	Sandstone and shale	Water, gas
	Nacimiento Formation	Shale and sandstone	Water, gas
	Ojo Alamo Sandstone	Sandstone and shale	Water, gas
Cretaceous	Kirtland Shale	Interbedded shale, sandstone	Water, oil, gas
	Fruitland Shale	Interbedded shale, sandstone, and coal	Coal, coalbed, methane
	Pictured Cliffs Sandstone	Sandstone	Oil, gas
	Lewis Shale	Shale, thin limestones	Gas
	Cliff House Sandstone	Sandstone	Oil, gas
	Menefee Formation	Interbedded shale, sandstone, and coal	Coal, coalbed, methane, gas
	Point Lookout Sandstone	Sandstone	Oil, gas, water
	Crevasse Canyon Formation	Interbedded shale, sandstone, and coal	Coal
	Gallup Sandstone	Sandstone, and a few shales, and coals	Oil, gas, water
	Mancos Shale	Shale, thin sandstones	Oil, gas
	Dakota Sandstone	Sandstone, shale, and coals	Oil, gas, water
Jurassic	Morrison Formation	Mudstones, sandstone	Uranium, oil, gas, water
	Wanakah/Summerville/Cow Springs/Bluff Formation	Siltstone, sandstone	N/A
	Entrada Sandstone	Sandstone	Oil, gas, water

Source: Kelley et al. (2014)

N/A = not applicable.

Note: Table is sorted by geologic age, youngest to oldest.

5.1.5 Water Use Mitigation Measures

Public concern about water use from hydraulic fracturing is especially high in semiarid regions. Overall, there have been calls to increase the use of alternative water sources such as brackish water and produced water to minimize the strain on local freshwater resources (Kondash et al. 2018). The BLM encourages the use of recycled water in hydraulic fracturing techniques, and in 2019, New Mexico passed the Produced Water Act, which encourages oil and gas producers to reuse produced water when possible rather than relying on freshwater sources for oil and gas extraction. Recent studies indicate that the water used for hydraulic fracturing may be retained within the shale formation, with only a small fraction of the fresh water injected into the ground returning as flowback water; water returning to the surface is highly saline, difficult to treat, and often disposed through deep injection wells (Kondash et al. 2018).
The NMED signed an MOU with New Mexico State University in 2022 to develop new technologies for treating produced water to inform future policies for produced water reuse.

In September 2023, NMED began drafting the State's Ground and Surface Water Protection – Supplemental Requirements for Water Reuse (20.6.8 NMAC) regulations which focus on the restricted reuse of produced water. The proposed regulation would prohibit the discharge of both untreated and treated produced water to groundwater, including subsurface water in aquifers that are used for drinking water and other purposes. Specifically, produced water would not be permitted to be discharged to or disposed of on land, as such practices could result in leaching into aquifers from the surface and subsequent contamination of groundwater. In addition, the regulation would prohibit the discharge of produced water to surface waters, such as rivers, streams, lakes, wetlands, and arroyos. Furthermore, the regulation would establish requirements for the use of produced water in "demonstration projects" and "industrial projects." These requirements include explicit prohibitions on the discharge of produced water to ground and surface waters, and mandates that project operators develop spill prevention plans and assume financial responsibility for cleanup in the event of a spill, accident, or discharge. A draft version of the proposed NMAC 20.6.8 regulations can be found on the NMED website (NMED 2024a).

5.2 WATER QUALITY

5.2.1 Groundwater

Results of the hydrologic assessment of oil and gas development of the Mancos Shale in the San Juan Basin (Kelley et al. 2014) indicate that groundwater quality in the San Juan Basin is variable (ranging from fresh to brackish) due to the complex stratigraphy and varying rock formations within the basin. Brackish and saline water is typically found in the center of the basin, while fresh groundwater is typically found along the basin margins. Deep saline water can migrate upward along cracks and fissures. Fresh water along the basin margins at depths greater than 3,500 feet indicates fast recharge rates influenced by geologic structures (Kelley et al. 2014).

The geologic formation where groundwater resides also influences groundwater salinity. Figure 5-4 (Kelley et al. 2014) is an illustrated geologic cross section showing the distribution of saline aquifers within the San Juan Basin.

TDS concentration is a measure of dissolved matter in a sample of water. TDS is the primary indicator of groundwater quality, as higher TDS concentrations typically make water less suitable for drinking or agricultural purposes such as irrigation. In groundwater, TDS is influenced by the dissolution of natural materials such as rock, soil, and organic material. Anthropogenic activities also contribute to TDS concentrations in shallow, unconfined aquifers.

TDS concentration in the San Juan Basin is dependent on the stratigraphic location and geologic formation where the water resides. Fresh water (TDS <1,000 mg/L) is typically found at depths less than 2,500 feet below the ground surface, although exceptions to this generalization occur in deeper layers such as the Gallup Sandstone and Morrison Formation. Saline and brackish water is dominant in the center of the basin at greater depths (Kelley et al. 2014).

