Fracking on University of Texas Lands

The Environmental Effects of Hydraulic Fracturing on Land Owned by the University of Texas System

Environment Texas Research & Policy Center

Frontier Group

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Executive Summary

Since 2005, oil and gas companies have drilled 4,350 wells on West Texas land owned by the University of Texas. Of those wells, 95 percent have been subject to high-volume hydraulic fracturing, or "fracking." Fracking threatens the environment and human health by consuming vast amounts of water, introducing toxic chemicals into our air and water, and damaging natural landscapes.

As the state's flagship educational institution and a significant landholder, the University of Texas has a particular responsibility to protect the environment, Texas' special places and public health. Fracking should not occur anywhere. But if fracking is to occur on University of Texas lands, **the university must at least act immediately to eliminate the worst industry practices and safeguard the environment and public health.**

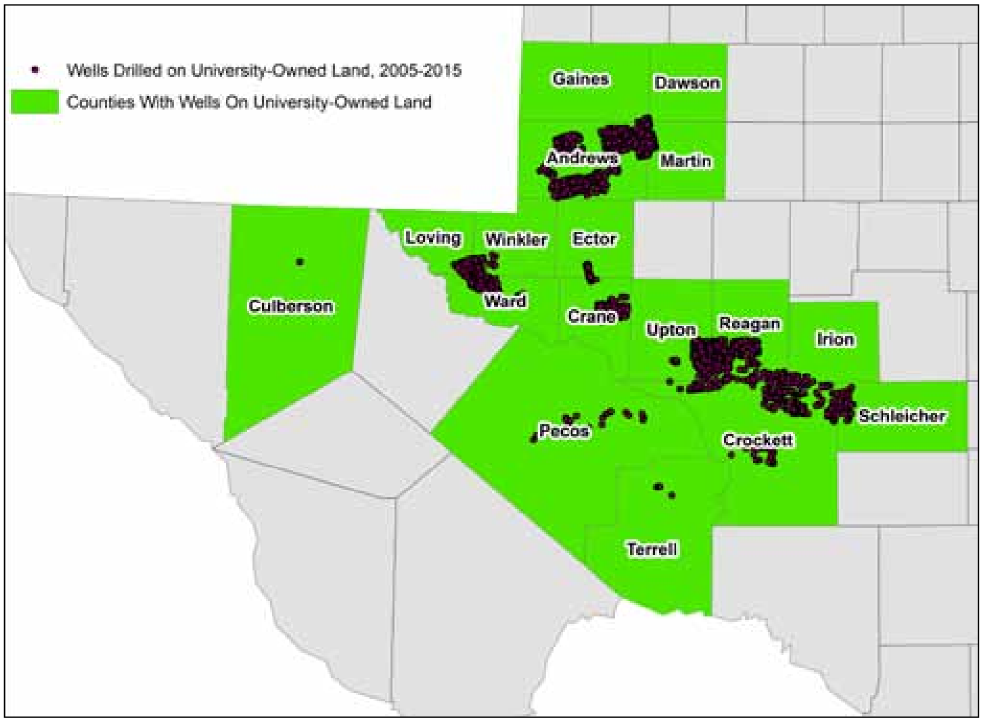
As many as 4,132 wells drilled on university-owned land since 2005 have been subject to high-volume hydraulic fracturing.

- All of those fracked wells are in rural West Texas. The university owns 2.1 million acres in 19 counties in the area, most of which are above the oil- and gas-rich Permian Basin.
- More than half of university land in West Texas is leased to the oil and gas industry.
- Andrews County alone has seen 2,051 wells drilled on university land since 2005, nearly half of all such wells statewide. Crockett County has the second-most wells (557) drilled since 2005 on university-owned land; Reagan County has the third-most, with 486. (See Table ES-1.)
- These counties are home to important natural areas and untainted stretches of the Pecos River that provide habitat for migratory birds and numerous endangered species.

Table ES-1. Wells Drilled On University of Texas Land, 2005-2015, by County

County	Wells Drilled
Andrews	2,051
Crockett	557
Reagan	486
Upton	266
Crane	226
Martin	206
Ward	145
Schleicher	86
Ector	85
Irion	82
Loving	63
Winkler	48
Pecos	27
Gaines	14
Terrell	5
Dawson	2
Culberson	1
Total	4,350

Figure ES-1. Wells Drilled on University-Owned Lands, 2005-2015



Oil and gas drilling on university lands put pressure on water supplies.

