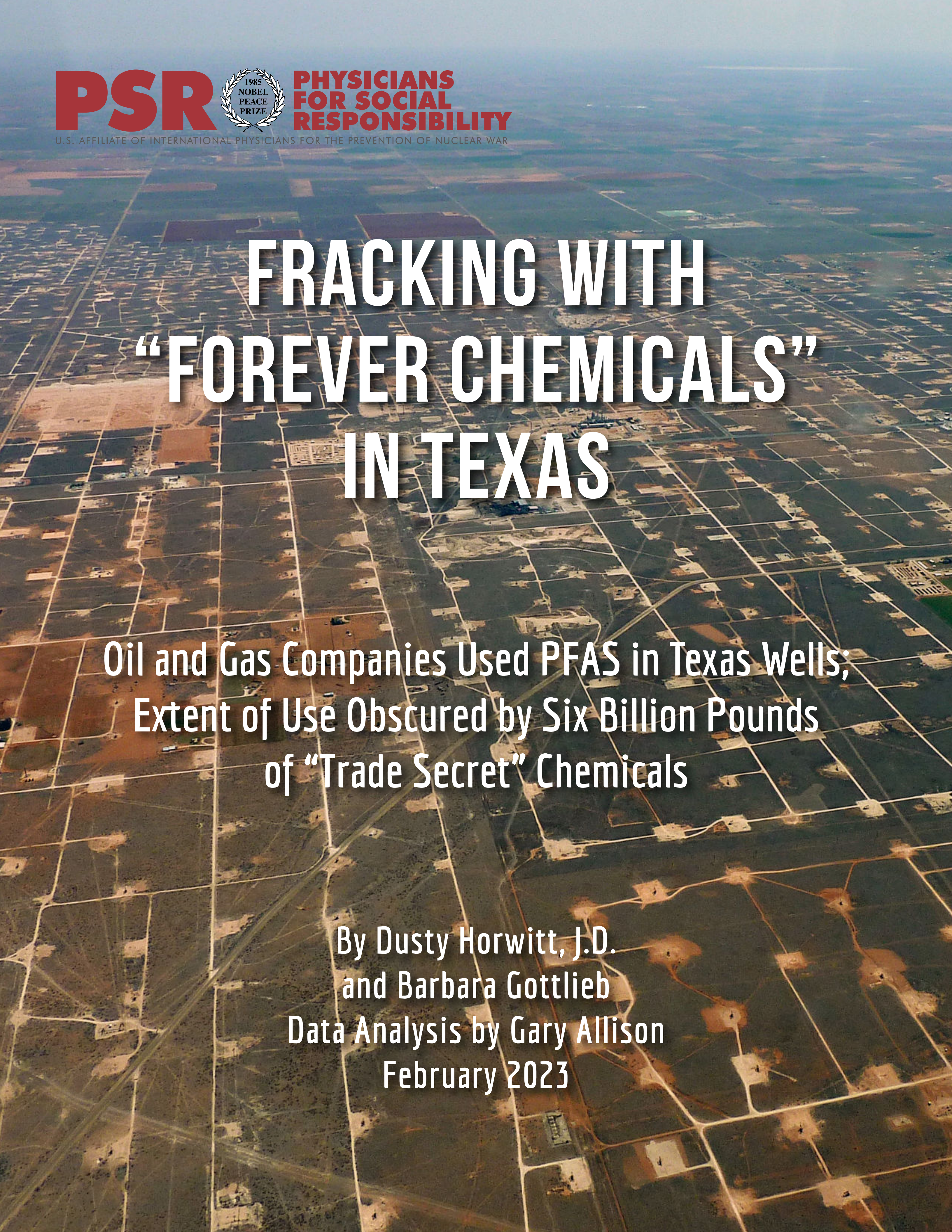

PSR PHYSICIANS FOR SOCIAL RESPONSIBILITY

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U.S. AFFILIATE OF INTERNATIONAL PHYSICIANS FOR THE PREVENTION OF NUCLEAR WAR

FRACKING WITH "FOREVER CHEMICALS" IN TEXAS

Oil and Gas Companies Used PFAS in Texas Wells; Extent of Use Obscured by Six Billion Pounds of "Trade Secret" Chemicals

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Cover photo shows oil and gas fields around Midland, Texas, April 2012. Photo credit: Jane Pargiter, EcoFlight.
Maps by Matt Kelso, FracTracker Alliance

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EXECUTIVE SUMMARY

Previously unpublicized information unearthed by Physicians for Social Responsibility (PSR) shows that since at least 2013, oil and gas companies used in Texas oil and gas wells more than 43,000 pounds of a class of extremely toxic and persistent chemicals known as PFAS. However, gaps in Texas's disclosure rules prevent the public from knowing how widely PFAS – or other toxic chemicals – have been used in oil and gas drilling and extraction. These findings raise concerns that Texans may unknowingly be exposed to highly hazardous substances.

PFAS are a highly dangerous class of chemicals, known for their toxicity at extremely low levels, their multiple negative health effects including cancer, and their resistance to breaking down in the environment, leading to their nickname, "forever chemicals."

PSR analyzed industry self-reported data recorded in FracFocus, the official repository for Texas's required disclosure of chemicals used in hydraulic fracturing ("fracking"), and found that between 2013 and 2022, oil and gas companies injected more than 1,600 oil and gas wells in 73 counties with some 43,000 pounds of the PFAS known as PTFE/Teflon. Oil and gas companies injected 1,222 wells in 66 counties with more than 53,000 pounds of additional chemicals that are PFAS, likely PFAS, or precursor chemicals that could degrade into PFAS.

However, the number of definitively identified or likely cases of PFAS use may significantly underrepresent the use and presence of PFAS associated with oil and gas operations in the state. That is in large part because Texas law allows oil and gas companies and chemical manufacturers to withhold fracking chemical identities from the public and potentially even from regulators by claiming them as a "trade secret." Between 2013 and 2022, companies claimed trade secret privileges in over 58,000 oil and gas wells located across 183 of Texas's 253 counties. The unidentified trade secret chemicals used in Texas over this roughly decade-long period totaled 6.1 billion pounds. An interactive map showing the locations of wells injected with PTFE/Teflon, fluorosurfactants, and trade secret chemicals is available here [https://ft.maps.arcgis.com/apps/webappviewer/index.html?appid=9cff28a549d84fbeb908444bbcaf16bf].

By shielding from public view the chemicals injected into oil and gas wells, trade secret claims and other gaps in disclosure rules raise the potential that Texans may be directly exposed, or their groundwater and well water may be exposed, to PFAS and other toxic chemicals from hundreds or even thousands of oil and gas production wells.

Among our key findings are:

- A PFAS known as PTFE/Teflon was used in oil and gas extraction in Texas over the past decade in at least 1,625 oil and gas wells in 73 counties.
- A PFAS and potential fluorosurfactant called fluoroalkyl alcohol substituted polyethylene glycol was used in at least 65 wells between 2013 and 2022. Fluorosurfactants are part of a larger group of chemicals known as "surfactants" that are commonly used in fracking and can reduce the surface tension of a liquid among other properties. Fluorosurfactants encompass the dangerous PFAS known as PFOA and PFOS and hundreds of other less-studied replacement chemicals and mixtures. Some are known to be extremely toxic to people, could be harmful to animals, and are expected to persist in the environment.
- Trade secrets make it extremely difficult to determine how extensively PFAS (and other highly toxic chemicals) have been used in Texas. PSR's analysis of FracFocus data revealed that, between 2013 and 2022, Texas well operators declared at least one fracking chemical a trade secret in 58,199 oil and gas wells in 183 counties. Trade secret chemicals used in Texas over this roughly decade-long period totaled 6.1 billion pounds.
- In addition, over the past decade, oil and gas firms fracked 30,700 wells, spread across 171 counties, with at least one trade secret surfactant totaling 331 million pounds. Some of these may be fluorosurfactants.

Evidence shows that fluorosurfactants that are PFAS have been used in oil and gas extraction for decades. This evidence combined with data showing extensive trade secret use in Texas's oil and gas wells indicates that PFAS has been used more extensively than publicly reported to FracFocus.

- PFAS pollution of groundwater, surface water and air in Texas is possible wherever these substances have been used at oil and gas wells and wherever oil and gas wastewater containing PFAS has been disposed of. This includes disposal in injection wells and spreading the fluid onto soil in various types of land application, both common practices in Texas.

- This variety of potential pathways to exposure raises concerns that PFAS could endanger the environment and people's health.

In light of these findings, PSR recommends the following:

- **Halt PFAS use in oil and gas extraction.** Texas should follow the lead of Colorado, a major oil- and gas-producing state which banned the use of PFAS in oil and gas wells through legislation passed in June 2022. Furthermore, Texas and the U.S. Environmental Protection Agency (EPA) should prohibit PFAS from being used, manufactured, or imported for oil and gas extraction. Many PFAS are immediately replaceable with less persistent and less toxic substances, including for use in the oil and gas industry.

- **Expand public disclosure.** Texas should greatly expand its requirements for public disclosure of oil and gas chemicals. The state could again follow the example offered by Colorado by requiring disclosure of all individual chemicals used in oil and gas wells without exceptions for trade secrets, while requiring disclosure on the part of chemical manufacturers who know best what chemicals are being used. Texas should also require chemical disclosure prior to fracking, as have several states including California, West Virginia, and Wyoming.

- **Increase testing and tracking.** Texas and/or the U.S. EPA should determine where PFAS have been used in oil and gas operations in the state and where related wastes have been deposited and should test nearby residents, water, soil, flora, and fauna for PFAS.

- **Require funding and cleanup.** Oil and gas and chemical firms should be required to fund environmental testing for PFAS in their areas of operation where these are needed, and should PFAS be found, be required to fund cleanup. If water cleanup is impossible, the companies responsible for the use of PFAS should pay for alternative sources of water for drinking, household uses, and agriculture, as needed.

- **Reform Texas's regulations for underground injection disposal wells to prohibit wells** close to underground sources of water, to require groundwater monitoring for contaminants near the wells, and to require full public disclosure of the chemicals in the wastewater.

- **Transition to renewable energy, better regulation.** Given the use of highly toxic chemicals in oil and gas extraction, including but not limited to PFAS, as well as climate impacts of oil and gas, Texas should transition away from fracking and move toward renewable energy and efficiency. This transition should be structured to provide economic support for oil and gas workers. However, as long as we have drilling and fracking, the state should better regulate these practices so that Texans are not exposed to toxic substances. The state should also empower local governments to regulate the industry. When doubt exists as to the existence or danger of contamination, the rule of thumb should be, "First, do no harm."

CH. 1 PFAS: A MANMADE THREAT TO HEALTH AND THE ENVIRONMENT

a. Introduction to PFAS: Toxic, Persistent, and Used Widely in Texas's Oil and Gas Wells

Physicians for Social Responsibility (PSR) has identified evidence from industry documents that a highly dangerous class of chemicals, known as per- and polyfluoroalkyl substances (PFAS), has been used in Texas's oil and gas* wells for hydraulic fracturing ("fracking"). PFAS are known for their toxicity at extremely low levels,[1] their multiple negative health effects including cancer,[2] and their persistence in the environment, hence their nickname, "forever chemicals."[3]

The Texas oil and gas wells definitively known to have been injected with PFAS between 2013 and 2022 include 1,625 wells in 73 counties that were injected with PTFE, also known as Teflon[4] and identified by EPA as a PFAS. (See Table 1, excerpted below and presented in full in the Appendix.) Another 1,222 wells in 63 counties were injected with fluorosurfactants or potential fluorosurfactants, including 65 wells injected with fluoroalkyl alcohol substituted polyethylene glycol, also identified as a PFAS by EPA.[5] The other fluorosurfactants are likely to be PFAS or precursors that could degrade into PFAS, according to three chemists and a board-certified toxicologist who reviewed the fluorosurfactants' names for PSR.[6] The likely use of PFAS in oil and gas production in Texas was first exposed in 2021, initially by PSR[7] and subsequently in a report by Public Employees for Environmental Responsibility.[8] The wells PSR was able to identify in this report as injected with PFAS or chemicals likely to be PFAS may significantly underrepresent the extent of PFAS use in the state's oil and gas wells due to

*Gas, the principal component of which is methane, is also known as "natural" gas, "fossil" gas and "fracked" gas.

Table 1. Excerpt (full table in Appendix). Disclosed Use in Fracking of Fluorosurfactants, Potential Fluorosurfactants, and PTFE in Texas Oil and Gas Wells, 2013-2022

County	Number of wells injected with fluorosurfactants, potential fluorosurfactants	Mass of fluorosurfactants, potential fluorosurfactants (lbs.)	Number of wells injected with PTFE	Mass of PTFE (lbs.)
Anderson	1	3	1	13
Andrews	74	1,024	115	3,231
Archer	1	15	0	0
Atascosa	0	0	51	299
Baylor	2	56	0	0
Bee	0	0	2	*ND
Borden	15	222	0	0
Bosque	1	ND	0	0
Brazos	0	0	1	13
Burleson	1	ND	7	44
C-Z in Appendix	see Appendix	see Appendix	see Appendix	see Appendix
Total	1,222	53,398	1,625	43,829

This table, based on FracFocus data covering the dates January 1, 2013 through Sept. 29, 2022, shows county-by-county the number of Texas wells in which oil and gas companies injected PTFE for fracking, identified by EPA as a PFAS, or used at least one fluorosurfactant or potential fluorosurfactant for fracking. In this table, the term "fluorosurfactant" encompasses disclosed uses of "nonionic fluorosurfactant" while the term "potential fluorosurfactant" encompasses disclosed uses of "fluoroalkyl alcohol substituted polyethylene glycol," identified by EPA as a PFAS. Two chemists identified nonionic fluorosurfactants as either PFAS or precursors that could degrade into PFAS. A third chemist identified them as likely PFAS, and a board-certified toxicologist identified them as potential PFAS. The total weight figures reflect the sum of all records for which we have enough information to calculate a chemical's weight.

*ND = No data available.

gaps in chemical disclosure rules that allow oil and gas companies to conceal from the public the identities of chemicals.

b. Manmade and Dangerous

PFAS are a class of thousands of manmade chemicals known for having properties that are valuable in multiple contexts, including being slippery, oil- and water-repellant, and able to serve as dispersants or foaming agents.[9] PFAS have been called "perfluorinated chemicals" and "polyfluorinated compounds," or PFCs, though the term currently preferred by EPA is PFAS.[10]

The first PFAS to be sold commercially was created by a chemist at Dupont and was patented as Teflon. Since 1949, it has been used in thousands of products, from nonstick cookware to waterproof clothing to plastics to dental floss.[11] Other PFAS chemicals, the most prominent of which are known as PFOA and PFOS, have been used in food packaging, fire-fighting foam, and in 3M's widely used fabric protector, Scotchgard.[12] EPA reported in 2022 that the manufacture and use of PFOA has been phased out in the U.S. and no chemical company has reported making PFOS in the U.S. since 2002. EPA states that existing stocks of PFOA might still be used, and imported products may contain some PFOA. There are limited ongoing uses of PFOS.[13] The U.S. Environmental Protection Agency (EPA) reports that there are currently about 650 types of PFAS in commerce.[14] Weak chemical disclosure laws make it difficult for the Agency to identify which PFAS chemicals are used, and where.