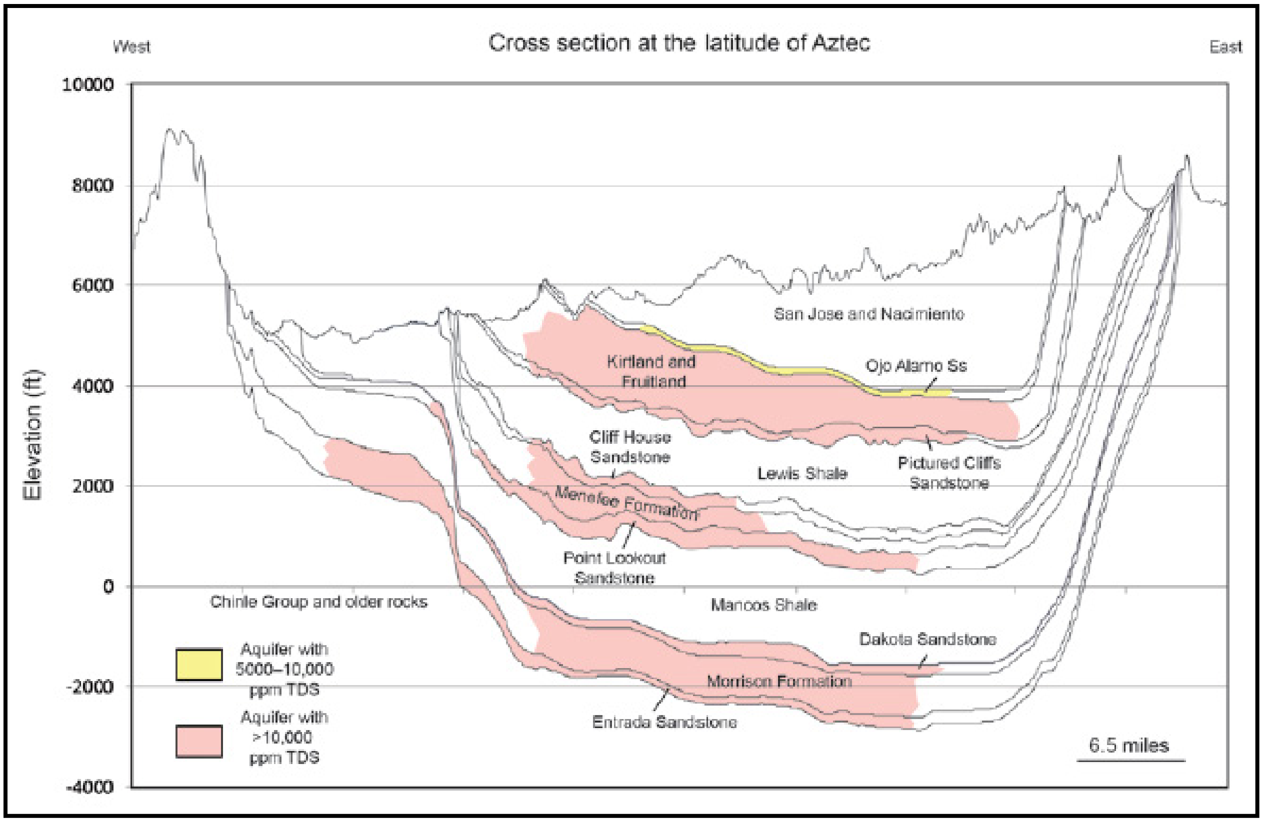

Figure 5-4. Geologic cross section showing the distribution of saline aquifers in the San Juan Basin (Kelley et al. 2014).

5.2.2 Surface Water

The dominant legislation affecting national water quality and BLM compliance with New Mexico water quality requirements is the CWA. The RPFO hosts diverse surface waters from reservoirs to streams and rivers. Many streams and rivers on BLM land within the RPFO are ephemeral, flowing during major precipitation events. The major river within the RPFO is the Rio Puerco. The Rio Puerco is intermittent through most of its length, with higher elevations receiving snowmelt and precipitation runoff events and the lower reach dominated by convective rainfall-runoff events (USGS 2000). High flows primarily occur between July and October from convective thunderstorms (Vincent et al. 2009). The Rio Puerco supplies more than 70% of suspended sediment entering the Rio Grande above Elephant Butte reservoir, all while providing 4% of the average annual runoff into the Rio Grande (Gellis et al. 2012; USGS 2000). Aside from the Rio Puerco, the RPFO region surface water systems are dominated by ephemeral drainages that only experience flows during monsoon rains.

A 2004 water quality study conducted in the Rio Puerco Watershed found water quality exceedances were attributed to various causes such as phosphorus, nitrogen, aluminum, sedimentation, temperature, and bacteria in several assessment units. Of these, the most ecologically significant are the effects of sedimentation and temperature. The watershed's sedimentation issues have led to decreases in sinuosity and increases in gradient that led to further downcutting. Additionally, increasing water temperatures can stress aquatic communities (NMED 2010).

The Rio Puerco Watershed (HUC 13020204) includes 17 assessment unit (AU) stretches of the river. Each stretch includes an IR category (Categories 1 through 5). Category 1 indicates that an AU meets designated uses. Category 2 indicates that at least one designated use is supported; however, there is insufficient data to permit assessment of all uses. Category 3 indicates that there is insufficient data to determine an IR Category. Category 4 includes waters that are impaired; however a plan or TMDL is already in place, or the impairment is due to pollution broadly, and not specifically identified pollutants. Finally, Category 5 includes AUs that are impaired and require a total maximum daily load (TMDL).