- These wells used at least 6 billion gallons of water between February 2012 and December 2014.
- During the recently ended four-year drought, officials pressed residents across the state to cut back on water use, while wells on university-owned land consumed increasing amounts of water every year.

University-owned land and the groundwater beneath it have been polluted by oil and gas extraction.

- At least 1.6 million gallons of pollutants have spilled into soil and groundwater from wells located on university land since 2008.
- Cleanups are not yet complete at five of those spill locations. The effort can take many years: At least one 2008 spill and another from 2009 were not yet cleaned up as of March 2015. Groundwater has been contaminated by oil and related pollutants in at least 13 locations on university-owned lands.

Fracking on university land has required the use of vast quantities of toxic chemicals known to harm human health. Wells drilled on University of Texas land from 2005 to 2015 used at least:

- 92.5 million pounds of hydrochloric acid, a caustic acid that can contaminate water;
- 8.5 million pounds of methanol, which is suspected to cause birth defects;
- More than 7.8 million pounds of chemicals that were not specifically identified or were only labeled as trade secrets, meaning their health and environmental effects cannot be determined;
- More than 166.8 million pounds of other chemicals and substances of varying toxicity.

Fracking on university land produces emissions that contribute to global warming.

- Methane, which is a global warming pollutant 34 times more powerful than carbon dioxide, is released at multiple steps during fracking, including during hydraulic fracturing and well completion, and in the processing and transport of gas to end users.
- Completing the 4,132 fracked wells on university-owned land released methane equivalent to between 244,000 and 7 million metric tons of carbon dioxide, according to two different methods of estimating methane emissions. That is as much as is emitted by between 50,000 and 1.5 million cars in a year of driving.

Fracking is so dangerous to the environment and human health that it should not occur anywhere. If the University of Texas continues to allow fracking on its land, the university should at least end the worst practices and take immediate steps to protect the public. Specifically, the university should:

- Prohibit drilling on lands with special environmental value, such as Diablo Plateau, the Pecos River watershed, and all land that is habitat for migratory birds and endangered or threatened species.
- Write strong environmental protections into the leases the university signs with oil and gas companies. Those protections should include:
    - Reducing pollution risks by banning toxic chemicals and strictly limiting emissions at well, storage and transmission sites, including wastewater holding locations;
    - Adopting best practices from other states to further prevent pollution;
    - Requiring operators to meet aggressive water use reduction goals and to recycle wastewater;
    - Setting strong clean air standards that minimize methane leakage and prevent toxic air pollution, including minimizing the use of flaring and venting;
    - Mandating the strongest standards for well siting, design, construction and operation;
    - Reducing earthquake risk by restricting fracking operations in known areas of seismic activity and requiring pre- and post-fracking monitoring for seismic activity;
    - Requiring advance notice of fracking operations be provided to nearby landowners, groundwater districts and municipal and county officials;
    - Requiring annual reporting on the disposal of produced water, flowback, drill cuttings and other waste materials generated by fracking on university-owned lands, to be compiled into a university-issued annual report;
    - Requiring pre- and post-drilling monitoring of groundwater and nearby surface waters to identify contaminants and their sources.

In addition, the university should, in keeping with its mission as an educational institution, collect and make available to the public more complete data on fracking, including water usage and chemicals involved, enabling Texans to understand the full extent of the harm that fracking causes to our environment and health.

Introduction

The very first well drilled on University of Texas-owned land, outside the small rural city of Big Lake, in Reagan County, started producing way back in 1923.

That well, Santa Rita No. 1, didn't just produce oil, but it also brought up salt water from deep underground. The salt wastewater was stored in surface ponds, which leaked into the surrounding environment and onto lands that had once been used for grazing livestock.[1] By the 1960s, 11 square miles – more than 7,000 acres – of the former pastureland had been rendered barren.[2]

That one well was the first of thousands drilled on millions of acres of West Texas land set aside by the state government as a form of an endowment to provide revenue for the state's public universities.[3]

Today, nearly a century after the first well was drilled, oil and gas production continues on land owned by the University of Texas. The introduction of high-volume hydraulic fracturing (also called "fracking") has led to new threats to the environment and public health from those wells.

Fracking of thousands of wells on university-owned land in recent years has consumed enormous quantities of water, introduced vast amounts of toxic chemicals into the environment, and threatened land that is valuable to the environment and wildlife. This report documents the extent of fracking on university lands and demonstrates the need for stronger measures to protect the public and the environment.