EPA and other regulators have identified PFAS as a serious threat to health and the environment.[15] Between the 1960s and 1990s, researchers inside Dupont and 3M became aware that the PFAS they were manufacturing or using were associated with health problems including cancers and birth defects, had accumulated in people worldwide, and persisted in the environment.[16] Many of these facts, kept internal by the companies, came to light after attorney Rob Bilott filed lawsuits in 1999 and 2001 accusing Dupont of causing pollution in and around Parkersburg, West Virginia with PFOA, the type of PFAS used in making Teflon.[17] In December 2011, as part of Dupont's settlement of the 2001 lawsuit, a team of epidemiologists completed a study of the blood of 70,000 West Virginians and found a probable link between PFOA and kidney cancer, testicular cancer, thyroid disease (over- or under-production of hormones by the thyroid gland), high cholesterol, pre-eclampsia (a potentially dangerous complication during pregnancy characterized by high blood pressure and signs of damage to other organ systems, most often the liver and kidneys), and ulcerative colitis (a disease causing inflammation and ulcers in the large intestine or colon).[18] PFAS are also extremely mobile in water.[19]

In June 2022, reflecting the growing concern about PFAS, EPA significantly lowered its health advisory level for PFOA and PFOS in drinking water. Previously, in 2016, EPA had set the combined health advisory level for these chemicals at 70 parts per trillion.[20] "The new published peer-reviewed data and draft EPA analyses…" EPA wrote in June 2022, "indicate that the levels at which negative health outcomes could occur are much lower than previously understood."[21] EPA set its new interim health advisory level for PFOA in drinking water to 0.004 parts per trillion and its interim health advisory level for PFOS to 0.02 parts per trillion.[22] EPA also set new final health advisory levels for two other PFAS known as GenX and PFBS at 10 parts per trillion and 2,000 parts per trillion, respectively.[23] EPA said that its interim health advisory levels are intended to provide guidance until enforceable drinking water regulations for PFAS take effect.[24]

EPA's new interim health advisory levels mean that the toxicity of PFOA is almost beyond comprehension. Under EPA's levels, one tablespoon of PFOA would be enough to contaminate 1.75 trillion gallons of water, which is greater than the total storage capacity of the Toledo Bend Reservoir (1.5 trillion gallons), Texas's largest reservoir,[25] and more than 4,000 times greater than the 435.4 million gallons of drinking water that the City of Houston's main system produces each day.[26] PFOS is extraordinarily toxic, too.

c. Persistent in the Environment, and Widespread

PFAS are not only highly toxic; they also demonstrate extreme persistence in the environment. PFAS' nickname "forever chemicals" reflects their chemistry – created by chemical manufacturers – that features a bond between fluorine and carbon atoms that is among the strongest in chemistry and rarely if ever exists in nature. The result: chemicals that are extremely resistant to breaking down in the environment.[27]

Evidence has mounted over the years of cases of PFAS pollution from a variety of sources, including in Texas. In 2019, the nonprofit Environmental Working Group reported that many of the nation's highest concentrations of PFAS in groundwater have been discovered at military sites, including in Texas, according to federal government data that the organization examined.[28] Of the 100 military bases with the highest concentrations of PFAS – many of them shockingly high – seven were located in Texas

- The eighth-highest concentration in the nation: Grand Prairie Armed Forces Reserve Complex in Grand Prairie near Dallas.[29] 1,247,000 parts per trillion for PFOA and PFOS.
- The sixteenth-highest concentration: Sheppard Air Force Base, just north of Wichita Falls.[30] 850,000 parts per trillion for PFHxS.
- The twentieth-highest concentration: Joint Base San Antonio,[31] located in and around San Antonio. 767,000 parts per trillion for PFOA and PFOS.
- The twenty-second-highest concentration: Dyess Air Force Base, located in Abilene.[32] 702,000 parts per trillion for PFHxS.
- The forty-ninth-highest concentration: Randolph Air Force Base, located northeast of San Antonio.[33] 175,000 parts per trillion for PFOA and PFOS.
- The seventy-ninth-highest concentration: Kelly Air Force Base, a now-closed base located in San Antonio.[34] 77,200 parts per trillion for PFHxS,
- The eighty-seventh-highest concentration: Ellington Field Joint Reserve Base, located in Houston.[35] 61,000 parts per trillion for PFOA and PFOS.[36]

The Pentagon helped develop fluorinated foams in the 1960s.[37]

In a report issued in April 2022, the U.S. Centers for Disease Control Agency for Toxic Substances and Disease Registry (ATSDR) concluded that firefighting foam had contaminated private drinking water wells near Reese Technology Center in Lubbock, formerly Reese Air Force Base.[38] The agency found that potentially as early as the 1970s, the base had used aqueous film-forming foam (AFFF) for firefighting training. The foam contained PFAS. "Over time," the agency found, "the PFAS from the AFFF entered the ground, moved into the groundwater to offsite locations, and affected nearby private wells."[39] For affected homes, the Air Force installed whole-house water treatment systems and supplied bottled water. The water in all households tested by the Air Force met or was below EPA's health advisory level for PFAS set in 2016. (Residents of a small number of homes declined to have their water tested, so it is possible that levels of PFAS in water at these homes could have been higher.)[40]

The ATSDR report also showed that the concentrations of two types of PFAS in blood samples from people who lived near the base were higher than the national average: Concentrations of PFHxS were 4.2 times the national average, while concentrations of PFOA were 1.2 times the national average. Concentrations of three other types of PFAS (PFOS, PFNA, and PFDA) were not higher than the national average.[41]

The case of the former Reese Air Force Base provides a window into Texas's lax standards for PFAS in water. The ATSDR wrote in its 2022 report on Reese Air Force Base that

> actions taken by the Air Force reduced PFAS levels in drinking water in the affected area below EPA [2016] health advisory for PFOS and PFOA and Texas Commission on Environmental Quality's (TCEQ's) protective concentration levels (PCLs) for multiple PFAS.[42]

However, ATSDR's statement raises concerns. First, the statement implies that Texas's protective concentration levels for PFAS apply to drinking water, when in fact, drinking water standards for PFAS do not exist in Texas.[43] The state's protective concentration levels apply to cleaning up groundwater contamination.[44] Second, these groundwater contamination limits for residential properties include limits of 290 parts per trillion for PFOA and 560 parts per trillion for PFOS. When compared with EPA's interim health advisory levels of 0.004 parts per trillion for PFOA and 0.02 parts per trillion for PFOS, it appears that Texas's limits on PFAS in groundwater are far from safe.

Finally, the case also highlights how any testing and regulatory standards for PFAS used prior to EPA's June 2022 interim health advisory levels may be inadequate to protect the public. ATSDR, for example, reported that its tests for most types of PFAS at Reese Air Force Base, including PFOA and PFOS, were not sensitive enough to detect concentrations lower than two parts per trillion.[45]

It is possible that these PFAS could have been present in drinking water at Reese Air Force Base at levels lower than the detection limit but far higher than EPA's June 2022 interim health advisory levels. ATSDR also reported that it used as a cleanup standard the EPA's health advisory level set in 2016 (70 parts per trillion for PFOA and PFOS) because that level is more conservative than Texas's protective concentration levels. But under EPA's more protective June 2022 interim health levels, the ATSDR's highest detected level of PFOA in drinking water at Reese Air Force Base, 4.6 parts per trillion, is 1,150 times too high, reflecting EPA's new understanding of PFAS' extreme toxicity.

Another example of PFAS pollution in Texas associated with the use of fire-fighting foam was the discovery of PFAS in the Houston Ship Channel in 2019 following a major fire. The fire began March 17 of that year in Deer Park at a chemical storage facility operated by Intercontinental Terminals Company (ITC). Use of fire-fighting foam containing PFAS may have been a source of the PFAS in the channel.[46]

Concern over PFAS pollution has led eight other states, including at least some with contaminated military sites, to develop enforceable standards for concentrations of several types of PFAS in drinking water.[47] One of the most recent to act is Michigan, which set standards in 2020 for limiting PFAS in drinking water and for removing PFAS from groundwater. The standards apply to PFOA and six other forms of PFAS. Michigan's maximum allowable level is no more than eight parts per trillion for PFOA,[48] a standard that is one of the lowest among states but is now much more permissive than EPA's interim health advisory level. Even Michigan's standard, however, shows how toxic PFAS can be. By extrapolation, Michigan's standards suggest that one measuring cup of PFOA could contaminate almost eight billion gallons of water – the amount of water needed to fill almost 12,000 Olympic-sized swimming pools at about 660,000 gallons per pool.[49] The extreme potency of PFOA, as with other PFAS, indicates why health experts are concerned about even minute quantities of these chemicals.

CH. 2 USE OF PFAS IN TEXAS BY OIL AND GAS COMPANIES

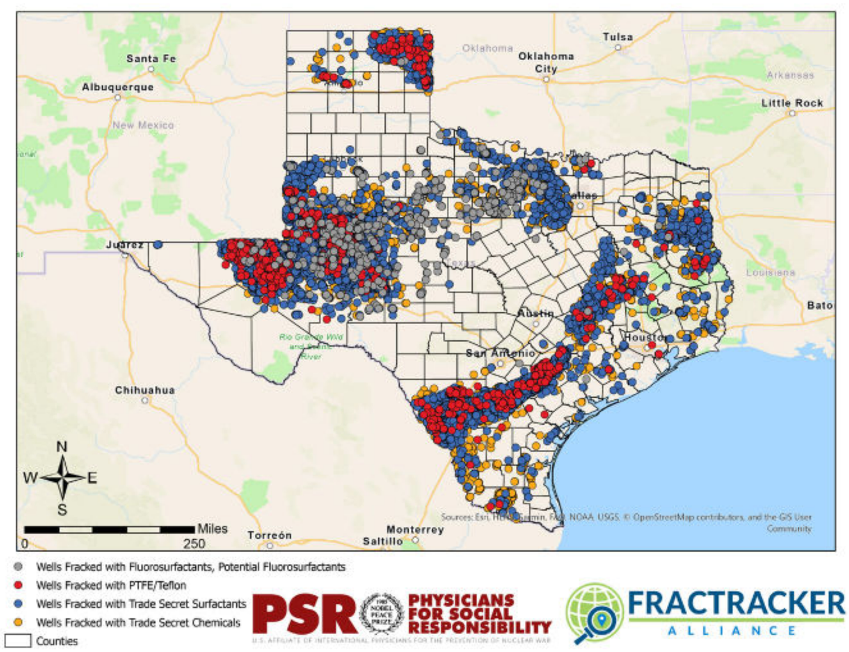
a. Disclosed Use of Fluorosurfactants, PTFE

While PFAS contamination in Texas is often associated with military bases, oil and gas operations in the state deserve scrutiny as a possible additional source of PFAS contamination. To identify where PFAS were used in Texas, PSR analyzed self-reported industry data on the well-by-well use of fracking chemicals recorded in FracFocus, a database for the oil and gas industry[50] maintained by the Groundwater Protection Council,[51] a nonprofit comprised of regulators from state agencies. PSR consulted the open-source version of FracFocus, Open-FF,[52] that is more accurate and informative than the original version of FracFocus.[53]

Under Texas law, operators must disclose in the FracFocus database the name of chemical products used in fracking and each individual component chemical used in each product.[54] Companies must also disclose each chemical's Chemical Abstracts Service (CAS) number, if available.[55] CAS numbers are unique numeric identifiers assigned to each chemical by the American Chemical Society.[56] They are the most accurate way to identify chemicals, as a chemical can have multiple names or trade names but only one CAS number.[57] CAS numbers enable researchers to access scientific information about each chemical including the chemical's structure and any available toxicological information. There is, however, a significant exception for chemicals designated a trade secret.[58] We discuss this important exception below in chapter three.

Our analysis of CAS numbers available in the industry's own entries shows that since 2013, oil and gas companies used at least two types of PFAS for fracking in oil and gas wells in Texas: fluoroalkyl alcohol substituted polyethylene glycol and PTFE. The industry also injected fluorosurfactants disclosed without CAS numbers that might be PFAS or could degrade into PFAS according to several scientists cited below, and injected into thousands of wells trade secret chemicals and trade secret surfactants that could be PFAS. This evidence

TEXAS OIL & GAS WELLS INJECTED WITH PTFE, FLUOROSURFACTANTS, POTENTIAL FLUOROSURFACTANS, AND TRADE SECRET CHEMICALS



This map shows the location of oil and gas wells in Texas known to have been fracked between January 1, 2013 and September 29, 2022 using PTFE/Teflon (a known PFAS), fluoroalkyl alcohol substituted polyethylene glycol (a known PFAS), fluorosurfactants that are likely to be PFAS or PFAS precursors, trade secret chemicals, and/or trade secret surfactants. An interactive version of the map and detailed explanation of the data are available at https://ft.maps.arcgis.com/apps/webappviewer/index.html?appid=9cff28a549d84fbeb908444bbcaf16bf.

raises the possibility that the use of PFAS has been much more extensive than publicly disclosed.

b. Industry Data Reveal Use of Fluorosurfactants

Fluorosurfactants are part of a larger group of chemicals known as "surfactants" that are commonly used in fracking.[59] According to EPA, surfactants lower the surface tension of a liquid, the interaction at the surface between two liquids (called interfacial tension), or that between a liquid and a solid.[60] Compared to other surfactants, fluorosurfactants are said to be "superior in their aqueous surface tension reduction at very low concentrations and are useful as wetting and leveling agents, emulsifiers, foaming agents, or dispersants."[61] Fluorosurfactants encompass the dangerous chemicals PFOA and PFOS, as well as hundreds of other less-studied replacement chemicals and mixtures.[62] Some are known to be extremely toxic to people,[63] could be harmful to animals,[64] and are expected to persist in the environment.[65] In most cases, it was unclear for what specific purposes the fluorosurfactants were used in Texas's oil and gas wells. Entries in the "purpose" field in FracFocus were vague, including "surfactants," "fluoro surfactant," or "water recovery surfactant."