According to the 2024–2026 State of New Mexico Clean Water Act §303(d)/§305(b) IR, there are six AU stretches of the Rio Puerco listed as Category 4 or 5. Causes of impairment across the six impaired AU stretches of the Rio Puerco include aluminum, temperature, turbidity, sedimentation/siltation, nutrients, and *E. coli*. Additionally, eight AU stretches of the Rio Puerco are Category 3, indicating there is insufficient data to come to an IR determination. Two AU stretches are listed as Category 2, and one AU stretch is listed as Category 1. Impaired stretches (Category 4 or 5) of the Rio Puerco and causes of impairment include the following (NMED 2024b):

- La Jara Creek (perennial reaches above Arroyo San Jose) listed Category: 4A; impairments include aluminum (2016 TMDL)
- Nacimiento Creek (perennial portion New Mexico State Road 126 to Clear Creek) listed Category: 5/5A; impairments include temperature (estimated 2026 TMDL), turbidity (2016 TMDL), and aluminum (2016 TMDL)
- Rio Puerco (Arroyo Chijuilla to northern boundary Cuba) listed Category 5/5A; impairments include aluminum (estimated 2026 TMDL), nutrients (2007 TMDL), and sedimentation/siltation (2007 TMDL)
- Rio Puerco (perennial portion northern boundary Cuba to headwaters) listed Category 5/5A; impairments include aluminum (estimated 2026 TMDL), sedimentation/siltation (2016 TMDL), and *E. coli* (estimated 2026 TMDL)
- Rio Puerco (non-pueblo Arroyo Chico to Arroyo Chijuilla) listed Category 5/5A; impairments include *E. coli* (estimated 2026 TMDL)
- Rio Puerco (non-pueblo Rio Grande to Arroyo Chico) listed Category 5/5A; impairments include *E. coli* (2022 TMDL), and aluminum (estimated 2026 TMDL)

5.2.3 Potential Sources of Surface Water or Groundwater Contamination

5.2.3.1 Spills

In total, 154 gaseous spills and seven liquid spills occurred in the Rio Puerco portion of the San Juan Basin in 2024 (NMOCD 2025a) (Table 5-11 and Table 5-12). The percentage of a spill that was not recovered (the amount lost) varied by material that was spilled, but on average, about 46% and 100% of liquid and gaseous spill materials were lost, respectively. Of the spills in 2024, no incidents were reported as having affected surface waterways (see Table 5-12) (NMOCD 2025a). The BLM works with NMOCD to remediate spills on BLM-managed lands. According to NMAC 19.15.29.11, the responsible person shall complete NMOCD-approved corrective action for releases that endanger public health or the environment in accordance with a remediation plan submitted to and approved by NMOCD or with an abatement plan submitted in accordance with NMAC 19.15.30. The remaining contaminants from unrecovered spills are remediated in accordance with federal and state standards. Some remediation consists of removing contaminated soil and replacing it with uncontaminated soil and performing corresponding chemical testing. See Table 5-11 for total spill counts from 2014 through 2024 and Table 5-12 for a breakdown of 2024 spills. The increase in reported natural gas spills observed since 2021 is a result of a new reporting rule. See Section 3.2.3.1 for more details. No spills were reported in Bernalillo, McKinley, Torrance, Valencia and Santa Fe counties in 2024.

Table 5-11. Summary of Spills by Year in the Rio Puerco Portion of the San Juan Basin (Sandoval County)

Material Type*	Spill Count by Year										
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Chemical (specify)	1	0	0	0	0	0	0	0	0	0	0
Crude oil	3	1	1	0	2	5	1	4	1	1	4
Other (specify)	4	1	0	1	0	1	0	0	0	0	1
Produced water	1	2	0	1	2	3	1	2	1	0	2
Total Liquid Spills	**9**	**4**	**1**	**2**	**4**	**9**	**2**	**6**	**2**	**1**	**7**
Natural gas (methane)	3	0	0	0	0	0	0	0	0	0	0
Natural gas (flared)	0	0	0	0	0	0	0	54	130	120	153
Natural gas (vented)	0	0	0	0	0	0	0	1	1	0	1
Total Gaseous Spills	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**55**	**131**	**120**	**154**

Source: NMOCD (2025a, 2025d)

Note: No spills were reported in Bernalillo, Cibola, McKinley, Torrance, Valencia, or Santa Fe counties in 2024.

* No spills of brine water, condensate, chemicals, drilling mud/fluid, gelled brine (hydraulic fracturing fluid), other, glycol, sulfuric acid, and lube oil were reported in 2024.

Table 5-12. Summary of 2024 Spills in the Rio Puerco Portion of the San Juan Basin (Sandoval County)

Material Type*	Spill Count	Volume Spilled	Volume Lost	Units	Average Spill Volume	Percent Lost	Waterway Affected	Groundwater Affected
Crude Oil	4	281	71	bbl	70.25	25%	0	0
Other (specify)	1	96	96	bbl	96	100%	0	0
Produced water	2	14	14	bbl	7	100%	0	0
Total Liquid Spills	**7**	**391**	**181**	**bbl**	**57.75**	**46%**	**0**	**0**
Natural gas (flared)	153	41,459	41,459	Mcf	270.97	100%	0	0
Natural gas (vented)	1	117	117	Mcf	117	100%	0	0
Total Gaseous Spills	**154**	**41,576**	**41,576**	**Mcf**	**193.99**	**100%**	**0**	**0**

Source: NMOCD (2025a, 2025d)

Note: No spills were reported in Bernalillo, McKinley, Torrance, Valencia, or Santa Fe counties in 2024.