Fracking Harms the Environment and Human Health

Fracking harms the environment and public health, polluting the air and water and using chemicals associated with significant health risks, such as cancer, breathing problems, neurological disorders and birth defects.

Fracking Can Contaminate Water Supplies

Fracking poses major risks for our water supplies, including potential underground leaks of toxic chemicals and contamination of groundwater.

The damage can be significant, and more fracking makes it more likely. As many as 9 percent of all oil and gas wells develop leaks shortly after being drilled that could contaminate nearby well water or aquifers.[4]

Research has tied fracking to drinking water contamination in Texas, including a 2015 study by a group of University of Texas researchers, which found 19 fracking-related toxic chemicals widespread across private drinking water supplies in north central Texas.[5]

Residents in counties across Texas have reported problems with their drinking water shortly after fracking began nearby.[6] The Railroad Commission of Texas, the state agency that oversees oil and gas drilling, has received dozens of complaints about contamination of drinking water wells by fracking wells at locations around Texas.[7]

Beyond affecting drinking water supplies, fracking also produces vast amounts of toxic wastewater that must be stored, transported and ultimately disposed of – posing the threat of water contamination at each step. In 2012 alone, Texas fracking wells produced 260 billion gallons of wastewater.[8]

Much of that water ends up being injected into deep disposal wells. Wastewater injected into just one such well near Midland contaminated at least 6.2 billion gallons of water in the Cenozoic Pecos Alluvium Aquifer, a source of drinking water for the city of Midland and a major source of irrigation water in the region.[9]

Defining “Fracking”

In this report, the term “fracking” is used to reference all of the activities needed to bring a shale gas or oil well into production using high-volume hydraulic fracturing, to operate that well, and to deliver the gas or oil produced from that well to market. The oil and gas industry often uses a more restrictive definition of “fracking” that includes only the actual moment in the extraction process when rock is fractured – a definition that obscures the broad changes to environmental, health and community conditions that result from the use of fracking in oil and gas extraction.

Fracking Consumes Vast Amounts of Water

Fracking consumes between tens of thousands and millions of gallons of water per well, turning it into a toxic soup that cannot be returned to the natural water cycle without extensive treatment. At the same time, excessive water withdrawals can reduce the local availability of clean water for wildlife and humans.

Between 2005 and 2012, fracking wells in Texas used 110 billion gallons of water.[10] According to industry information, little to no water used at fracking wells in the Permian Basin is recycled from prior frack jobs.[11]

Farmers are particularly affected by fracking water use, as they must now compete with the deep-pocketed oil and gas industry for water, especially in regions of the state that frequently experience drought. In some areas, such as the South Texas Eagle Ford Shale Play and some West Texas counties, fracking makes up a significant share of overall water demand.[12]

An official at the Texas Water Development Board estimated that one county in the Eagle Ford Shale region will see the share of water consumption devoted to fracking and similar activities increase from zero a few years ago to 40 percent by 2020.[13] In Dimmitt County, it accounts for 40 percent of water consumption.[14]

Already, that increasing demand for water by oil and gas companies has harmed farmers and local communities. For example, water withdrawals by drilling companies caused drinking water wells in the town of Barnhart to dry up in 2013 and 2014. Companies drilling in the Permian Basin – where all of the wells on university land have been drilled since 2005 – purchased well water drawn from the Edwards-Trinity-Plateau Aquifer, forcing new wells to be drilled to supply water for residential and agricultural use.[15]

Fracking-related water demand may also lead to calls for increased public spending on water infrastructure. Texas adopted a State Water Plan in 2012 that calls for $53 billion in investments in the state water system, including $400 million to address unmet needs in the mining sector (which includes hydraulic fracturing) by 2060.[16] Fracking is projected to account for 42 percent of water use in the Texas mining sector by 2020.[17]

Water use by fracking operations also threatens the fragile ecosystem of West Texas, where many species depend on springs and small streams that could dry up if enough groundwater is not available.[18]

Fracking Causes Toxic Air Pollution

Natural gas that leaks or is vented from fracking sites can contain toxic chemicals such as toluene, which can cause cancer and is also linked to central nervous system damage and breathing problems, and benzene, which can cause leukemia.[19]

A series of 2012 measurements by officials of the Texas Commission on Environmental Quality found volatile organic compounds (VOCs) levels so high at one fracking location that the officials themselves were forced to stop taking measurements and leave the site because it was too dangerous for them to remain.[20] Impoundment ponds where fracking wastewater is stored are also sources of air pollution, as chemicals – some linked to human health problems – evaporate from the open-air pits.[21] In addition, increased truck traffic needed to service the drilling sites contributes to air pollution.[22]