Industry sources suggest that fluorosurfactants are commonly used in oil and gas extraction. In July 2021, PSR found that according to FracFocus data, between 2012 and 2020, oil and gas companies used PFAS or chemicals that could break down into PFAS in fracking in more than 1,200 wells in six states including in Texas. Most were fluorosurfactants.[66] In 2020, several scientists published an article in *Environmental Science: Processes and Impacts* showing that since 1956, PFAS including fluorosurfactants had been used or proposed to be used globally in oil and gas extraction techniques including chemical-driven gas production, chemical flooding, fracking, and the drilling that precedes fracking and other oil and gas production techniques.[67] In 2008, two authors, one of whom was identified as an employee at DuPont, wrote in the peer-reviewed *Open Petroleum Engineering Journal* that the use of fluorosurfactants was relatively common in the oil and gas industry and that their use was about to surge. They referred to fluorosurfactants as an "emerging technology" and stated,

> While fluorosurfactants have been used in gas and oil exploration for four decades, the increased demand for petroleum and the greater understanding of the benefits of fluorosurfactants have led to growing acceptance for fluorosurfactants throughout the petroleum industry.[68]

c. Possibly a Fluorosurfactant, Definitely PFAS

Information from several reputable sources (see section d on next page) show that oil and gas companies injected into 1,222 oil and gas wells in Texas fluorosurfactants or potential fluorosurfactants that are PFAS, likely PFAS, or PFAS precursors that can degrade into PFAS. These chemicals were listed as "fluoroalkyl alcohol substituted polyethylene glycol" and "nonionic fluorosurfactants." Fluoroalkyl alcohol substituted polyethylene glycol, injected into 65 wells, is clearly a PFAS because it is listed on EPA's Master List of PFAS Substances. The FracFocus records showed that this substance has a CAS number of 65545-80-4.[69] This identifier enabled PSR to locate the chemical on EPA's Master List of PFAS Substances where it is listed under a different name.[70] Its purpose as declared in FracFocus records is "oil field surfactant," suggesting that it could be a fluorosurfactant.[71]

Limited toxicological data is available about this substance, but according to data on the website of the National Library of Medicine's ChemIDplus, at high doses, the chemical is associated with convulsions or effects on the threshold at which a seizure could occur; dyspnea, or shortness of breath; and muscle weakness.[72] A safety data sheet for the chemical published by its manufacturer says little about human health effects. "To the best of our knowledge," the safety data sheet says, referencing the substance using a trade name Zonyl® FSO-100, "the chemical, physical, and toxicological properties have not been thoroughly investigated." Regarding impacts to the environment, the safety data sheet says, "Toxic to aquatic life with long lasting effects…Avoid release to the environment…Collect spillage… Dispose of contents/ container to an approved waste disposal plant."[73] A message on the website of ChemPoint, a chemical distributor, suggests that this chemical was phased out due to concerns that it could break down into PFOA or

Photo credit: Mansfield, Texas neighborhood with drill rigs in the background (Earthworks)

PFOS. A message apparently from Chemours, a company spun off from Dupont, says

> Zonyl® fluorosurfactant and repellent grades were discontinued between 2009 and 2014. Capstone® fluorosurfactants [a new type of fluorosurfactant] and repellents were introduced as sustainable replacements that meet the goals of the U.S. EPA 2010/15 PFOA Stewardship Program. They are based on short-chain molecules that cannot break down to PFOA or PFOS in the environment.[74]

As is discussed below, scientists have raised concerns about the health and environmental effects of these replacement chemicals.

In total, fluoroalkyl alcohol substituted polyethylene glycol and nonionic fluorosurfactants were injected into 1,222 oil and gas wells located in 66 counties. The weight of these chemicals totaled at least 53,398 pounds[75] (see Table 1 in Appendix). Even if some of that volume were PFAS, it could pose significant health and environmental risks, depending on the chemicals' toxicity. The locations of the wells where fluorosurfactants or potential fluorosurfactants were used are displayed in the map on page 5; the counties where they were used are shown in Table 1 in the Appendix. As detailed below, the use of fluorosurfactants and perhaps other PFAS may be much wider in Texas than the Open-FF records indicate.

d. Challenges in Identifying Fluorosurfactants

The fluorosurfactants listed as being used in most of the 1,222 wells were "nonionic fluorosurfactants." According to two Texas university-based chemists, both of whom are authors of multiple peer-reviewed articles about chemicals related to oil and gas production,[76] nonionic fluorosurfactants are PFAS or could degrade into PFAS. The two chemists are Zacariah Hildenbrand, Ph.D., a research professor in Chemistry and Biochemistry at the University of Texas at El Paso, and Kevin Schug, Ph. D., Shimadzu Distinguished Professor of Analytical Chemistry at the University of Texas at Arlington.[77] In addition, Wilma Subra, holder of a master's degree in chemistry and recipient of a John D. and Catherine T. MacArthur Foundation "Genius" grant for her work helping to protect communities from toxic pollution, identified both chemicals as potential PFAS. Subra, based in Louisiana, has spent decades working to reduce and remediate pollution from oil and gas operations.[78] And yet another expert, Linda Birnbaum, a board-certified toxicologist and former director of the National Institute of Environmental Health Sciences, informed PSR that the chemicals are likely to be PFAS.[79]

PSR had to rely on scientists to identify these chemicals as PFAS or PFAS precursors because the oil and gas companies that made the public disclosures to FracFocus withheld as trade secrets the chemicals' CAS numbers, data that would have enabled a precise identification of the chemicals. The identification that was available in the FracFocus records included only generic names such as nonionic fluorosurfactant and trade names such as "S-222" and "Plexsurf WRS A," information insufficient to identify the chemicals with specificity. The purposes for which these chemicals were used included "water recovery surfactant," "fluorosurfactant," and "surfactant."

Another hurdle was the multiple spellings of "nonionic fluorosurfactant" that made it difficult to identify all of the wells into which these substances were injected. Open-FF was able to identify wells in which these chemicals were used by accounting for misspellings (e.g. "noionic fluorosurfactant"). However, a member of the public searching FracFocus might not realize that the database allows multiple spellings of the same substance and could fail to identify wells injected with nonionic fluorosurfactants simply by searching for the correct spelling of the term but not any of the incorrect spellings.[80] As a result, some users of FracFocus might not know that a PFAS or potential PFAS was used in an oil and gas well in their community. This shortcoming highlights the advantage of Open-FF and points to the need for FracFocus to correct misspellings.

e. Use of PTFE, a PFAS Fluoropolymer

PSR also found, based on industry data in FracFocus, that the known PFAS polytetrafluoroethylene (PTFE) was used for fracking in 1,625 oil and gas wells in 73 Texas counties between 2013 and 2022. This chemical was listed in FracFocus by CAS number (9002-84-0)[81] and appears on EPA's Master List of PFAS Substances.[82] The weight of these uses of PTFE totaled 43,829 pounds (see Table 1 in Appendix). The FracFocus records do not show for what purpose the PTFE was used; however, PTFE, which is marketed as Teflon, is known for its slipperiness, and some fracking chemicals are used as friction reducers.[83] The locations of the wells where PTFE was used are displayed in the map on page 5, and the counties where they were used appear in Table 1 in the Appendix.

PTFE is a fluoropolymer, a type of plastic.[84] Scientists' and environmentalists' major concerns about PTFE and other fluoropolymers are related less to these substances themselves, but rather to the associated impacts of their production, use, and disposal, according to a 2020 scientific report.[85] The production of PTFE and other fluoropolymers relies on other, highly toxic PFAS that are used as production aids. As the report noted, these other PFAS have included fluorosurfactants such as PFOA, whose risks are discussed in the previous chapter, and GenX, which is similarly harmful and has replaced PFOA in fluoropolymer production.[86] (PFOA has been phased out as a manufacturing aid in the U.S. but is still used in Asia.[87]) PTFE and other fluoropolymers may contain these more toxic PFAS fragments that can leach out of the PTFE during use.[88] The authors of the 2020 paper noted that

> The levels of leachables…in individual fluoropolymer substances and products depend on the production process and subsequent treatment processes; a comprehensive global overview is currently lacking.[89]

PTFE may also generate other PFAS if the PTFE breaks down under heat.[90] In addition, the authors noted that the persistence in the environment of PTFE and other fluoropolymers could pose problems during disposal. "Landfilling of fluoropolymers leads to contamination of leachates with PFAS and can contribute to release of plastics and microplastics," they wrote.[91] One of the authors added in an email to PSR that if PTFE were used in oil and gas wells that have especially high temperatures, it could undergo a process called "thermolysis" and generate toxic PFAS called perfluoroalkyl carboxylic acids (PFCAs). As a result, he wrote, "there could be some additional problems that need some investigation."[92] A 2008 publication from oilfield services company Schlumberger indicated that at least some "high-pressure, high-temperature" wells (defined as having temperatures of at least 300º F and pressures of at least 10,000 pounds per square inch) are located in Texas.[93] In 2021, a coalition of environmental groups including the Center for Environmental Health, Clean Water Action, Ecology Center, Environmental Working Group, Natural Resources Defense Council, Safer States, and the Sierra Club shared similar concerns, based on their review of multiple scientific articles, regarding the risks of fluoropolymers such as PTFE. The groups also noted that fluoropolymers are manufactured with chemicals that have an outsized negative effect on climate change.[94] Disclosure gaps in Texas law, discussed below, may prevent scientists and the public from knowing the extent of PTFE use in oil and gas operations.

f. PFAS Joins a Roster of Dangerous Chemicals Used in Fracking

PFAS has joined the roster of potentially dangerous chemicals used in fracking. When used in oil and gas operations, PFAS may add to the cumulative human exposure to a host of toxic substances.

For years, scientists, advocates and regulators in Texas and other states have raised concerns about the hundreds of industrial chemicals used in fracking of oil and gas wells, including their potential threats to human health and to water resources. In fracking, energy companies inject into oil and gas wells a mixture of up to tens of millions of gallons of water, sand, and chemicals at high pressure to fracture underground rock formations, unlocking trapped oil and gas. The chemicals serve a variety of purposes including killing bacteria inside the wellbore, reducing friction during high-pressure fracking, and as gelling agents to thicken the fluid so that the sand, suspended in the gelled fluid, can travel farther into underground formations.[95] In 2016, EPA published a study that identified 1,606 chemicals used in fracking fluid and/or found in fracking wastewater. While the agency found high-quality information on health effects for only 173 of these chemicals, that information was troubling. EPA found that health effects associated with chronic oral exposure to these chemicals include carcinogenicity, neurotoxicity, immune system effects, changes in body weight, changes in blood chemistry, liver and kidney toxicity, and reproductive and developmental toxicity.[96]

In 2022, a team of chemists led by the University of Toledo used specialized extraction methods to establish the presence of many toxic and cancer-causing contaminants in fracking wastewater collected from the Permian Basin and Eagle Ford formations in Texas. The pollutants, which can cause harm to humans and wildlife, included volatile organic compounds, hazardous heavy metals such as lead, and radioactive uranium. Some of these hazardous contaminants represent chemical additives used in the fracking fluid, while others represent naturally occurring contaminants mobilized from the underground fracture zone. In total, the researchers detected 266 different dissolved organic compounds and 29 elements.[97]

Chemicals used in the drilling stage that precedes fracking can also pose health risks, including developmental toxicity and the formation of tumors, according to EPA regulators.[98] A disclosure form filed with the state of Ohio, one of only two states to require public disclosure of drilling chemicals (Colorado is the other),[99] shows that Statoil, Norway's state oil company (since renamed Equinor), has used a neurotoxic chemical, xylene, in drilling.[100] If chemicals used in drilling, fracking or other stages and methods of oil and gas operations were to come into contact with people or the environment, negative health effects could result.

CH. 3 TEXAS'S CHEMICAL DISCLOSURE LAW SHIELDS CHEMICAL IDENTITIES

a. Texas's "Trade Secret" Law Shields Possible Use of PFAS

The danger of exposure to unknown chemicals – PFAS and others – from oil and gas operations persists in Texas. This risk continues, despite state rules enacted in 2012[101] that generally require public disclosure of fracking and drilling chemicals.[102] The rules require that within 90 days after completion of an oil or gas well or 150 days after drilling is complete, whichever is first, well operators must disclose their fracking chemicals to FracFocus.[103]

On the face of it, these disclosure requirements seem effective; however, an important exception allows companies to avoid full and meaningful disclosure: The law allows chemical manufacturers, well operators and other companies in the chemical supply chain to withhold exact fracking and drilling fluid ingredient information if they deem it a trade secret.**[104] In place of specific fracking chemical identities, oil and gas companies must list "the chemical family or other similar description associated with such chemical ingredient."[105] In the Texas FracFocus records, examples of these generic descriptions include "nonionic fluorosurfactant"[106] and "proprietary surfactant blend."[107] Regrettably, the use of such vague descriptors can hide from public view the true identities of dangerous chemicals, including PFAS.

Texas's rules suggest that even regulators may not learn the identities of all chemicals claimed as trade secrets. The rules provide that chemical disclosure begins with chemical suppliers and service companies disclosing fracking chemical identities to well operators, who must ultimately make disclosure to the public and the agency that regulates Texas's oil and gas operations, the Railroad Commission of Texas.[108] However, an investigation by the U.S. House of Representatives found in 2011 that between 2005 and 2009, the 14 leading service providers

> …used 94 million gallons of 279 products that contained at least one chemical or component that the manufacturers deemed proprietary or a trade secret. Committee staff requested that these [service] companies disclose this proprietary information. Although some companies did provide information about these proprietary fluids, in most cases the companies stated that they did not have access to proprietary information about products they purchased "off the shelf" from chemical suppliers. In these cases, the companies are injecting fluids containing chemicals that they themselves cannot identify.[109]

If these practices have continued, service companies will be unable to inform well operators about every chemical identity in fracking chemical products, and the well operators would be unable to inform the Railroad Commission.

The use of trade secrets to conceal chemicals' specific identities effectively undermines the public health benefits of disclosure by preventing health professionals, the public, and potentially state regulators, from knowing where PFAS – or other toxic chemicals – have been used in oil and gas wells.