* No spills of brine water, condensate, chemicals, drilling mud/fluid, gelled brine (hydraulic fracturing fluid), other, glycol, sulfuric acid, and lube oil were reported in 2024.

5.2.3.2 Drilling and Completion Activities

When wells are drilled, they most likely pass through usable groundwater aquifers currently or potentially supplying stock, residential, and/or irrigation water. If proper cementing and casing programs are not followed, there may be a loss of well integrity, surface spills, or loss of fluids in the drilling and completion process that could result in large volumes of chemicals reaching groundwater resources. The NMAC sets water quality standards for usable water aquifers of less than or equal to 10,000 mg/L

(NMAC 20.6.2.3103). If contamination from any source occurs, changes in groundwater quality could impact springs and water wells that are sourced from the affected aquifers.

The BLM and NMOCD have casing, cementing, and inspection requirements in place to limit the potential for surface water, groundwater reservoirs, and shallow aquifers to be impacted by hydraulic fracturing or the migration of hydrocarbons during oil and gas drilling and production activities. The BLM requires operators to comply with the regulations at 43 C.F.R. § 3160. In addition, these regulations require oil and gas development to comply with directives in the Onshore Oil and Gas Orders and the orders of the Authorized Officer. The regulations at 43 C.F.R. § 3162.3-3 and 43 C.F.R. § 3170 provide regulatory requirements for hydraulic fracturing, including casing specifications, monitoring and recording, and management of recovered fluids. New Mexico also has regulations for drilling, casing and cementing, completion, and plugging to protect freshwater zones (NMAC 19.15.16). Complying with the aforementioned regulations requires producers and regulators to verify the integrity of casing and cementing jobs. Casing specifications are designed and submitted to the BLM in a drilling plan as a component of an APD. The BLM petroleum engineer independently reviews the drilling plan and, based on site-specific geologic and hydrologic information, ensures that proper drilling, casing, and cementing procedures are incorporated into the plan to protect usable groundwater. The aforementioned regulations and review practices surrounding proper casing and cementing procedures isolate usable water zones from drilling, completion/hydraulic fracturing fluids, and fluids from other mineral-bearing zones, including hydrocarbon-bearing zones. COAs may be attached to the APD, if necessary, to ensure groundwater protection. These may include requirements for closed loop drilling systems, spill prevention plans, leak detection plans, and appropriate equipment (leak detection and automatic shutoff system) in sensitive groundwater recharge areas. Casing and cementing operations are witnessed by certified BLM PETs. At the end of the well’s economic life, the operator is required to submit a plugging plan to the BLM for approval. A BLM petroleum engineer will review the plan prior to commencement of plugging operations. The BLM PETs witness plugging operations to ensure the planned procedures are properly followed. The BLM’s review, approval, and inspections ensure the permanent isolation of usable groundwater from hydrocarbon-bearing zones.

In summary, the BLM, the NMED, and NMOCD have put in place numerous requirements for oil and gas producers so that drilling fluids, hydraulic fracturing fluids, and produced water and hydrocarbons remain within the well bore and do not enter surface water, groundwater, or any other formations. These include BLM regulations covered under 43 C.F.R. § 3160; 43 C.F.R. § 3170; 43 C.F.R. § 3162.3-3; 43 C.F.R. § 3162.3-5; NTL-3A; NMOCD regulations under NMAC 19.15.26; and the state’s primacy agreement under the Safe Drinking Water Act. With these requirements in place, including the use of casing and cementing measures, contamination of surface water or groundwater resources from development of the lease parcels is highly unlikely. In addition, the BLM has authority under standard terms and conditions to require additional measures to protect water quality if site-specific circumstances require them. Site-specific mitigation tools would be developed as appropriate for the individual circumstances, including groundwater-quality monitoring studies. The regulations at 43 C.F.R. § 3162.5-2(d) give the BLM the authority to require an operator to monitor water resources to ensure that the isolation procedures used to protect water and other resources are effective.

CHAPTER 6. LITERATURE CITED

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APPENDIX A

Data Processing Information
(Information on FracFocus, U.S. Geological Survey, and Spill Data)

PURPOSE AND SCOPE

This appendix is intended to provide a general methodology to the public permitting reproduction of the summaries provided within this Water Support Document. These instructions are publicly available and can be used by Bureau of Land Management (BLM) staff, BLM contractors, and National Environmental Policy Act of 1969 (NEPA) authors. This appendix provides the basic methodology for data analysis and processing, so that the process can be replicated accurately by others and updated annually, due to changes in technologies, the inclusion of other operators' data, or other factors.

DATA SOURCES

Several sources of data were reviewed, compiled, and analyzed where appropriate to address all relevant topics of the Water Support Document. Table A-1 provides a summary of data sources and the context in which they are presented in the Water Support Document. Data for the sources listed in Table A-1—FracFocus, U.S. Geological Survey (USGS), and State of New Mexico Oil Conservation Division—are downloaded and analyzed per the methodologies described in the following sections. Other sources of data include state and federal agency reports that are reviewed and summarized to meet the informational requirements of the Water Support Document. Table A-1 provides an overview of major data sources used in the Water Support Document. However, the data sources listed below are not comprehensive. The final Water Support Document provides a comprehensive list of references that includes additional literature sources not listed in this table. For each data set described in this appendix, 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).