Flaring at fracking sites is often used to burn off excess gas that cannot be captured. This process can release xylenes, ethylbenzene and hexane, which can cause neurological and respiratory problems.[23]

Air pollution related to fracking can travel long distances downwind, affecting people who live far from fracking areas, in addition to those who live near where fracking occurs.[24]

Pollution in Texas is worse than it could be because Texas regulators and the Texas Legislature have missed opportunities to improve air quality regulations. In 2011 lawmakers blocked the extension of air regulations from the Barnett Shale to other parts of the state.[25] Even as states like Colorado have significantly improved air quality regulations on oil and gas facilities, including flaring and venting, storage tanks, pneumatic devices and compressor engines, Texas has not updated its rules.[26]

Fracking Jeopardizes Human Health

A growing number of scientific studies link hydraulic fracturing with various health risks. Proximity to well pads has been associated with increases in a person's risk for respiratory and neurological problems, as well as birth defects.[27]

Cancer-causing chemicals are used at one-third of all fracking sites in the country, according to an analysis of fracking companies' self-reported disclosures.[28] These include compounds such as naphthalene, benzyl chloride and formaldehyde, which in addition to being carcinogens are also toxic to human reproductive, neurological, respiratory and gastrointestinal systems.[29] When the analysis was expanded to look at suspected carcinogens, including both common household chemicals and elements such as arsenic and chromium, it found those substances used in 90 percent of reported fracking jobs around the country.[30]

More than three-quarters of the chemicals used in fracking can, at varying dosage levels, harm skin, eyes, breathing, digestion and liver functions.[31] More than half can damage the nervous system.[32] And more than one-third are potential disruptors of the endocrine system – affecting neurological and immune system function, reproduction, and fetal and child development.[33]

Air pollutants at fracking sites include volatile organic compounds (VOCs) such as benzene, xylene and toluene, which can cause varied health problems, from eye irritation and headaches to asthma and cancer.[34] With the rapid and widespread expansion of fracking, releases of these and other toxic chemicals are increasing at Texas fracking sites.[35]

Investigations and analysis in Texas by the online journalism site ProPublica and the non-profit group Earthworks have linked fracking operations to significant damage to nearby residents' health.[36] In Texas, the Earthworks study examined fracking activity in Karnes County, finding elevated levels of toxic contaminants in the air, leading to health problems.[37]

In 2014, a Dallas jury awarded a north Texas ranching family $3 million from a natural gas company whose fracking operations had released emissions that sickened family members and forced them to move out of their home.[38]

Fracking also puts the health and safety of the industry's workers at risk. The National Institute for Occupational Safety and Health has raised concerns about the risk of workers contracting lung disease after inhaling silica dust produced during handling of the sand that is injected, along with fluid, into fracking wells. The research prompted the U.S. Occupational Safety and Health Administration to issue a hazard alert for workers at fracking sites.[39]

Fracking Emits Global Warming Pollution

Methane is an extremely powerful greenhouse gas – 86 times more potent than carbon dioxide over a 20-year period, and 34 times more powerful over a 100-year period.[40] Methane leaks into the atmosphere are large and common from fracking well and storage facilities, both as a result of intentional discharges and unintentional leaks.[41] The industry has, so far, failed to take relatively simple steps that could reduce methane leaks.[42]

Fracking Causes Earthquakes

Recent reports by Texas researchers have confirmed that fracking and the disposal of fracking wastewater caused a series of earthquakes near Azle and Reno, Texas, just northwest of Fort Worth.[43] From November 2013 through January 2014, 27 quakes rattled the area, including two magnitude-3.6 quakes.[44] The quakes were linked not only to two wells for wastewater disposal but also to more than 70 fracked wells producing oil and natural gas.[45]

Injecting high-pressure fluid underground as part of fracking, and as part of the operations of wells for disposal of fracking wastewater, has been linked to earthquakes in the U.S. and in Canada.[46]

In April 2015, the U.S. Geological Survey concluded that injecting fracking wastewater underground causes earthquakes.[47] The agency began including "induced" or "man-made" earthquakes in the National Seismic Hazard Model.[48]

Fracking on University Lands Endangers the Environment and the Public

From its beginning as 220,000 acres set aside by the Texas Congress in 1839 as the basis for a public education system, Texas' university-owned lands have grown to comprise 2.1 million acres in 19 West Texas counties, most of which are above the oil- and gas-rich Permian Basin.[49] More than half of that university-owned land is leased to the oil and gas industry.[50]

The UT Board of Regents Is Responsible for Management of University Lands

Oversight of the university-owned lands is spread among several organizations, all of which are ultimately responsible to and under the control of the Board of Regents of the University of Texas System.