In addition to allowing trade secret exemptions for fracking and drilling chemicals, Texas does not require public disclosure of chemicals used in drilling, enhanced oil recovery, or in other extraction techniques that are distinct from fracking per se. EPA has indicated that any chemicals used during the first stage of the drilling process would be highly likely to leach into groundwater since during this stage, drilling passes directly through groundwater zones[110] before any casing or cement is placed in the well to seal it off. The resulting potential for groundwater contamination makes public disclosure of chemicals used in drilling especially important. These regulatory gaps increase the potential that Texans could unknowingly be exposed to PFAS and other chemicals used during multiple phases and methods of oil and gas extraction.[111]

b. Extensive Use of 'Trade Secret' Claims

Extensive application of the trade secret provisions under

** Trade secret information is also called "proprietary" or "confidential business information" (CBI).

Texas's fracking chemical disclosure rules may mask even more extensive use of PFAS in the state's oil and gas wells than has been disclosed. PSR's data analysis revealed that, between 2013 and 2022, Texas well operators claimed at least one fracking chemical as a trade secret in 58,199 oil and gas wells located across 183 of Texas's 253 counties. The trade secret chemicals used in Texas over this roughly 10-year period totaled 6.1 billion pounds (see Table 2 excerpted below and available in full in the Appendix).[112] If even a small fraction of this weight were PFAS, that fraction could pose significant risks to health and the environment. (PSR included in our analysis of trade secret chemicals those chemicals in Open-FF whose specific identities were explicitly labelled "proprietary," "trade secret," or "confidential business information" in place of a CAS number. PSR did not include as trade secrets additional unidentified chemicals for which the CAS number in Open-FF is blank.)

In an effort to identify any PFAS among these trade secret chemicals, PSR examined whether any were listed as a surfactant. Surfactants, as noted above, encompass dangerous fluorosurfactants, some of which are extremely toxic to people[113] and persistent in the environment.[114] We found thousands of cases of oil and gas companies using at least one trade secret chemical that they described as a surfactant. These occurred in 30,700 wells, spread across 171 counties.[115] (See the excerpt from Table 2, below, and the full table in the Appendix.) Operators' names for these chemicals were vague, including "surfactant" and "surfactant blend." These trade secret surfactants totaled 331 million pounds. (See examples from individual wells in Table 3 below.) While we cannot know what these trade secret chemicals are, should even a small percentage of them be fluorosurfactants, they could pose significant threats to human health and the environment.

Table 2. Disclosed Use in Fracking of Trade Secret Chemicals in Texas Oil and Gas Wells, 2013-2022

County	Number of wells injected with at least one trade secret chemical	Mass of all trade secret records (lbs.)	Number of wells injected with at least one trade secret surfactant	Mass of trade secret surfactants (lbs.)
Anderson	4	39,100	1	443
Andrews	2,603	70,400,000	1,670	8,050,000
Angelina	18	1,640,000	2	9,450
Aransas	6	2,680	2	458
Archer	47	12,200	19	3,560
Atascosa	772	21,000,000	332	2,280,000
Austin	2	6,880	1	1,450
Bastrop	1	28,700	0	0
Baylor	3	12,500	0	0
Bee	5	297,000	4	11,300
Additional B-Z in Appendix	See Appendix	See Appendix	See Appendix	See Appendix
Total	58,199	6,120,000,000	30,700	331,000,000

This excerpted table, based on FracFocus data covering the dates January 1, 2013 through Sept. 29, 2022, shows county-by-county the number of Texas wells in which oil and gas companies injected for fracking at least one trade secret chemical or at least one trade secret surfactant. The total weight figures reflect the sum of all records for which we have enough information to calculate a chemical's weight. However, the total weight figures represent an undercount because many fracking chemical disclosures lack sufficient data to perform this calculation.

Below, Table 3 shows examples of the types and quantities of fracking chemicals injected into individual wells. In some cases, oil and gas companies injected hundreds or even thousands of pounds of PFAS or trade secret chemicals into oil and gas wells for fracking. Even in the case below in which a company injected just two pounds of fluorosurfactant for fracking, this quantity would be enough to contaminate vast amounts of water if the fluorosurfactant had a toxicity similar to that of PFOA or PFOS.

Table 3. Examples of Chemical Reporting on Individual Oil and Gas Wells in Texas

Well Operator	Well Number	County	Year Fracking Completed	Chemical used in Well	CAS Number	Trade Name	Mass (lbs.)
Sable Permian Resources	4238340217	Reagan	2019	PTFE	9002-84-0	not reported	2,035
Juno Operating Company II, LLC	4210731828	Crosby	2014	nonionic fluorosurfactant	Proprietary	S-222	2
Endeavor Energy Resources	4231740584	Martin	2017	nonionic fluorosurfactant	00-00-0 (ambiguous)	WRS-3	1,349
Chesapeake Operating, Inc.	4212738447	Dimmit	2022	proprietary surfactant blend	Proprietary	not reported	95
Pioneer Natural Resources	4231740216	Martin	2016	surfactant	Proprietary	not reported	9,554

This table shows illustrative samples of specific oil and/or gas wells injected with the types of fracking chemicals referenced in the larger tables above, including fluorosurfactants, trade secret surfactants such as the "proprietary surfactant blend," and PTFE. The examples cover a range of years and represent wells fracked in several Texas counties.

Tables 4 and 5, excerpted on the following page, show some of the oil and gas companies that fracked the most wells in Texas between 2013 and 2022 using fluorosurfactants and PTFE, respectively. (Both tables are displayed in full in the Appendix.) Companies that used these chemicals include prominent oil and gas producers ExxonMobil, the nation's largest publicly traded oil and gas company,[116] Chevron USA, Inc., the nation's second largest oil and gas company,[117] and Pioneer Natural Resources Co., the largest oil producer in the Permian Basin which straddles Texas and New Mexico.[118]

Table 4. Excerpt (full table in Appendix). Oil and Gas Companies that Fracked the Most Wells in Texas Using Fluorosurfactants, 2013-2022

Well Operator	Number of wells injected with fluorosurfactants potential fluorosurfactants	Total weight of fluorosurfactants (lbs.)
Athlon Energy Operating LLC	195	10,771
Juno Operating Company II, LLC	148	141
Delta Oil & Gas Ltd.	110	4
EOG Resources, Inc.	67	22,336
XTO Energy/ExxonMobil	67	745
LCS Production Company	48	16
Citation Oil and Gas Corp.	30	31
Chevron USA Inc.	26	155
Brigadier Operating LLC	25	ND*
Urban Oil and Gas Group	25	10
PPC Operating Company LLC	22	ND
Petrobal Omega 1, LLC	21	186
Apache Corporation	18	180
Laredo Petroleum, Inc.	16	4,721
Blackbeard Operating	14	393

This excerpted table shows the oil and gas companies that fracked the greatest number of oil and gas wells in Texas with fluorosurfactants or potential flurosurfactants between January 1, 2013 and Sept. 29, 2022. More companies are listed in the full table in the appendix. Fluorosurfactants may be PFAS or precursors that could degrade into PFAS. The full table contains an expanded caption.

Table 5. Excerpt (full table in Appendix). Oil and Gas Companies that Fracked the Most Wells in Texas Using PTFE, 2013-2022

Well Operator	Number of wells with PTFE	Total mass of PTFE (lbs.)
BHP Billiton Petroleum	196	3,237
Cimarex Energy Co.	123	1,172
Pioneer Natural Resources	117	670
Occidental Oil and Gas	115	2,718
Ring Energy, Inc.	113	4,827
EXCO Resources, Inc.	87	1,003
Chesapeake Operating, Inc.	86	329
Apache Corporation	70	738
Forest Oil Corporation	69	897
Guidon Energy Management Services LLC	55	9,301
Matador Production Company	39	382
Lonestar Resources, Inc.	32	892
XTO Energy/ExxonMobil	32	1,208
ConocoPhillips Company/Burlington Resources	26	243
Sundance Energy	26	57

This excerpted table shows the fifteen oil and gas companies that fracked the greatest number of oil and gas wells in Texas with PTFE between January 1, 2013 and Sept. 29, 2022. More companies are listed in the full table in the appendix. The full table contains an expanded caption.

CH. 4 PFAS USE IN OIL AND GAS OPERATIONS ENDANGERS HEALTH IN TEXAS

a. Multiple Potential Pathways to Exposure

Where PFAS are among the chemicals used in oil and gas extraction, they could enter water supplies through spills, injection wells, land application, or other pathways, thus placing drinking water and agricultural water sources at risk. That risk is potentially substantial, given PFAS' characteristics: toxic in minuscule concentrations, linked to cancer, birth defects, pre-eclampsia, and other serious health effects, highly mobile in water, and extremely persistent in the environment.

EPA in its 2016 national report on fracking and drinking water found that fracking-related pollution could follow a number of pathways. Even without examining water contamination risks from underground disposal wells,[119] the agency cited the following possible pathways to exposure:

- spills of fracking fluid that seep into groundwater;
- injection of fracking fluid into wells with cracks in the casing or cement, allowing the fluid to migrate into aquifers;
- injection of fracking fluids directly into groundwater;
- underground migration of fracking fluids through fracking-related or natural fractures;
- intersection of fracking fluid with nearby oil and gas wells,
- spills of wastewater after the fracking process is completed, and
- inadequate treatment and discharge of fracking wastewater to surface water supplies.[120]

b. Evidence of Fracking-Related Water Contamination

The potential in Texas for water contamination through these pathways, from PFAS or other fracking chemicals, is not just hypothetical. In 2017, the news outlet EnergyWire reported on spills at oil and gas sites in Texas and other states that had occurred over a five-year period. EnergyWire found that the number of reported spills in Texas was 1,965 in 2012; 2,142 in 2013; 2,500 in 2014; 2,793 in 2015; and 2,069 in 2016.[121]

Texas faces particular risks of spills at well sites due to hurricanes and heavy storms. According to an El Paso Times report from 2016,

> Scores of photographs taken by state emergency-management officials show that when floodwaters rise in Texas, they inundate oil wells and fracking sites, sweeping crude and noxious chemicals into rivers throughout the Lone Star State....Many of the photos shot during Texas's recent floods show swamped wastewater ponds at fracking sites, presumably allowing wastewater to escape into the environment — and potentially into drinking-water supplies.[122]

If even small amounts of PFAS were involved in some of these spills, they could cause significant contamination.

Evidence suggests that underground migration of contaminants from oil and gas production wells has occurred. In 2017, an analysis published in *Science of the Total Environment* of groundwater in the Eagle Ford Shale region in southern Texas found sporadic instances of multiple volatile organic compounds (VOCs) and dissolved gas, providing evidence that "groundwater quality is potentially being affected by neighboring [drilling and fracking] activity, or other anthropogenic activities, in an episodic fashion." The authors concluded that more extensive investigation was needed of possible groundwater contamination in the Eagle Ford basin.[123]

Several earlier studies also found evidence of underground contamination that appeared to be associated with fracking operations. In 2016, a team of researchers from the University of Texas compared measurements of contaminants in groundwater collected before the expansion of unconventional oil and gas development in the Cline Shale region of western Texas to subsequent measurements made over a 13-month period. The researchers detected alcohols, chlorinated compounds, and hydrocarbon co-contaminants that corresponded with the number of oil and gas production wells in the area.[124] In 2015, many of the same researchers published a study in which they documented widespread drinking water contamination throughout the Barnett Shale in northern Texas, a region that has been heavily drilled for gas. The study, which analyzed 550 water samples from public and private water wells, found elevated levels of 19 different chemical compounds associated with fracking including the carcinogen benzene, neurotoxic toluene, methanol, ethanol, and strikingly high levels of 10 different metals. The researchers said that the findings

> do not necessarily identify [unconventional oil and gas] activities as the source of contamination; however, they do provide a strong impetus for further monitoring and analysis of groundwater quality in this region as many of the compounds we detected are known to be associated with [unconventional oil and gas extraction] techniques.[125]

In 2013, University of Texas at Arlington researchers found elevated levels of arsenic and other heavy metals in some samples from private drinking water wells located within three kilometers of active natural gas wells in the Barnett Shale region. The levels of contaminants were higher than those in well water inside the region that was farther than three miles from gas wells and higher than levels in well water outside the region.[126]

These studies did not test for PFAS. This lack of testing is not surprising; there were few if any grounds to test for PFAS in connection with oil and gas operations prior to July 2021, when PSR first publicized the probable use of these chemicals in oil and gas extraction.

c. Disposal of Wastewater Raises Pollution Concerns

Another risk that is especially high in Texas is that PFAS and other chemicals could pollute the environment through the disposal of fracking and/or drilling wastewater. Fracking fluid wastewater, which is brought back to the surface after fracking is completed, can contain chemicals injected during the fracking process, including trade secret chemicals,[127] and thus, potentially, PFAS. It can also contain naturally occurring toxics found underground such as radium, a radioactive element and known human carcinogen.[128, 129, 130] Much of the oil and gas wastewater generated in Texas is subsequently disposed in underground injection or disposal wells.[131] In the case of injection wells, wastewater from oil and gas wells is injected into oil wells in order to facilitate oil production. The wastewater increases or maintains pressure in an oil field depleted by prior production and displaces or sweeps additional oil toward producing wells. This type of secondary recovery is sometimes called waterflooding.[132] In the case of disposal wells, oil and gas wastewater is injected for permanent disposal.[133] As of July 2015, there were 26,100 active injection wells and 8,100 active disposal wells in the state.[134]

The environmental nonprofit Earthworks detailed in a 2021 report that between January 2012 and December 2020, oil and gas companies injected into underground wells 28.4 billion gallons of fracking “flowback” waste, the wastewater that first comes out of wells during fracking; 3.1 trillion gallons of “produced water” that flows out of wells after the flowback, and almost 332 million gallons of liquid, radioactive waste.[135] If even a small percentage of this staggering amount of wastewater were tainted with PFAS, it could create significant pollution if it were to enter groundwater or surface water.