Table A-1. Data Sources by Water Support Document Topic

Water Support Document Topic	Data Source
Statewide water quantity data associated with oil and gas development	USGS Estimated Use of Water in the United States in 2015 (Dieter et al. 2018)
Summary of water use per well associated with oil and gas development	FracFocus (2025)
State of New Mexico spills	New Mexico Oil Conservation Division Permitting Spill Search (New Mexico Oil Conservation Division [NMOCD] 2025)

For data sources where data are downloaded and analyzed, all data are read, cleaned, summarized, and aggregated in R. R serves as a powerful tool for data manipulation, cleaning, summarization, aggregation, and visualization. Within R, data scientists can 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 to data processing and analysis. All code is on file with the Bureau of Land Management (BLM) and contains more specific, annotated data processing steps in addition to what is described in this appendix.

FRACFOCUS DATA PROCESSING INSTRUCTIONS

The FracFocus database serves as the national registry for hydraulic fracturing chemicals and water used in hydraulic fracturing across the United States. When FracFocus was initiated in 2011, many companies voluntarily disclosed hydraulic fracturing chemicals; however, some states later permitted disclosure to FracFocus to fulfill mandatory reporting requirements. As of August 2021, FracFocus emerged as the exclusive national regulatory reporting system used across many states. Housing a repository of data with more than 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 2022).

Data Acquisition and Preparation

FracFocus data require substantial cleaning, processing, and data checks prior to reporting. After the data set is read into R, the data are checked, reorganized, and summarized to develop summary reports for the Water Support Document. A master data set is created that includes each state and the counties therein. The master data set includes all the original data columns from the FracFocus registry, and additional columns are created for easy downstream grouping and summarizing (e.g., unit conversions). Some counties span multiple field offices. In that instance, it is possible that a county can be associated with multiple field offices. Data for the county will be reported in full for each field office that it overlaps.

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 following data quality criteria are flagged and rejected from analysis. Flagged records are not deleted but are flagged in a new column in the data and are not included in further data aggregation. The following steps are taken to acquire, clean, organize, and generate the master data set:

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.
    c. FracFocus data are divided into registries (Registry 1 through Registry 14) to reduce file size. Each registry can be read into R simultaneously as a CSV file.
2. Filter all data to isolate data for desired years (e.g., 2014–2024) and states using column heading JobStartDate, which is the “date on which the hydraulic fracturing job was initiated” (FracFocus 2025) and state (e.g., New Mexico).
3. Screen the data and perform quality control.
    a. Create a new column—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. 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. The “Job” column will contain a hyper-unique ID based on the well, American Petroleum Institute (API) number, month, day, year, and time that can be used to determine whether there is a duplicate entry for any given job within a year. If so, duplicate entries will be

assessed and the entry with the average reported water usage will be recorded for the summary. Otherwise, all other jobs using the same well within the same year represent unique jobs within the same well, and their water volumes are counted separately.

c. Check the API well identification numbers. API 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. Differing well names having the same API number should be flagged and rejected from the final summary, as this indicates a non-unique API number (e.g., a 1:2 relationship). Similarly, if the same well name is given two different API numbers, these records should be flagged and rejected from the analysis.

d. Check well designations for accuracy. Federal well designations should be mutually exclusive. A well can either be federal or non-federal but not both. Wells that are given both designations will be reclassified as non-federal wells.

e. Check total base water volume data for accuracy. Any row where TotalBaseWaterVolume = 0 gallons should be flagged and rejected from analysis based on the assumption that all drilling activities require water. Therefore, if a well reports 0 gallons of water use, it is likely erroneous data and should be rejected from analysis.

    i. For each job (note that a job is the well name and job start date) in the FracFocus data, there are several rows to document the various ingredients and chemicals used in the drilling activity, and the total base water volume is duplicated in each row for the specific ingredient. Therefore, the duplicate entries for total base water volume will be averaged across each job in R to generate one volume per job.

Unit Conversions

Water use in FracFocus is reported in gallons and water use in the Water Support Document is reported in acre-feet (AF). The following conversion factors can be used to convert from gallons to AF and vice-versa:

$$1 \text{ AF} = 325{,}851 \text{ gallons}$$
$$1 \text{ gallon} = 3.0689 \times 10^{-6} \text{ AF}$$

Data Aggregation

To create tables summarizing water use by oil and gas wells for hydraulic fracturing in New Mexico 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.

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 county water usage by year) (Wickham et al. 2023). Data tables will be built in R and used to populate tables within the Water Support Document. The following data summaries will be conducted at the state and regional level (field offices; Pecos, Farmington, Rio Puerco) 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 federal job in AF.
2. **Non-Federal Water**: The sum of the total base water volumes for each non-federal job in AF.

3. **Total Water Use**: The accumulating sum of base water volumes for federal, tribal, and non-federal jobs from 2014 to 2024 in AF.
4. **Federal Water Use (%)**: The percentage of federal water use out of the total water use.
5. **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: $2020_{FCWU} = 2020_{FWU} + 2019_{FWU} + 2018_{FWU} + 2017_{FWU} + 2016_{FWU} + 2015_{FWU} + 2014_{FWU}$
    b. FCWU = federal cumulative water use
    c. FWU = federal water use
6. **Total Combined Water Use**: The year's total water use plus the sum of all previously reported total water use estimates.
7. **Average Water Use Per Well**: The average water use for federal, tribal, and non-federal wells.
8. **Total Well Count**: The total number of federal, tribal, and non-federal wells in a given year.

U.S. GEOLOGICAL SURVEY DATA PROCESSING INSTRUCTIONS

The following processes are intended to guide obtaining data from the USGS 2015 data file to include in the state and field office water use tables throughout the Water Support Document.