The UT Board of Regents appoints the university's chancellor, its chief executive officer.[51] Reporting to that person is the executive vice chancellor of business affairs, who heads the university's Office of Business Affairs.[52] Part of that office is the University Lands Office.[53]

In 2014 the UT Board of Regents augmented its oversight of the University Lands Office by appointing a University Lands Advisory Committee to, among other duties, revise contract terms and operations policies for oil and gas leases of university-owned land, subject to the Regents' final approval.[54] That committee is made up of two members of the UT Board of Regents, the UT System executive vice chancellor of business affairs, two petroleum industry executives chosen by the UT Board of Regents, and one member of the Board of Regents of the Texas A&M University System.[55] (The UT System and the A&M System are separate institutions; proceeds from revenue from university-owned lands is split between the two systems, with two-thirds going to UT and one-third going to A&M.[56])

The University Lands Office staff provides geological and engineering data to companies operating, or considering operating, oil and gas wells on university-owned land, and prepares and evaluates contracts and leases.[57]

Leases of university-owned land are approved by the Board for Lease of University Lands, a four-person body chaired by the commissioner of the Texas General Land Office.[58] Two of the board's members are members of the UT Board of Regents; the fourth is a member of the A&M Board of Regents.[59]

Accounting responsibility for the University Lands was assigned to the UT Board of Regents starting in 1979; the board created University Lands Accounting, a part of the University Lands Office.[60]

Investment of the funds generated by the University Lands is overseen by the University of Texas Investment Management Company (UTIMCO), under contract with the UT Board of Regents.[61] The UTIMCO board has nine members: three members of the UT Board of Regents, four members appointed by the UT Board of Regents, and two members of the A&M Board of Regents.[62]

Fracking Operations Are Common on University Lands

A public records request to the University Lands Office revealed that 4,350 wells have been drilled on university-owned land since 2005.[63] University officials estimate that as many as 4,132 – 95 percent – have been fracked.[64]

Andrews County has the lion's share of those 4,350 wells – 2,051, or nearly half. Crane County has 557 wells on university-owned land that have been drilled since 2005; Crockett County has 486. (See Table 1.) The other counties with wells drilled since 2005 on university-owned land are: Culberson, Dawson, Ector, Gaines, Irion, Loving, Martin, Pecos, Reagan, Schleicher, Terrell, Upton, Ward and Winkler.[66]

Since 2012, fracking companies in Texas have been required to report data about their frack jobs to FracFocus.org, an online database compiling chemicals and water use at fracking wells.[67]

Of the 4,350 wells reported in university data, 2,049 of them have reported data to FracFocus. Of those wells, 41 percent – 847 – are in Andrews County. Crockett County has 313 wells on university-owned land in FracFocus data, and Reagan County has 300.[68]

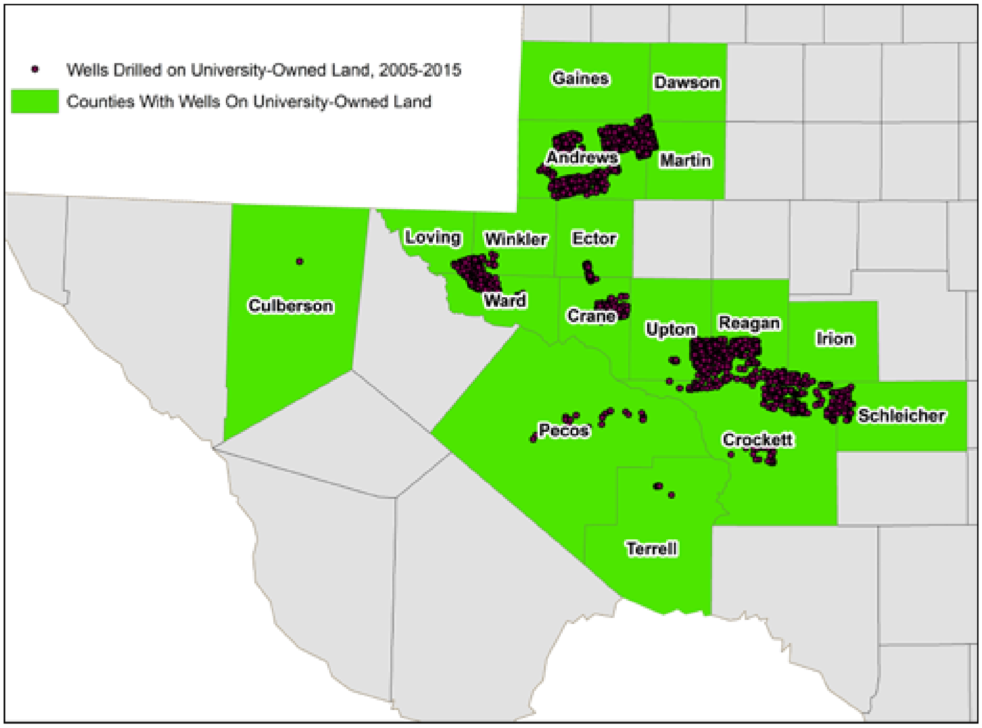
Table 1. Wells Drilled On University of Texas Land, 2005-2015, by County[69]