Meanwhile, researchers have known for decades that wastewater from injection wells can migrate upward from deep underground, moving through nearby oil and gas wells, many of which have ceased operating but have not been properly sealed off from the surrounding underground rock formations.[136] This migrating wastewater can break out of the abandoned wells and contaminate groundwater located near the earth’s surface.[137] The threat that this scenario creates is particularly acute in Texas, where 60 percent of the state’s water comes from groundwater.[138] In 1985, the Texas Department of Agriculture reported that oil and gas wastewater migrating up through abandoned, improperly plugged wells was a common source of water contamination in oil and gas production areas:

> When a water well is experiencing an oilfield pollution problem (typically, high chlorides), the pollution source is often difficult to track down. The source could be a leak in the casing of a disposal well, leakage behind the casing due to poor cement bond, old saltwater evaporation pits, or, most often, transport of contaminants through an <u>improperly plugged abandoned well</u> [underscore in original].[139]

The department even had a name for this phenomenon: "saltwater breakout," in which the salty oil and gas wastewater migrated up the abandoned well and then broke out near the surface, contaminating groundwater.[140] In one case in 1984 in Palo Pinto County, the department reported, "investigation found oil and salt coming up through an improperly plugged well. The water was coming from an injection well one-half mile away."[141] The department quoted the Congressional Office of Technology Assessment regarding the "insidious" problem of underground injection of oil and gas wastewater: that it is typically injected in exactly the places where prior drilling has opened up opportunities for the wastewater to migrate into groundwater.[142]

James Osborne, a reporter with the Houston Chronicle, wrote in September 2022 that the potential that injected oil and gas wastewater could migrate up abandoned oil and gas wells is still a risk to Texas's groundwater supplies. He reported that according to the Railroad Commission of Texas there are 150,000 inactive oil and gas wells in Texas.[143] An advocacy group, Commission Shift, that tracks the Railroad Commission, found that 17,000 of these wells have not operated for 20 years.[144]

Additionally, as Cyrus Reed, Conservation Director at the Texas chapter of the Sierra Club told Osborne, the list of known abandoned wells is always growing. "The Railroad Commission is plugging about 1,000 to 1,400 wells a year, but as you plug one well, another comes on," Reed said. "We're always playing catchup." Ron Green, a former hydrologist at the Southwest Research Institute, a non-profit research organization in San Antonio, told Osborne that the extent of groundwater pollution caused by injected wastewater migrating up abandoned oil and gas wells is unknown and may not manifest itself for years, but there is at least one indication that it is occurring:[145] Water sampling in the Carrizo-Wilcox aquifer in South Texas beneath the Eagle Ford shale, a major oil- and gas-producing region, shows that the aquifer has become more saline, Green said, indicating that injected wastewater could be infiltrating water supplies.[146] Further compounding the problem, the true number of abandoned wells in Texas may never be known due to poor or nonexistent record-keeping, according to reporting by StateImpact in 2012.[147]

Several other types of oil and gas waste disposal could pose serious risks to Texans if the waste were contaminated with PFAS. One disposal technique used in Texas is the spreading of wastewater on land ("land application").[148] Texas's permitting process does not require testing of this wastewater for radioactive contaminants, even though it is well known that such wastewater may contain radioactivity. Nor does the state require testing for PFAS.[149] Other oil and gas waste disposal methods used in Texas include taking waste to commercial surface waste management facilities or landfills, burial of wastes in pits at well sites or other locations, and surface water discharge.[150] The presence of PFAS could add to contamination threats in each type of disposal.

Local governments have little say in waste disposal decisions, even when oil and gas waste disposed of in Texas comes from out of state. An investigation conducted in 2021 by DeSmog found that at least one company imported oilfield waste for disposal at a West Texas facility from other states and even other countries. Some of the waste had extremely high levels of radioactivity. It is unclear whether this waste was tested for PFAS, but any PFAS in the waste would add to its risk.[151] Earthworks noted that local governments have little power to prevent waste facilities from locating in or near their jurisdictions.[152] In addition, in 2015, state lawmakers passed HB 40 that stripped local governments of most power to regulate oil and gas production wells.[153]

d. Volatilizing, Flaring Could Pollute Air with PFAS

PFAS used in oil and gas wells could follow airborne exposure routes, according to toxicologist Dave Brown, former director of environmental epidemiology at the Connecticut Department of Health who has investigated health effects associated with unconventional gas drilling with the Southwest Pennsylvania Environmental Health Project. He warned that if PFAS were to enter drinking water, it could subsequently volatilize or become airborne inside homes. Brown also added another potential pathway for airborne exposure: PFAS could become airborne when gas is burned off during flaring at the wellhead.[154]

Flaring is significant in Texas, creating a potential pathway for PFAS-tainted air emissions from oil and gas wells. A study published in 2018 used remote sensing data that incorporated infrared observations of combustion sources to estimate exposure of local residents to hazardous air pollutants from associated flaring operations in the Eagle Ford shale region in South Texas. The researchers confirmed extensive flaring in close proximity to homes.[155] In 2014, a four-part investigation by the San Antonio Express-News found that natural gas flaring in the Eagle Ford Shale in 2012 emitted more than 15,000 tons of volatile organic compounds such as carcinogenic benzene and other contaminants. This quantity of pollution was roughly equal to the pollution that would be released each year by six oil refineries. No state or federal agency was tracking the emissions from individual flares, the Express-News found.[156] These studies did not examine PFAS pollution but raise the potential that PFAS could have been present in the staggering amount of pollution emanating from the flared gas.

Pump jack and flare in Eagle Ford Shale in South Texas, May 2015. Photo credit: Earthworks

e. PFAS Could Compound Health Harms from Other Oil and Gas Chemicals

PFAS is by no means the only chemical associated with oil and gas extraction that could cause harm to health. Deeper investigation of PFAS use in oil and gas operations is especially important because exposure to PFAS may be additional to those other chemicals and could impact or intensify health effects caused by them. It is unknown if any of the problems associated with fracking chemicals, some of which are referenced below, are linked to or aggravated by PFAS used in oil and gas operations, but researchers should investigate.

Peer-reviewed studies of people living near oil and gas operations, including those in Texas, have found that proximity to active well sites correlates with a variety of diseases and other health effects. A 2021 study of more than three million pregnant women in Texas showed that living within one kilometer of an active oil or gas well increased the odds of gestational hypertension (high blood pressure) and eclampsia[157] (onset of seizures or coma during pregnancy or childbirth).[158] A 2020 study of pregnant women living in the Eagle Ford Shale area of South Texas found that exposure to a high number of nightly flaring events was associated with a 50 percent increase in the risk of preterm birth.[159] A 2020 study in Texas documented a link between natural gas extraction from both conventional and unconventional wells and frequency of hospitalization for childhood asthma.[160] Several studies conducted in Colorado, another major producer of oil and gas, also found associations between proximity to oil and gas operations and health effects, including congenital heart defects in newborns[161] and cancer diagnoses among Coloradans from birth to 24 years old.[162]

On a national scale, PSR and Concerned Health Professionals of New York have collaborated to compile and summarize the substantial and growing number of scientific studies that have found serious health effects associated with oil and gas drilling. In the eighth edition (2022) of our report, we wrote,

> Public health problems associated with fracking include prenatal harm, respiratory impacts, cancer, heart disease, mental health problems, and premature death…. Poor birth outcomes have been linked to fracking activities in multiple studies in multiple locations using a variety of methods. Studies of mothers living near oil and gas extraction operations consistently find impaired infant health, especially elevated risks for low birth weight and preterm birth. As we go to press, a new study in Pennsylvania finds "consistent and robust evidence that drilling shale gas wells negatively impacts both drinking water and quality of infant health."[163]

Low birthweight is a leading contributor to infant death in the United States.[164]

Many residents living near oil and gas operations have expressed frustration over the secrecy surrounding chemicals used by the oil and gas industry.[165] In 2020, Pennsylvania's Attorney General issued a report based on a criminal grand jury investigation of oil and gas drilling pollution in the Keystone State. Drilling for gas in shale formations has surged in that state over the past 15 years,[166] vaulting it into the number two spot among gas-producing states (Texas is number one)[167] and bringing many more Pennsylvanians into contact with gas drilling and its impacts. Based on testimony from over 70 households, the attorney general compiled evidence of serious health impacts, finding that

> Many of those living in close proximity to a well pad began to become chronically, and inexplicably, sick. Pets died; farm animals that lived outside started miscarrying, or giving birth to deformed offspring. But the worst was the children, who were most susceptible to the effects. Families went to their doctors for answers, but the doctors didn't know what to do. The unconventional oil and gas companies would not even identify the chemicals they were using, so that they could be studied; the companies said the compounds were "trade secrets" and "proprietary information." The absence


Marathon Oil facility in Karnes County Texas, May 2015. Photo credit: Earthworks

of information created roadblocks to effective medical treatment. One family was told that doctors would discuss their hypotheses, but only if the information never left the room.[168]

Now that we know PFAS have been used in oil and gas operations for years, scientists should determine whether there are connections between this use and health effects, for PFAS chemicals individually and as a compounding factor in conjunction with exposure to other fracking chemicals.

f. Fracking and Chemical Exposure as an Environmental Justice Issue

"Fenceline" communities – people living close to oil and gas operations – often bear a disproportionate risk of exposure to toxic chemicals and may be particularly at risk from PFAS used in oil and gas extraction. Although drilling and fracking take place in the majority of U.S. states, not everyone shares in that risk equally. Rather, oil and gas infrastructure and associated chemicals are frequently located in or adjacent to low-income, underserved, and marginalized communities, Indigenous communities, and other communities of color.

In 2021, researchers used satellite observations and census data to show that 83 percent of the flaring from unconventional oil and gas wells in the contiguous United States between March 2012 and February 2020 took place in three basins: the Williston Basin in North Dakota, Permian Basin in west Texas, and the Western Gulf Basin in southern Texas and Louisiana. They estimated that over half a million people in these basins lived within three miles of a flare, with 39 percent of them living near more than 100 flares each night. The researchers also reported that in these regions, Black, Indigenous, and people of color were disproportionately exposed to flaring.[169]

Other studies have also found disproportionate impacts on people of color. A 2020 study found that compared to white residents, Hispanic residents living in the Eagle Ford shale region were disproportionately exposed to flaring from unconventional oil and gas wells.[170] Hispanic residents were exposed to more (or more frequent) flares even though they were less likely than white residents to live near unconventional oil and gas wells. The researchers speculated that the increased exposure "may be driven by difference in political marginalization between Hispanic and non-Hispanic white communities in the region." They explained that

> marginalized communities are often targeted for the citing of locally unwanted land uses because of the perceived lack of political power and limited resources to challenge industrial practices [endnotes omitted]. These communities often receive less government oversight, which may increase the local levels of pollution, ultimately exacerbating health disparities.

In 2016, a public health research team showed that in the Eagle Ford shale region, disposal wells for fracking wastewater were more than twice as common in areas where residents are more than 80 percent people of color than in majority-white communities. They also found that disposal wells were disproportionately located in areas with high rates of poverty.

But even in these areas, the association with race was predominant. "Adjusting for both poverty and rurality," the researchers wrote, "we still found that as the proportion of people of color in the census block group increased, so did the presence of disposal wells." Since 2007, they reported, Texas had permitted more than 1,000 waste disposal wells in the Eagle Ford Shale region, where groundwater is the primary source of drinking water.[171]

A 2019 analysis conducted in Colorado, Oklahoma, Pennsylvania, and Texas found strong evidence that African Americans disproportionately lived near fracking wells in Texas and Oklahoma, while Hispanics disproportionately lived near fracking wells in Texas and urban Colorado. "The question, who bears the costs of unconventional natural gas drilling, is of great relevance not only for the U.S., but worldwide," the researchers wrote.

According to estimates by Measham and Fleming (2014), around 300 million people across six continents in populated areas live on land that overlies shale-energy reservoirs. As unconventional gas drilling is expanding across the world, regulation of hydraulic fracturing in the U.S. will have an impact on its regulation in other countries, and hereby on its environmental and human health consequences.[172]

Economics as well as race can be a determinant of disproportionate risk. In 2015, a study found that those economically benefiting most from shale gas fracking in Denton, Texas, mostly lived elsewhere, while the environmental impacts remained local and affected those who did not have a voice in mineral-leasing decisions. "Non-mineral owners are essentially excluded from the private decisions," the authors wrote, "as the mineral owners not only receive the direct monetary benefits, but also hold a great deal of state-sanctioned power to decide if and how [shale gas development] proceeds."[173]

Where a pattern of risks affects people of color and/or lower-income people disproportionately, fracking should be viewed as an Environmental Justice issue – and so too should any resultant exposure to PFAS.

POLICY CAN HELP PROTECT TEXANS FROM PFAS IN FRACKING

a. EPA Regulation of PFAS: Lax

Governments at all levels will have to do more to protect the public from PFAS, in large part because EPA has taken only modest steps to do so, while Congress and the executive branch have exempted the oil and gas industry from major provisions of multiple federal environmental laws. For example, oil and gas waste is exempted from the hazardous waste rules that require cradle-to-grave tracking and safe handling of hazardous substances under the Resource Conservation and Recovery Act. These exemptions increase the burden on state governments to address any PFAS pollution associated with oil and gas extraction.[174]

EPA has taken some steps to protect the public from dangerous PFAS. In 2005, EPA reached a then-record $16.5 million settlement with chemical manufacturer Dupont after accusing the company of violating the federal Toxic Substances Control Act (TSCA) by failing to disclose information about PFOA's toxicity and presence in the environment.[175] In 2006, EPA invited Dupont, 3M and six other companies to join a "stewardship" program in which the companies promised to achieve a 95 percent reduction of emissions of PFOA and related chemicals by 2010, compared to a year 2000 baseline. The agreement also required the companies to eliminate such emissions and use of these chemicals by 2015.[176] In 2022, EPA said on its website that the companies reported that they had accomplished those goals either by exiting the PFAS industry or by transitioning to alternative chemicals.[177] However, since the announcement of its PFAS stewardship program in 2006, EPA has allowed nearly unlimited use of closely related "replacement" chemicals in dozens of industries.[178] In response, in 2015 a group of more than 200 scientists raised health and environmental concerns that the new PFAS designed to replace PFOA and PFOS may not be safer for health or the environment.[179]

In October 2021, EPA announced a "strategic roadmap" for regulating PFAS. This plan encompasses a goal of setting federal drinking water standards for several PFAS chemicals by 2023, as well as commitments to "use all available regulatory and permitting authorities to limit emissions and discharges from industrial facilities" and "hold polluters accountable."[180] The plan does not, however, include an examination of PFAS use in the oil and gas industry. (Later that month, 15 members of the U.S. House of Representatives asked EPA to examine this topic.[181] The month before, PSR asked EPA to collect data on PFAS use in oil and gas extraction, utilizing its authority under TSCA.[182]) As previously stated, in June 2022, EPA announced new health advisory levels for several types of PFAS. Unfortunately, these standards are advisory and not legally enforceable.[183]

And in August 2022, EPA proposed designating PFOA and PFOS as hazardous under Superfund.[184] This designation would enable affected parties to more easily hold oil and gas companies accountable for cleanup costs if PFOA and PFOS were found at oil and gas sites because under Superfund, liability does not require negligence and any potentially responsible party (PRP) can be held liable for cleanup of an entire site when it is difficult to distinguish contributions to pollution among several parties. As EPA writes about Superfund, "[i]f a PRP sent some amount of the hazardous waste found at the site, that party is liable.[185]

b.Texas Disclosure Rules: In Need of Reform

In Texas, multiple reforms are needed to protect the public from the use of PFAS in oil and gas operations, including changing the state's chemical disclosure rules to lift the veil of secrecy that oil and gas companies have used to conceal the use of potentially dangerous chemicals including, perhaps, PFAS. One such change should be tighter limits on the use of trade secret provisions.