Data Acquisition and Preparation

Download *Estimated Use of Water in the United States County-Level Data for 2015* (Dieter et al. 2018) from https://www.sciencebase.gov/catalog/item/get/5af3311be4b0da30c1b245d8; file name usco2015v2.0.xlsx All Data XLSX.

Data Aggregation

To present the summarized water use data in tables throughout the Water Support Document, USGS data are processed and aggregated by state and county. The instructions below describe the process by which the summarized totals are obtained.

State of New Mexico 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 the total water use per category for the state must be manually generated. Follow the steps listed below to generate totals for New Mexico.

1. Isolate data for New Mexico using the column titled STATE, copy the data to a new tab, and generate state grand total values (in AF). The grand total values should be a sum of all county values for each water use.
    a. Columns selected for values can include all columns.
    b. Retain the Excel data dictionary with the original data using the DataDictionary tab in the downloaded data file.

2. Once the grand totals are calculated, copy and paste data into a new tab as values, making sure to transpose the data.
    a. It is helpful to set up a definition lookup table for the abbreviated column names by using the translations found in the DataDictionary tab in the original data during this step.
3. Filter all data so the column tag can be filtered to fill out data tables later.

County Water Use: Similar to state water use, county water use is generated for each county in each field office. The following steps are used to prepare the data for the County Water Use data table entry.

1. Isolate data by filtering the original data by STATE = NM. For each county, use the column titled COUNTY to filter data further.
2. Create a new row to generate totals per field office and use the =sum Excel formula to sum each county value per water use.

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 gallons to AF and vice-versa.

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

Data Tables

To present the summarized information in Table 2-1, State of New Mexico Water Use by Category in 2015, in the Water Support Document and individual county water use data included in each field office chapter, USGS data are processed and aggregated. Some counties span multiple field offices. In that instance, it is possible that a county can be associated with multiple field offices. Data for the county will be reported in full for each field office that it overlaps. The following instructions describe the process by which the summarized total water use values are obtained. These instructions provide specific column names in the USGS data to guide data entry.

State of New Mexico Water Use: State water use for each water use category is included in the USGS data. Each entry in Table 2-1 in the Water Support Document corresponds with a specific column header in the USGS data. For each category and water use (surface water, groundwater, and total withdrawals), refer to Figure A-1 when pulling data from the USGS data. Text in Figure A-1 and associated data dictionary terms in Table A-2 refer to the specific column tag that should be used for each data entry.

County Water Use: Similar to state water use, county water use is generated for each county in each field office. Using the specific county data of interest and Table A-2, data can be entered into tables in each field office section of the Water Support Document.

Total Water Use Percentage: The total water use percentage is generated individually by dividing the total water use of a specific category in either surface water, groundwater, or total withdrawals by the total water use for the state, county, or field office of interest. See Table A-2 and Table A-3 for guidance.

Table A-2. Abbreviated column names for water use tables.

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	AQ-WSWFr	AQ-WSWSa	AQ-WSWTo	AQ-WSWTo/ TO-Wtotl	AQ-WGWFr	AQ-WGWSa	AQ-WGWTo	AQ-WGWTo/ TO-Wtotl	AQ-WFrTo	AQ-WFrTo/ TO-Wtotl	AQ-WSaTo	AQ-WSaTo/ TO-Wtotl	AQ-Wtotl	AQ-Wtotl/ TO-Wtotl
Domestic	DO-WSWFr	–	DO-WSWFr	DO-WSWTo/ TO-Wtotl	DO-WGWFr	–	DO-WGWFr	DO-WGWFr/ TO-Wtotl	DO-WFrTo	DO-WFrTo/ TO-Wtotl	–	DO-WFrTo/ TO-Wtotl	DO-WFrTo	DO-WFrTo/ TO-Wtotl
Industrial	IN-WSWFr	IN-WSWSa	IN-WSWTo	IN-WSWTo/ TO-Wtotl	IN-WGWFr	IN-WGWSa	IN-WGWTo	IN-WGWTo/ TO-Wtotl	IN-WFrTo	IN-WFrTo/ TO-Wtotl	IN-WSaTo	IN-WSaTo/ TO-Wtotl	IN-Wtotl	IN-Wtotl/ TO-Wtotl
Irrigation	IR-WSWFr	–	IR-WSWFr	IR-WSWTo/ TO-Wtotl	IR-WGWFr	–	IR-WGWFr	IR-WGWFr/ TO-Wtotl	IR-WFrTo	IR-WFrTo/ TO-Wtotl	–	IR-WFrTo/ TO-Wtotl	IR-WFrTo	IR-WFrTo/ TO-Wtotl
Livestock	LI-WSWFr	–	LI-WSWFr	LI-WSWTo/ TO-Wtotl	LI-WGWFr	–	LI-WGWFr	LI-WGWFr/ TO-Wtotl	LI-WFrTo	LI-WFrTo/ TO-Wtotl	–	LI-WFrTo/ TO-Wtotl	LI-WFrTo	LI-WFrTo/ TO-Wtotl
Mining	MI-WSWFr	MI-WSWSa	MI-WSWTo	MI-WSWTo/ TO-Wtotl	MI-WGWFr	MI-WGWSa	MI-WGWTo	MI-WGWTo/ TO-Wtotl	MI-WFrTo	MI-WFrTo/ TO-Wtotl	MI-WSaTo	MI-WSaTo/ TO-Wtotl	MI-Wtotl	MI-Wtotl/ TO-Wtotl
Public water supply	PS-WSWFr	PS-WSWSa	PS-WSWTo	PS-WSWTo/ TO-Wtotl	PS-WGWFr	PS-WGWSa	PS-WGWTo	PS-WGWTo/ TO-Wtotl	PS-WFrTo	PS-WFrTo/ TO-Wtotl	PS-WSaTo	PS-WSaTo/ TO-Wtotl	PS-Wtotl	PS-Wtotl/ TO-Wtotl
Thermoelectric power	PT-WSWFr	PT-WSWSa	PT-WSWTo	PT-WSWTo/ TO-Wtotl	PT-WGWFr	PT-WGWSa	PT-WGWTo	PT-WGWTo/ TO-Wtotl	PT-WFrTo	PT-WFrTo/ TO-Wtotl	PT-WSaTo	PT-WSaTo/ TO-Wtotl	PT-Wtotl	PT-Wtotl/ TO-Wtotl
County Totals	TO-WSWFr	TO-WSWSa	TO-WSWTo	TO-WSWTo/ TO-Wtotl	TO-WGWFr	TO-WGWSa	TO-WGWTo	TO-WGWTo/ TO-Wtotl	TO-WFrTo	TO-WFrTo/ TO-Wtotl	TO-WSaTo	TO-WSaTo/ TO-Wtotl	TO-Wtotl	TO-Wtotl/ TO-Wtotl