Oil and gas companies have argued that chemical trade secrets are necessary to protect their intellectual property from competitors. However, this interest does not have to mean a complete lack of information on chemical identities for scientists, regulators, or the public. In 2015, California, a major oil-producing state,[186] began requiring full disclosure of chemicals used for well stimulation, including fracking. The policy did away with trade secret exemptions for the individual chemicals used in fracking products.[187] In June 2022, Colorado, another major producer of oil and gas, followed in California's footsteps but extended the disclosure requirements to all chemicals used in oil and gas wells, not just fracking or stimulation chemicals.[188]

The methodology utilized in California and Colorado is consistent with a recommendation issued in 2014 by an advisory panel to the U.S. Department of Energy: that companies reveal the fracking chemicals injected into each well, providing that information in a list in which the chemicals are disassociated from the trade name of the commercial products they are part of.[189] This form of disclosure enables the public to know all the chemicals used in fracking without disclosing to rival chemical manufacturers the exact components of any proprietary formulas.[190] California also has a process under which state regulators review secrecy requests from chemical companies to determine whether the information must be kept proprietary.[191] Health and safety data related to fracking fluids are not allowed to be hidden from public view under California law.[192] California also requires disclosure of the chemicals used prior to fracking,[193] as do West Virginia[194] and Wyoming.[195]

Texas should also ensure that full chemical disclosure is required from all the companies in the chemical supply chain. Currently, Texas rules require chemical disclosure from the supplier or service provider to the well operator, who is ultimately responsible for making public disclosure.[196] Chemical manufacturers, however, are explicitly exempted from this chain of reporting, despite being the only entity that always knows the precise contents of the chemicals they produce. Texas's existing rules exempt chemical manufacturers by providing that

> a supplier is not responsible for any inaccuracy in information that is provided to the supplier by a third party manufacturer of the [fracking] additives. A service company is not responsible for any inaccuracy in information that is provided to the service company by the supplier. An operator is not responsible for any inaccuracy in information provided to the operator by the supplier or service company.[197]

Therefore, the operator, who must ultimately make public disclosure, has no legal incentive to hold the supplier or service company accountable for providing accurate fracking chemical information, as the operator cannot be held accountable for inaccurate information from those sources. The service company likewise has no incentive to hold the supplier accountable, and the supplier has no similar incentive to hold the manufacturer accountable. In theory, the operator might have the ability to hold the manufacturer accountable for providing accurate chemical information if the manufacturer provided chemical additives directly to the operator, but this scenario seems unlikely; manufacturers can avoid that type of accountability by providing their chemicals for use in fracking through a supplier.

An additional section in Texas law provides that "a supplier, service company, or operator is not required to…disclose ingredients that are not disclosed to it by the manufacturer, supplier, or service company."[198] This section more definitively eliminates the incentive that an operator, supplier, or service company might have to demand full disclosure of fracking chemical ingredients by a chemical manufacturer.

The 2011 congressional investigation mentioned in chapter three, as well as additional evidence, suggests that chemical manufacturers do not always tell companies farther down the supply chain the full contents of the chemical products they are using. Rather, they provide these companies with vague descriptions, generic chemical family names, or Material Safety Data Sheets with an incomplete list of chemicals.[199] In such cases, the end users may legitimately be unable to disclose all the identities of chemicals used at a particular well – including PFAS – whether under trade secret protection or not. They simply would not have the information. Requiring disclosure of oil and gas chemicals by chemical manufacturers would avoid this problem. Colorado took this step in its June 2022 legislation.[200]

Oil and gas fields around Midland, Texas, April 2012. Photo credit: Jane Pargiter, EcoFlight

These eminently reasonable and feasible reforms are valuable steps to protect the health of people who may be exposed to PFAS and other dangerous oil and gas chemicals, be they industry workers, residents living near well sites, or first responders called to the scene of an accident. They can improve health and potentially save lives. Additional steps to reduce the harms caused by oil and gas extraction are outlined in the following section, including a ban on the use of PFAS in oil and gas operations, an action that Colorado took in 2022.[201] Among the evidence supporting the feasibility of this measure is a peer-reviewed analysis published in 2021 showing that many PFAS are immediately replaceable with less persistent and less toxic substances, including for use in the oil and gas industry.[202]

RECOMMENDATIONS

In light of the findings shared in this report, PSR recommends the following:

• **Halt PFAS use in oil and gas extraction.** Texas should follow the lead of Colorado, a major oil- and gas-producing state which banned the use of PFAS in oil and gas wells through legislation passed in June 2022. Furthermore, Texas and the U.S. Environmental Protection Agency (EPA) should prohibit PFAS from being used, manufactured, or imported for oil and gas extraction. Many PFAS are immediately replaceable with less persistent and less toxic substances, including for use in the oil and gas industry.

• **Expand public disclosure.** Texas should greatly expand its requirements for public disclosure of oil and gas chemicals. The state could again follow the example offered by Colorado by requiring disclosure of all individual chemicals used in oil and gas wells without exceptions for trade secrets, while requiring disclosure on the part of chemical manufacturers who know best what chemicals are being used. Texas should also require chemical disclosure prior to fracking, as have several states including California, West Virginia, and Wyoming.

• **Increase testing and tracking.** Texas and/or the U.S. EPA should determine where PFAS have been used in oil and gas operations in the state and where related wastes have been deposited and should test nearby residents, water, soil, flora, and fauna for PFAS.

• **Require funding and cleanup.** Oil and gas and chemical firms should be required to fund environmental testing for PFAS in their areas of operation where these are needed, and should PFAS be found, be required to fund cleanup. If water cleanup is impossible, the companies responsible for the use of PFAS should pay for alternative sources of water for drinking, household uses, and agriculture, as needed.

• **Reform Texas's regulations for underground injection disposal wells** to prohibit wells close to underground sources of water, to require groundwater monitoring for contaminants near the wells, and to require full public disclosure of the chemicals in the wastewater.

• **Transition to renewable energy, better regulation.** Given the use of highly toxic chemicals in oil and gas extraction, including but not limited to PFAS, as well as climate impacts of oil and gas, Texas should transition away from fracking and move toward renewable energy and efficiency. This transition should be structured to provide economic support for oil and gas workers. However, as long as we have drilling and fracking, the state should better regulate these practices so that Texans are not exposed to toxic substances. The state should also empower local governments to regulate the industry. When doubt exists as to the existence or danger of contamination, the rule of thumb should be, "First, do no harm."

APPENDIX

Table 1. Disclosed Use in Fracking of Fluorosurfactants, Potential Fluorosurfactants, and PTFE in Texas Oil and Gas Wells, 2013-2022

County	Number of wells injected with fluorosurfactants, potential fluorosurfactants	Mass of fluorosurfactants, potential fluorosurfactants (lbs.)	Number of wells injected with PTFE	Mass of PTFE (lbs.)
Anderson	1	3	1	13
Andrews	74	1,024	115	3,231
Archer	1	15	0	0
Atascosa	0	0	51	299
Baylor	2	56	0	0
Bee	0	0	2	ND*
Borden	15	222	0	0
Bosque	1	ND	0	0
Brazos	0	0	1	13
Burleson	1	ND	7	44
Callahan	2	ND	0	0
Cherokee	0	0	1	3
Cochran	4	37	0	0
Coke	3	ND	0	0
Coleman	15	2	0	0
Concho	9	5	0	0
Cottle	1	ND	1	1
Crane	14	148	1	ND
Crockett	27	5,479	5	87
Crosby	163	158	0	0
Culberson	0	0	83	864
Dawson	6	31	1	2
De Witt	0	0	86	418
Dimmit	0	0	105	824
Eastland	7	2	0	0
Ector	6	216	1	1
Fayette	0	0	5	ND
Fisher	8	15	1	37
Frio	0	0	20	666
Gaines	22	131	43	1,525
Garza	2	7	0	0
Glasscock	55	6,622	30	172
Gonzales	0	0	74	1,313
Grayson	3	165	3	3
Grimes	0	0	2	68
Guadalupe	1	1	0	0
Hansford	0	0	1	22
Hardeman	1	ND	0	0
Harris	0	0	5	1
Harrison	0	0	1	1,015
Haskell	10	1	0	0
Hemphill	1	1	22	103

Table 1. Continued

County	Number of wells injected with fluorosurfactants, potential fluorosurfactants	Mass of fluorosurfactants, potential fluorosurfactants (lbs.)	Number of wells injected with PTFE	Mass of PTFE (lbs.)
Hockley	3	ND	0	0
Houston	0	0	6	27
Howard	78	2,765	12	289
Irion	16	5,516	8	101
Jack	69	470	0	0
Jackson	1	ND	0	0
Jones	7	3	0	0
Karnes	0	0	42	1,173
Kent	2	ND	0	0
King	14	4	0	0
La Salle	0	0	62	579
Lee	0	0	2	7
Leon	0	0	8	81
Lipscomb	0	0	20	102
Live Oak	0	0	16	113
Loving	27	5,542	61	1,816
Madison	0	0	9	135
Marion	0	0	1	ND
Martin	29	4,491	92	9,617
Maverick	0	0	3	5
McMullen	0	0	34	215
Midland	55	6,363	34	240
Mitchell	11	34	0	0
Montague	2	9	0	0
Nacogdoches	0	0	5	34
Nolan	35	13	0	0
Ochiltree	0	0	43	175
Oldham	0	0	5	4
Palo Pinto	25	81	0	0
Pecos	22	278	14	145
Potter	0	0	3	20
Reagan	19	5,565	10	9,291
Reeves	21	4,412	208	5,256
Roberts	1	36	7	26
Robertson	0	0	1	ND
Runnels	2	ND	0	0
Rusk	1	ND	4	16
San Augustine	0	0	5	ND
San Jacinto	0	0	1	3
Schleicher	6	9	0	0

Table 1. Continued

County	Number of wells injected with fluorosurfactants, potential fluorosurfactants	Mass of fluorosurfactants, potential fluorosurfactants (lbs.)	Number of wells injected with PTFE	Mass of PTFE (lbs.)
Scurry	6	ND	3	605
Shackelford	6	7	0	0
Shelby	0	0	1	40
Smith	1	1	0	0
Starr	0	0	2	ND
Stephens	126	9	0	0
Sterling	7	113	3	31
Stonewall	63	48	0	0
Sutton	1	2	0	0
Taylor	15	5	0	0
Terrell	0	0	1	5
Terry	0	0	1	ND
Throckmorton	8	86	0	0
Tom Green	1	2	0	0
Upton	19	1,705	20	62
Walker	0	0	1	ND
Ward	7	600	62	568
Washington	0	0	4	40
Webb	0	0	22	128
Wharton	0	0	1	ND
Wheeler	0	0	11	29
Wichita	29	10	0	0
Wilson	0	0	1	ND
Winkler	18	318	3	655
Wise	5	558	0	0
Yoakum	0	0	16	486
Young	9	2	0	0
Zapata	0	0	1	0
Zavala	0	0	88	985
Total	1,222	53,398	1,625	43,829

This table, based on FracFocus data covering the dates January 1, 2013 through Sept. 29, 2022, shows county-by-county the number of Texas wells in which oil and gas companies injected PTFE, identified by EPA as a PFAS, or used at least one fluorosurfactant or potential fluorosurfactant for fracking. In this table, the term "fluorosurfactant" encompasses disclosed uses of "nonionic fluorosurfactant" while the term "potential fluorosurfactant" encompasses disclosed uses of "fluoroalkyl alcohol substituted polyethylene glycol," identified by EPA as a PFAS. Nonionic fluorosurfactants may be PFAS or precursors that could degrade into PFAS. The total weight figures reflect the sum of all records for which we have enough information to calculate a chemical's weight. However, the total weight figures represent an undercount because many fracking chemical disclosures lack sufficient data to perform this calculation. Not all Texas counties are shown; only those in which FracFocus showed the use in fracking of fluorosurfactants, potential fluorosurfactants, and PTFE.

*ND = No data available.

Table 2. Disclosed Use in Fracking of Trade Secret Chemicals in Texas Oil and Gas Wells, 2013-2022

County	Number of wells injected with at least one trade secret chemical	Mass of all trade secret records (lbs.)	Number of wells injected with at least one trade secret surfactant	Mass of trade secret surfactants (lbs.)
Anderson	4	39,100	1	443
Andrews	2,603	70,400,000	1,670	8,050,000
Angelina	18	1,640,000	2	9,450
Aransas	6	2,680	2	458
Archer	47	12,200	19	3,560
Atascosa	772	21,000,000	332	2,280,000
Austin	2	6,880	1	1,450
Bastrop	1	28,700	0	0
Baylor	3	12,500	0	0
Bee	5	297,000	4	11,300
Bexar	4	ND*	4	0
Borden	145	5,130,000	53	127,000
Bosque	1	5	1	2
Brazoria	1	ND	1	ND
Brazos	324	17,600,000	182	1,800,000
Brewster	1	566	1	333
Brooks	39	1,960,000	1	ND
Brown	1	ND	1	ND
Burleson	420	16,700,000	160	1,890,000
Caldwell	3	1,200	1	ND
Calhoun	4	10,500	0	0
Callahan	5	71	3	19
Carson	2	ND	0	0
Cass	7	331,000	3	8,310
Chambers	4	11,100	3	197
Cherokee	47	1,550,000	21	226,000
Clay	42	34,800	20	9,580
Cochran	54	362,000	49	132,000
Coke	12	57,300	3	7,120
Coleman	13	98	2	26
Colorado	4	6,840	3	723
Concho	9	682	8	59
Cooke	41	536,000	13	16,900
Cottle	6	88,900	5	22,200
Crane	796	5,790,000	651	847,000
Crockett	468	4,890,000	242	1,440,000
Crosby	367	240,000	338	45,400
Culberson	813	43,100,000	453	2,130,000
Dallas	22	203,000	0	0
Dawson	130	46,500,000	85	493,000
De Witt	1,259	73,200,000	576	1,600,000
Denton	362	2,600,000	28	102,000

Table 2. Continued

County	Number of wells injected with at least one trade secret chemical	Mass of all trade secret records (lbs.)	Number of wells injected with at least one trade secret surfactant	Mass of trade secret surfactants (lbs.)
Dickens	2	352	2	100
Dimmit	2,472	184,000,000	1,060	48,200,000
Duval	9	29,700	4	516
Eastland	5	4,390	5	804
Ector	1,347	24,600,000	1,030	5,270,000
Fayette	99	5,230,000	61	438,000
Fisher	34	56,400,000	15	34,300
Fort Bend	3	3,160	1	2,010
Freestone	51	108,000	32	40,000
Frio	321	39,500,000	155	461,000
Gaines	600	3,590,000	432	310,000
Garza	37	59,600	15	7,160
Glasscock	1,932	80,200,000	1,110	10,300,000
Goliad	7	17,800	5	3,180
Gonzales	1,129	31,700,000	394	1,890,000
Grayson	45	132,000	28	70,600
Gregg	20	445,000	10	22,800
Grimes	28	531,000	20	60,700
Hale	1	7,210	1	2,900
Hansford	21	395,000	13	23,700
Hardeman	10	36,300	5	1,740
Hardin	7	17,400	2	977
Harris	4	1,210	0	0
Harrison	228	9,450,000	101	341,000
Hartley	12	116,000	5	5,320
Haskell	16	6,600	7	806
Hemphill	292	16,500,000	122	816,000
Henderson	5	5,540	3	1,460
Hidalgo	127	2,390,000	11	9,820
Hockley	71	149,000	61	36,100
Hood	21	226,000	8	3,480
Hopkins	3	479	1	308
Houston	48	428,000	17	76,800
Howard	2,639	570,000,000	1,390	18,800,000
Hudspeth	3	13,300	3	7,330
Hutchinson	9	132,000	3	1,200
Irion	825	634,000,000	440	4,040,000
Jack	428	867,000	325	278,000
Jackson	2	ND	2	ND
Jasper	9	25,600	5	5,020
Jeff Davis	4	316,000	1	362
Jefferson	5	5,260	2	165
Jim Hogg	10	14,200	0	0

Table 2. Continued

County	Number of wells injected with at least one trade secret chemical	Mass of all trade secret records (lbs.)	Number of wells injected with at least one trade secret surfactant	Mass of trade secret surfactants (lbs.)
Jim Wells	1	242	1	74
Johnson	56	557,000	25	31,600
Jones	21	582	3	8
Karnes	3,059	187,000,000	1,260	5,780,000
Kenedy	14	134,000	3	6,470
Kent	4	9,060	4	4,510
King	21	4,290	9	25
Kleberg	24	93,700	12	13,200
Knox	1	39	0	0
La Salle	2,590	192,000,000	1,030	27,200,000
Lavaca	276	20,000,000	180	877,000
Lee	55	1,810,000	26	76,800
Leon	57	554,000	28	112,000
Liberty	6	23,400	3	2,980
Limestone	23	319,000	11	24,600
Lipscomb	203	5,840,000	128	737,000
Live Oak	429	32,100,000	218	896,000
Loving	2,156	98,500,000	910	3,220,000
Lubbock	7	6,160	6	1,440
Lynn	2	990	0	0
Madison	149	1,790,000	75	349,000
Marion	1	ND	0	0
Martin	3,543	213,000,000	1,940	26,900,000
Matagorda	4	19,400	4	3,590
Maverick	57	1,030,000	19	42,700
McCulloch	3	301	2	49
McMullen	1,342	111,000,000	667	29,700,000
Medina	49	7	0	0
Midland	4,447	572,000,000	2,920	31,900,000
Milam	48	1,060,000	19	178,000
Mitchell	125	645,000	97	69,200
Montague	326	6,440,000	133	28,800
Montgomery	3	10,000	1	529
Moore	7	1,540	5	307
Nacogdoches	50	3,790,000	4	14,800
Navarro	4	55,800	4	2,900
Newton	7	230,000	3	7,760
Nolan	50	116,000	35	46,200
Nueces	4	6,800	3	1,480
Ochiltree	268	3,890,000	168	767,000
Oldham	15	197,000	6	7,520
Orange	10	26,200	8	18,200
Palo Pinto	107	173,000	76	49,100

Table 2. Continued

County	Number of wells injected with at least one trade secret chemical	Mass of all trade secret records (lbs.)	Number of wells injected with at least one trade secret surfactant	Mass of trade secret surfactants (lbs.)
Panola	446	17,500,000	152	1,260,000
Parker	79	336,000	32	32,900
Pecos	602	35,700,000	349	4,840,000
Polk	30	391,000	11	9,720
Potter	25	612,000	8	9,080
Reagan	1,745	1,210,000,000	1,040	14,800,000
Reeves	3,561	254,000,000	1,640	21,600,000
Roberts	145	10,100,000	73	297,000
Robertson	101	3,430,000	50	219,000
Runnels	6	9,000	3	187
Rusk	132	8,330,000	85	909,000
San Augustine	110	5,000,000	30	401,000
San Jacinto	8	5,540	2	42
San Patricio	12	16,200	9	3,800
Schleicher	42	845,000	33	469,000
Scurry	171	42,800,000	77	147,000
Shackelford	10	387	4	140
Shelby	49	1,220,000	27	335,000
Sherman	3	148	2	20
Smith	45	4,180,000	20	149,000
Starr	63	292,000	3	1,940
Stephens	78	36,400	57	7,560
Sterling	77	938,000	48	203,000
Stonewall	85	32,700	31	10,400
Sutton	15	45,500	13	22,900
Tarrant	518	6,780,000	216	279,000
Taylor	17	467	5	191
Terrell	10	165,000	8	25,600
Terry	30	114,000	20	26,900
Throckmorton	75	180,000	27	41,700
Tom Green	14	184,000	10	19,200
Trinity	2	154,000	1	1,260
Tyler	12	516,000	5	11,200
Upshur	17	454,000	10	86,300
Upton	2,567	863,000,000	1,820	19,400,000
Van Zandt	4	114,000	1	24
Victoria	1	ND	0	0
Walker	10	403,000	7	14,500
Waller	5	3,520	5	1,790
Ward	1,368	39,900,000	658	1,860,000
Washington	79	2,270,000	21	81,900
Webb	1,784	112,000,000	862	11,900,000
Wharton	16	6,670	9	215

Table 2. Continued

County	Number of wells injected with at least one trade secret chemical	Mass of all trade secret records (lbs.)	Number of wells injected with at least one trade secret surfactant	Mass of trade secret surfactants (lbs.)
Wheeler	270	15,200,000	182	3,040,000
Wichita	78	23,000	40	4,220
Wilbarger	48	42,600	23	11,200
Willacy	4	10,700	4	2,790
Wilson	90	1,870,000	45	175,000
Winkler	591	17,700,000	333	1,220,000
Wise	519	3,110,000	80	212,000
Wood	15	719,000	11	248,000
Yoakum	709	8,390,000	546	1,410,000
Young	37	12,800	19	1,760
Zapata	45	54,700	9	3,950
Zavala	192	18,100,000	85	3,030,000
Total	58,199	6,120,000,000	30,700	331,000,000

This table, based on FracFocus data, shows county-by-county the number of Texas wells in which oil and gas companies injected at least one trade secret fracking chemical or at least one trade secret surfactant between January 1, 2013 and September 29, 2022. The total weight figures reflect the sum of all records for which we have enough information to calculate a chemical's weight. However, the total weight figures represent an undercount because many fracking chemical disclosures lack sufficient data to perform this calculation. Not all Texas counties are shown, only those in which FracFocus showed the use in fracking of trade secret chemicals.

*ND = No data available.

Table 4. Oil and Gas Companies that Fracked Wells in Texas Using Fluorosurfactants or Potential Fluorosurfactants, 2013-2022

Well Operator	Number of wells injected with fluorosurfactants, potential fluorosurfactants	Total weight of fluorosurfactants (lbs.)
Athlon Energy Operating LLC	195	10,771
Juno Operating Company II, LLC	148	141
Delta Oil & Gas Ltd.	110	4
EOG Resources, Inc.	67	22,336
XTO Energy/ExxonMobil	67	745
LCS Production Company	48	16
Citation Oil and Gas Corp.	30	31
Chevron USA Inc.	26	155
Brigadier Operating LLC	25	ND*
Urban Oil and Gas Group	25	10
PPC Operating Company LLC	22	ND
Petrobal Omega 1, LLC	21	186
Apache Corporation	18	180
Laredo Petroleum, Inc.	16	4,721
Blackbeard Operating	14	393
Hunt Oil Company	12	4
Atlas Energy, L.P.	11	ND
Bullet Development, LLC	11	ND
Sheridan Production Company, LLC	10	11
RSP Permian, LLC	9	2,160
Anadarko Petroleum Corporation	8	32
Cinnabar Energy, LTD.	8	5
Jilpetco, Inc.	8	ND
PETEX	8	ND
Resolute Natural Resources	8	593
Sojourner Drilling Corporation	8	3
Clear Fork, Inc.	7	ND
Endeavor Energy Resources	7	7,051
Oakridge Oil and Gas, LP	7	3
Phoenix PetroCorp, Inc.	7	ND
S. B. Street Operating, Inc.	7	2
TXP, Inc.	7	6
Boaz Energy II Operating, LLC	6	10
Delta CO2, LLC	6	3
GeoSurveys, Inc.	6	6
Griffin Petroleum Company	6	6
The Cumming Company, Inc.	6	11
Best Petroleum Explorations, Inc.	5	89
Mid-Con Energy Operating, LLC	5	1
Midville Energy	5	7
Prime Operating Company	5	364
5L Properties, Inc.	4	2
Abraxas Petroleum Corporation	4	3

Table 4. Continued

Well Operator	Number of wells injected with fluorosurfactants, potential fluorosurfactants	Total weight of fluorosurfactants (lbs.)
Compass Energy Operating, LLC	4	ND
Green Century Exploration & Production, LLC	4	4
Merit Energy Company	4	14
Sharp Image Energy, Inc.	4	ND
Stovall Operating Co.	4	3
Surge Operating, LLC	4	5
Walter Exploration Company	4	23
Arrington Oil & Gas Operating LLC	3	549
Choice Exploration, Inc.	3	ND
LADD OIL & GAS CORPORATION	3	ND
Lime Rock Resources, LP	3	56
MWS Producing, Inc.	3	22
Newark E&P Operating, LLC	3	162
Stanolind Operating LLC	3	8
TALL CITY OPERATIONS LLC	3	668
Telesis Operating Co., Inc.	3	ND
Verado Energy, Inc.	3	2
Atoka Operating Permian, LLC	2	56
Bridwell Oil Company	2	2
Buffco Production,Inc	2	4
Cazar Energy, Inc.	2	ND
Cholla Petroleum, Inc.	2	ND
Encana Oil & Gas (USA) Inc.	2	59
Imperial Gas Resources, LLC	2	ND
MECO IV, LLC	2	ND
Pendragon Oil Co.	2	ND
Quantum Resources Management, LLC	2	82
Rainbow Seven Oil and Gas	2	6
Raw Oil & Gas, Inc.	2	5
Rover Operating Company, LLC	2	ND
Silver Creek Oil & Gas, LLC	2	ND
Silver Creek Permian OP CO, LLC	2	38
THE EDMAR COMPANY, LLC	2	53
Texas Energy Holdings, Inc.	2	1
Texxol Operating Company	2	370
Tradition Resources LLC	2	2
Unit Petroleum	2	38
Allegro Investments, Inc.	1	ND
Antle Operating, Inc.	1	ND
Atoka Operating, Inc.	1	23
BKM Production	1	54
BRG Lone Star LTD	1	1
BlackWell Exp & Development, LLC	1	89
Braka Operating, LLC	1	1

Table 4. Continued

Well Operator	Number of wells injected with fluorosurfactants, potential fluorosurfactants	Total weight of fluorosurfactants (lbs.)
Breck Operating Corp.	1	ND
Canan Mowrey Operating, LLC	1	1
Clayton Williams Energy, Inc.	1	2
Cooper Oil & Gas, LLC	1	84
Dallas Production, Inc	1	ND
Devon Energy Production Company L.P.	1	ND
E. N. Patton Oil Company, Inc.	1	1
Elephant Oil & Gas	1	16
EnerVest, Ltd.	1	2
Enexco, Inc.	1	10
Finley Resources, Inc.	1	ND
Four C Oil and Gas Corporation	1	ND
Gunn Oil Company	1	ND
HW Operating, LLC	1	ND
Heights Energy Corporation	1	2
HighMount Exploration & Production	1	431
JVA Operating Company, Inc.	1	ND
Jagged Peak Energy	1	ND
John M. Clark, Inc.	1	ND
Katsco Energy, Inc.	1	ND
King Operating Corp.	1	ND
LP Operating, LLC	1	ND
Lainco, Inc.	1	2
Legacy Exploration, LLC I	1	10
N S P Operating Group LLC	1	ND
Ogden Resources Corporation	1	6
Oil Projects, LLC	1	ND
Pablo Energy II, LLC	1	56
Ray Richey Managment Company, Inc.	1	189
Redbud E&P, Inc.	1	9
Rover Petroleum Operating, LLC	1	3
SDX Resources, Inc.	1	27
Scout Energy Partners	1	ND
Southlake Exploration Inc.	1	ND
Southwest Royalties, Inc.	1	5
Stephens & Johnson Operating Co.	1	2
Strand Energy, L.C.	1	22
TACOR Resources, Inc.	1	10
Three J Energy, Inc.	1	1
Trey Resources Inc.	1	ND
Trio Consulting & Management, LLC	1	ND
Upham Oil & Gas Company	1	ND
Van Operating	1	ND
White Knight Production LLC	1	78

Table 4. Continued

Well Operator	Number of wells injected with fluorosurfactants, potential fluorosurfactants	Total weight of fluorosurfactants (lbs.)
Worsham-Steed Gas Storage, LLC	1	ND

This excerpted table shows oil and gas companies that fracked oil and gas wells in Texas with fluorosurfactants or potential fluorosurfactants between January 1, 2013 and September 29, 2022. In this table, the term “fluorosurfactant” encompasses disclosed uses of “nonionic fluorosurfactant” while the term “potential fluorosurfactant” encompasses disclosed uses of “fluoroalkyl alcohol substituted polyethylene glycol.” Fluorosurfactants may be PFAS or precursors that could degrade into PFAS. “Fluoroalkyl alcohol substituted polyethylene glycol” is a PFAS according to EPA. The total weight figures for each company reflect the sum of all records for which we have enough information to calculate a chemical’s weight. However, the total weight figures for each company may represent an undercount because many fracking chemical disclosures lack sufficient data to perform this calculation.

*ND = No data available.