Source: Dieter et al. (2018).

Table A-3. Data Dictionary Terms and Associated Abbreviated Column Names for Water Use Data (Dieter et al. 2018)

Dictionary Term	Abbreviated Column Name
Aquaculture, groundwater withdrawals, saline	AQ-WGWSa
Aquaculture, groundwater withdrawals, total	AQ-WGWTo
Aquaculture, surface-water withdrawals, fresh	AQ-WSWFr
Aquaculture, surface-water withdrawals, saline	AQ-WSWSa
Aquaculture, surface-water withdrawals, total	AQ-WSWTo
Aquaculture, total withdrawals, saline	AQ-WSaTo
Aquaculture, total withdrawals, total (fresh+saline)	AQ-Wtotl
Aquaculture, total withdrawals, fresh	AQ-WFrTo
Domestic, self-supplied groundwater withdrawals, fresh	DO-WGWFr
Domestic, self-supplied surface-water withdrawals, fresh	DO-WSWFr
Domestic, total self-supplied withdrawals, fresh	DO-WFrTo
Industrial, self-supplied groundwater withdrawals, fresh	IN-WGWFr
Industrial, self-supplied groundwater withdrawals, saline	IN-WGWSa
Industrial, self-supplied groundwater withdrawals, total	IN-WGWTo
Industrial, self-supplied surface-water withdrawals, fresh	IN-WSWFr
Industrial, self-supplied surface-water withdrawals, saline	IN-WSWSa
Industrial, self-supplied surface-water withdrawals, total	IN-WSWTo
Industrial, self-supplied total withdrawals, saline	IN-WSaTo
Industrial, self-supplied total withdrawals, total (fresh+saline)	IN-Wtotl
Irrigation, groundwater withdrawals, fresh	IR-WGWFr
Irrigation, surface-water withdrawals, fresh	IR-WSWFr
Irrigation, total withdrawals, fresh	IR-WFrTo
Livestock, groundwater withdrawals, fresh	LI-WGWFr
Livestock, surface-water withdrawals, fresh	LI-WSWFr
Livestock, total withdrawals, fresh	LI-WFrTo
Mining, groundwater withdrawals, fresh	MI-WGWFr
Mining, groundwater withdrawals, saline	MI-WGWSa
Mining, groundwater withdrawals, total	MI-WGWTo
Mining, surface-water withdrawals, fresh	MI-WSWFr
Mining, surface-water withdrawals, saline	MI-WSWSa
Mining, surface-water withdrawals, total	MI-WSWTo
Mining, total withdrawals, fresh	MI-WFrTo
Mining, total withdrawals, saline	MI-WSaTo
Mining, total withdrawals, total (fresh+saline)	MI-Wtotl
Public Supply, groundwater withdrawals, fresh	PS-WGWFr
Public Supply, groundwater withdrawals, saline	PS-WGWSa
Public Supply, groundwater withdrawals, total	PS-WGWTo

Dictionary Term	Abbreviated Column Name
Public Supply, surface-water withdrawals, fresh	PS-WSWFr
Public Supply, surface-water withdrawals, saline	PS-WSWSa
Public Supply, surface-water withdrawals, total	PS-WSWTo
Public Supply, total withdrawals, fresh	PS-WFrTo
Public Supply, total withdrawals, saline	PS-WSaTo
Public Supply, total withdrawals, total (fresh+saline)	PS-Wtotl
Thermoelectric, groundwater withdrawals, fresh	PT-WGWFr
Thermoelectric, groundwater withdrawals, saline	PT-WGWSa
Thermoelectric, groundwater withdrawals, total	PT-WGWTo
Thermoelectric, surface-water withdrawals, fresh	PT-WSWFr
Thermoelectric, surface-water withdrawals, saline	PT-WSWSa
Thermoelectric, surface-water withdrawals, total	PT-WSWTo
Thermoelectric, total withdrawals, saline	PT-WSaTo
Thermoelectric, total withdrawals, total (fresh+saline)	PT-Wtotl
Thermoelectric, total withdrawals, fresh	PT-WFrTo
Total groundwater withdrawals, fresh	TO-WGWFr
Total groundwater withdrawals, saline	TO-WGWSa
Total groundwater withdrawals, total (fresh+saline)	TO-WGWTo
Total surface-water withdrawals, fresh	TO-WSWFr
Total surface-water withdrawals, saline	TO-WSWSa
Total surface-water withdrawals, total (fresh+saline)	TO-WSWTo
Total withdrawals, fresh,	TO-WFrTo
Total withdrawals, saline	TO-WSaTo
Total withdrawals, total (fresh+saline)	TO-Wtotl