Table 5. Oil and Gas Companies that Fracked Wells in Texas Using PTFE, 2013-2022

Well Operator	Number of wells injected with PTFE	Total mass of PTFE (lbs.)
BHP Billiton Petroleum	196	3,237
Cimarex Energy Co.	123	1,172
Pioneer Natural Resources	117	670
Occidental Oil and Gas	115	2,718
Ring Energy, Inc.	113	4,827
EXCO Resources, Inc.	87	1,003
Chesapeake Operating, Inc.	86	329
Apache Corporation	70	738
Forest Oil Corporation	69	897
Guidon Energy Management Services LLC	55	9,301
Matador Production Company	39	382
Lonestar Resources, Inc.	32	892
XTO Energy/ExxonMobil	32	1,208
ConocoPhillips Company/Burlington Resources	26	243
Sundance Energy	26	57
Texas American Resources Company	24	132
Atlas Energy, L.P.	21	191
Rosetta Resources	21	454
COG Operating LLC	19	96
Murphy Exploration and Production USA	19	288
MEWBOURNE OIL COMPANY	17	90
Carrizo Oil & Gas, Inc.	15	ND*
U.S. Energy Development Corp.	15	61
Parsley Energy Operations, LLC	14	130
Pacesetter Energy, LLC	12	64
Aethon Energy Operating LLC	11	75
Devon Energy Production Company L. P.	11	137
Protege Energy III LLC	10	337
SM Energy	10	98
Energy & Exploration Partners Operating, LP	8	89
LeNorman Operating LLC	8	35
REOC, LLC	8	22
Sanguine Gas Exploration	8	25
Brigham Resources Operating, LLC	6	128
Freedom Production, Inc.	6	51
Parallel Petroleum LLC	6	36
Caird Operating, LLC	5	21
Clayton Williams Energy, Inc.	5	64
Endeavor Energy Resources	5	67
Linn Energy, LLC	5	ND
Sable Permian Resources	5	9,268
Titan Energy, LLC	5	ND
Verdun Oil Company	5	4
VirTex Operating Company, Inc.	5	589

Table 5. Continued

Well Operator	Number of wells injected with PTFE	Total mass of PTFE (lbs.)
EOG Resources, Inc.	4	24
Eagle Oil & Gas co.	4	9
Kinder Morgan Tejas Pipeline, LLC	4	ND
CML Exploration, LLC	3	103
CRIMSON ENERGY PARTNERS IV, LLC	3	23
Discovery Natural Resources LLC	3	55
El Toro Resources LLC	3	8
Greystone Oil & Gas LLP	3	30
Penn Virginia Corporation	3	6
Resolute Natural Resources	3	41
Sabine Oil & Gas LLC	3	19
SilverBow Resources	3	9
Smith Production	3	1
Tracker Resource Dev III, LLC	3	11
Verado Energy, Inc.	3	605
Arris Petroleum Corporation	2	7
BP America Production Company	2	1
BlackBrush O & G, LLC	2	488
EnerQuest Operating L.L.C.	2	2
GeoSouthern Operating II, LLC	2	ND
Halcon Resources Corporation	2	23
ImPetro Operating LLC	2	655
JAMEX, Inc.	2	14
Juneau Energy, LLC	2	1
Lime Rock Resources, LP	2	8
Longfellow Energy, LP	2	2
MD America Energy LLC	2	50
MDC TEXAS ENERGY	2	79
Mr. (sic)	2	14
Sabinal Energy	2	5
Slawson Exploration Company, Inc.	2	2
Sundown Energy L.P.	2	1
Teal Natural Resources	2	4
Unit Petroleum	2	10
Woodbine Production Corp	2	15
ZTC Petro Investments LP	2	10
American Energy Permian Basin	1	11
Arrow Oil & Gas, LLC.	1	1
BVX OPerating Inc.	1	2
Ballard Exploration Company, Inc.	1	1
Brahman Resource Partners LLC	1	6
Bright Horizon Resources	1	22
Cabot Oil & Gas Corp	1	2
Cimarron Engineering LLC	1	ND
Clear Water, Inc.	1	ND

Table 5. Continued

Well Operator	Number of wells injected with PTFE	Total mass of PTFE (lbs.)
Comstock Oil & Gas	1	7
Covey Park Operating, LLC	1	ND
Endeavor Natural Gas, LP	1	1
Enduring Resources LLC	1	ND
EnerVest, Ltd.	1	1
Gunn Oil Company	1	1
Hurd Enterprises	1	ND
ITEXCO TEXAS, LLC	1	ND
Jagged Peak Energy	1	8
Jones Energy llc	1	ND
Lewis Energy Group	1	7
Mego Resources, LLC	1	ND
Metano Energy III, LP	1	ND
Moriah Operating, LLC	1	38
Oasis Petroleum	1	55
Primexx Operating Corporation	1	9
Recoil Resources Operating Inc.	1	ND
Sabalo Operating, LLC	1	13
SandRidge Energy	1	1
Sierra Resources, LLC	1	30
Siltstone Resources Operating II, LLC	1	10
Silver Tusk Operating Co. LLC	1	23
Spindletop Oil & Gas	1	4
Stroud Petroleum, Inc.	1	ND
THE EDMAR COMPANY, LLC	1	2
Tanos Exploration II, LLC	1	1,016
Texas Presco, Inc.	1	15
Tidal Petroleum, Inc.	1	3
Triumph Exploration, Inc.	1	7
Vess Oil Corp	1	4
W&T Offshore, Inc.	1	ND

This excerpted table shows the oil and gas companies that fracked oil and gas wells in Texas with PTFE between January 1, 2013 and September 29, 2022.

*ND = No data available.

ENDNOTES

[1] U.S. Environmental Protection Agency. Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). June 2022, at 4. Accessed Nov. 7, 2022, at https://www.epa.gov/system/ files/documents/2022-06/technical-factsheet-four-PFAS.pdf.

[2] U.S. Environmental Protection Agency. Our Current Understanding of the Human Health and Environmental Risks of PFAS. Accessed Nov. 23, 2022, at https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas.

[3] Toxic Synthetic "Forever Chemicals" are in Our Water and on Our Plates. NOVA (PBS) (Nov. 2, 2020). Accessed Sept. 5, 2022, at https://www.pbs.org/wgbh/nova/article/pfas-synthetic-chemicals-water-toxic/.

[4] U.S. Environmental Protection Agency. Master List of PFAS Substances. Polytetrafluoroethylene. CAS number 9002-84-0. Accessed Nov. 9, 2022, at https://comptox.epa.gov/dashboard/chemical/details/DTXSID7047724?list=PFASMASTER.

[5] U.S. Environmental Protection Agency. Master List of PFAS Substances. Poly(oxy-1,2-ethanediyl), .alpha.-hydro-. omega.-hydroxy-, ether with .alpha.-fluoro-.omega.-(2-hydroxyethyl) poly(difluoromethy. CAS number 65545-80-4. Accessed Nov. 9, 2022, at https://comptox.epa.gov/dashboard/chemical/details/DTXSID6049727.

[6] The three chemists are Zacariah Hildenbrand, a research professor in Chemistry and Biochemistry at the University of Texas at El Paso, Kevin Schug, Shimadzu Distinguished Professor of Analytical Chemistry at the University of Texas at Arlington, and Wilma Subra, holder of a master's degree in chemistry and recipient of a John D. and Catherine T. MacArthur Foundation "Genius" Grant for her work helping to protect communities from toxic pollution. The board-certified toxicologist is Linda Birnbaum, former director of the National Institute of Environmental Health Sciences.

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[10] U.S. Environmental Protection Agency. What are PFCs and How Do They Relate to Per- and Polyfluoroalkyl Substances (PFASs)? (Jan. 19, 2017). Accessed Nov. 7, 2022, at https://19january2017snapshot.epa.gov/pfas/what-arepfcs-and-how-do-they-relate-and-polyfluoroalkyl-substances-pfass_.html. EPA noted that the acronym, PFCs, can also refer to perfluorocarbons that are distinct from PFAS or perfluorinated chemicals. Perfluorocarbons are not toxic, but they are a powerful and long-lasting greenhouse gas. Andrew B. Lindstrom et al. Polyfluorinated Compounds: Past, Present, and Future. Environmental Science & Technology (2011), 45, 7954-7961, 7954. Accessed Nov. 7, 2022, at https://pubs.acs.org/doi/pdf/10.1021/es2011622.

[11] David Andrews and Bill Walker. Environmental Working Group. Poisoned Legacy (April 2015), at 6. Accessed Nov. 7, 2022, at https://www.ewg.org/research/poisoned-legacy. Nathaniel Rich. The Lawyer Who Became Dupont's Worst Nightmare. New York Times Magazine (Jan. 6, 2016). Accessed Nov. 7, 2022, at https://www.nytimes.com/2016/01/10/ magazine/the-lawyer-who-became-duponts-worst-nightmare.html?searchResultPosition=1. Andrew B. Lindstrom et al. Polyfluorinated Compounds: Past, Present, and Future. Environmental Science & Technology (2011), 45, 7954-7961, 7954, 7956. Accessed Nov. 7, 2022, at https://pubs.acs.org/doi/pdf/10.1021/es2011622.

[12] David Andrews and Bill Walker. Environmental Working Group. Poisoned Legacy (April 2015), at 6. Accessed Nov. 7, 2022, at https://www.ewg.org/research/poisoned-legacy. Andrew B. Lindstrom et al. Polyfluorinated Compounds: Past, Present, and Future. Environmental Science & Technology (2011), 45, 7954-7961, 7954. Accessed Nov. 7, 2022, at https://pubs.acs.org/doi/pdf/10.1021/es2011622.

[13] U.S. Environmental Protection Agency. Fact Sheet: 2010/2015 PFOA Stewardship Program. Accessed Nov. 7, 2022, at https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-20102015-pfoa-stewardship-program.

[14] U.S. Environmental Protection Agency. PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024 (Oct. 2021), at 23. Accessed Nov. 7, 2022, at https://www.epa.gov/system/files/documents/2021-10/pfas-roadmap_final-508.pdf.

[15] U.S. Environmental Protection Agency. PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024 (Oct. 2021), at 5. Accessed Nov. 7, 2022, at https://www.epa.gov/system/files/documents/2021-10/pfas-roadmap_final-508.pdf.

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[17] David Andrews and Bill Walker. Environmental Working Group. Poisoned Legacy (April 2015), at 8, 23. Accessed Nov. 7, 2022, at https://www.ewg.org/research/poisoned-legacy. Nathaniel Rich. The Lawyer Who Became Dupont's Worst Nightmare. New York Times Magazine (Jan. 6, 2016). Accessed Nov. 7, 2022, at https://www.nytimes.com/2016/01/10/magazine/the-lawyer-who-became-duponts-worst-nightmare.html?searchResultPosition=1.

[18] Nathaniel Rich. The Lawyer Who Became Dupont's Worst Nightmare. New York Times Magazine (Jan. 6, 2016). Accessed Nov. 7, 2022, at https://www.nytimes.com/2016/01/10/magazine/the-lawyer-who-became-duponts-worst-nightmare.html?searchResultPosition=1. Cleveland Clinic. Thyroid Disease. Accessed Sept. 5, 2022, at https://my.clevelandclinic.org/health/diseases/8541-thyroid-disease. Graham J. Burton et al. Pre-eclampsia: Pathophysiology and Clinical Implications. National Library of Medicine. PubMed.gov (July 15, 2019). Accessed Nov. 7, 2022 at https://pubmed.ncbi.nlm.nih.gov/31307997/. Mahesh Gajendran et al. A Comprehensive Review and Update on Ulcerative Colitis (March 2, 2019). National Library of Medicine. PubMed.gov. Accessed Sept. 5, 2022, at https://pubmed.ncbi.nlm.nih.gov/30837080/.

[19] U.S. Environmental Protection Agency. Addressing Challenges of PFAS: Protecting Groundwater and Treating Contaminated Sources (Sept. 20, 2021). Accessed Nov. 7, 2022, at https://www.epa.gov/sciencematters/addressing-challenges-pfas-protecting-groundwater-and-treating-contaminated-sources. U.S. Environmental Protection Agency. EPA's Per- and Polyfluoroalkyl Action Plan (Feb. 2019) at 13. Accessed Nov. 7, 2022, at https://www.epa.gov/sites/default/files/2019-02/documents/pfas_action_plan_021319_508compliant_1.pdf.

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[21] U.S. Environmental Protection Agency. Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). June 2022, at 2. Accessed Nov. 7, 2022, at https://www.epa.gov/system/files/documents/2022-06/technical-factsheet-four-PFAS.pdf.

[22] U.S. Environmental Protection Agency. Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). June 2022, at 4. Accessed Nov. 7, 2022, at https://www.epa.gov/system/files/documents/2022-06/technical-factsheet-four-PFAS.pdf.

[23] U.S. Environmental Protection Agency. Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). June 2022, at 4. Accessed Nov. 7, 2022, at https://www.epa.gov/system/files/documents/2022-06/technical-factsheet-four-PFAS.pdf.

[24] U.S. Environmental Protection Agency. Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). June 2022, at 4. Accessed Nov. 7, 2022, at https://www.epa.gov/system/files/documents/2022-06/technical-factsheet-four-PFAS.pdf.

[25] PSR calculated the amount of PFOA that could contaminate the total storage capacity of the Toledo Bend Reservoir using the following data: EPA's interim health advisory level for PFOA is 0.004 parts per trillion. U.S. Environmental Protection Agency. Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). June 2022, at 4. Accessed Sept. 20, 2022, at https://www.epa.gov/system/files/documents/2022-06/technical-factsheet-four-PFAS.pdf. Parts per trillion refers to milligrams per one million liters of water. U.S. Environmental Protection Agency. Environmental Science and Technology Briefs for Citizens. Center for Hazardous Substance Research. Understanding Units of Measurement. Accessed Sept. 20, 2022, at https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.files/fileid/14285. One measuring cup contains approximately 237 milliliters. Exploratorium. Cooking Equivalents and Measures. Accessed September 20, 2022, at https://www.exploratorium.edu/food/measurements. The density of PFOA is 1.8 grams per milliliter. National Institutes of Health. National Library of Medicine. National Center for Biotechnology Information. PubChem. Perfluorooctanoic Acid. Density. Accessed September 20, 2022, at https://pubchem.ncbi.nlm.nih.gov/compound/Perfluorooctanoic-acid. Therefore, the mass of one measuring cup of PFOA is 426.6 grams or 426,600 milligrams. This mass of PFOA is 106,650,000 times greater than 0.004 milligrams (EPA's interim health advisory level per million liters). In order to dilute the mass of the PFOA in an equivalent volume of water, we multiplied 106,650,000 by 1,000,000. The result is 106,650,000,000,000 liters of water. There are 3.785 liters of water per gallon. U.S. Environmental Protection Agency. EPA. ExpoBox Unit Conversion Table. Accessed September 20, 2022, at https://www.epa.gov/expobox/epa-expobox-unit-conversion-table. Therefore, 106,650,000,000,000 liters of water is equal to a bit more than 28 trillion gallons of water – the amount of water that could be contaminated to EPA's interim health advisory level by one measuring cup of PFOA. There are 16 tablespoons in a measuring

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[26] PSR made this statement by starting with 1.75 trillion gallons, the amount of water that could be contaminated under EPA's interim health advisory level by one tablespoon of PFOA (see endnote 17) and comparing it to the amount of drinking water produced by the city of Houston's main system each day, 435.4 million gallons. Houston Public Works. Water Quality Report 2021. Accessed Sept. 25, 2022, at https://www.publicworks.houstontx.gov/sites/default/files/assets/003-water-quality-report-2021.pdf.

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