SPILL DATA ANALYSIS METHODOLOGY

Spill data are available for download from the NMOCD spills database (NMOCD 2025a). For the purpose of this report, a *spill* is defined as the loss of a measurable volume of a material on a given day. The entire spills database contains records with incident dates ranging from 1900 to 2025 (at the time this update to the report was written). For each update to this report, spill data are analyzed for the completed year prior to the report revision. For example, the 2020 Water Support Document summarized records in the spills database with incident dates in the year 2019. Spill data for New Mexico include the quantity of each reported spill, the amount recovered, impacts to surface water, and impacts to groundwater.

A spills data dictionary from NMOCD is not available to accompany the data. Therefore, several assumptions and definitions were made about the data that are summarized below. 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 data quality criteria are flagged and rejected from analysis. Flagged records are not deleted but are marked as ‘Flagged’ in a new column in the data and are not included in further data aggregation.

Data Acquisition and Preparation

After each state data set is read into R, a master data set is created that includes relevant data for this analysis. The master data set includes the following information:

- County
- Date of incident
- Spill material
- Quantity of spill
- Quantity of spill recovered
- Percentage of spill recovered
- Waterway or groundwater affected

To create this data set, the following step is taken:

1. The columns above will be extracted or calculated when applicable from the New Mexico state data set in R and stored in a new data frame, which is a two-dimensional data structure with data organized into rows and columns.
    a. This step will remove all additional column data not relevant to this report.

The above step will yield a data set that will be easy to use and filter according to the county 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 accordingly. 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 data quality criteria are flagged and are rejected from analysis. Flagged records are not deleted but are reclassified in a new column to ensure that quantitative data are not lost; however, data limitations and mistakes are accounted for in each entry. For example, if a spill type is not clear, the entry would be reclassified as “Spill Type: Unknown.” To further clean and process the master spill data set, the following steps will be taken for each of the data columns defined above.

1. *Date of Incident* will be split into month, day, and year. Code will be applied to create three additional columns (i.e., Month, Day, and Year) that will each contain the corresponding parts of the date. For example, **"2024-04-11"** will be recoded as 2024, April, and 11.
    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.”
2. *Type of Spill* will be factored 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).
3. *Quantity of Spill* will require numeric data quality checks.
    a. New Mexico spill data generally include 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, “0” or missing entries are removed from the analysis.
4. *Quantity of Spill Recovered* will be denoted as a percentage of the original volume of oil spilled.

5. *Waterway or Groundwater Affected* is reported as unknown, surface water, non-surface water, or groundwater.

Unit Conversions

Spills within the New Mexico data set may be reported differently. All oil spills are reported in barrels (bbl) or gallons, and all gaseous spills are reported in thousands of cubic feet (Mcf). In R, code is 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.

Conversion examples:

- Gallons to barrels: $bbl = gallons \times 0.02381$
- Barrels to thousands of cubic feet: $Mcf = bbl / 5.615$

Data Screening and Quality Control

- The incident number is not unique, and for any one incident number, there may be many spill materials.
- Incidents where the volume released is 0 are flagged and rejected from further analysis because these records are not in alignment with the definition of a spill, where a measurable volume of material has been released.
- Incidents where the unit of volume is not volumetric (e.g., pounds) are flagged and rejected from analysis.
- Records where the spill material type is gaseous, including natural gas (methane) or natural gas liquids, should be reported in Mcf and not bbl; therefore, gaseous spills reported in bbl will be rejected from analysis. Records where the material is natural gas flared or vented are not counted in the spills summary on the assumption that these are lost to the air.

Data Aggregation

Once the data have been cleaned and a master data set has been generated that consists of spills at the county levels, data will be filtered and grouped by field office. 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 field office data will be grouped by the date of spill and type of spill, and summary tables will be generated to report the quantity of spill, quantity of spill recovered, and percentage of spill recovered. The tables include a column that specifies whether a waterway was affected by the spill.

Spill Count: Spill count is the number of spill records within a field office for a particular material.

Volume Spilled: Volume released is a sum of the volume released for all spills of a particular material within a field office. The data should be filtered to remove the flagged data.

Volume Lost: Volume lost is a sum of the volume lost for all spills of a particular material within a field office. The data should be filtered to remove the flagged data.

Average Spill Volume: Average volume spilled is an average of the volume released for all spills or all types of material within a field office. Data should be filtered to not include flagged data.

Percentage Lost: This is the proportion of the spilled volume that was not recovered. The average percentage lost for all spilled material in a field office can be used to represent the overall average volume lost across that office.

Other Relevant Reports and Studies

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:

- USGS *Assessment of per-and polyfluoroalkyl substances in water resources of New Mexico, 2020-21* (USGS 2024)
- 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.

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