County	Wells Drilled
Andrews	2,051
Crockett	557
Reagan	486
Upton	266
Crane	226
Martin	206
Ward	145
Schleicher	86
Ector	85
Irion	82
Loving	63
Winkler	48
Pecos	27
Gaines	14
Terrell	5
Dawson	2
Culberson	1
Total	4,350

Images from Google Earth.

Before and after: A site of fracking operations on university-owned land in Reagan County, as seen April 17, 2012, and December 15, 2013.[65]

Figure 1. Wells Drilled on University-Owned Lands, 2005-2015[70]



Wells on University Land Use Large Amounts of Water

Wells on university-owned land used at least 6 billion gallons of water between February 2012 and December 2014.[71]

Recent rains have recharged some aquifers and led the U.S. Drought Monitor to declare an end to Texas's four-year drought.[72] But drought is a long-term norm in West Texas, and will certainly return, especially as global warming worsens.

A report commissioned by the university urged the University Lands Office to do more to reduce use of water on university-owned property, including financing water recycling facilities itself, for use by drilling companies leasing rights from the university.[73] The report also highlighted the importance of UT's brand, writing that "the expectation is that [the university] will ultimately be a better energy entity."[74] During the recently ended four-year drought, government officials pressed residents across the state to cut back on water use, while wells on university-owned land sucked up more and more water every year.[75] (See Table 2.)

Table 2. Water Use at Wells on University Land, 2012-2014[76]

Year	Gallons of Water Used (millions)
2012*	737
2013	2,643
2014	2,932

*2012 data begins February 1, 2012.

A university spokeswoman has said publicly that the university "require[s] that only non-potable water be used in hydraulic fracturing on University Lands."[77] The university's Groundwater Management Plan, adopted in January 2013, indicates that "University Lands promotes best management practices of all groundwater resources."[78]

Technically, the university's rules could include freshwater as well as brackish water. Its definition of "non-potable water" is water that "has not been analyzed, properly treated, and is not approved as being safe for consumption."[79] That description could apply not only to salty, undrinkable groundwater but also to freshwater from an aquifer supplying drinking water to the public – so long as the freshwater has not yet been through a treatment plant.

Fracking Chemicals Used on University Land Are Dangerous

Chemicals used in fracking operations pose significant risks to human health, should they enter the air or water. Wells on University of Texas land from 2005 to 2015 used at least:

- 92.5 million pounds of hydrochloric acid, a caustic acid that can contaminate water;[80]
- 8.5 million pounds of methanol, which is suspected to cause birth defects;[81]
- More than 7.8 million pounds of chemicals that were not specifically identified or were only labeled as trade secrets, meaning their health and environmental effects cannot be determined; and,
- More than 166.8 million pounds of other chemicals and substances of varying toxicity.

Spills on University Land Pollute the Land and Groundwater

University-owned land and the groundwater beneath it have been polluted by oil and gas extraction:

- At least 1.6 million gallons of pollutants have spilled into soil or groundwater from wells located on university land, with spills taking place on more than 160 occasions since 2008.[82]
- Cleanups are not yet complete at five of those locations. The effort can take many years: At least one 2008 spill and another from 2009 were not yet cleaned up as of March 2015.[83]
- Groundwater has been contaminated by oil and related pollutants in at least 13 locations on university-owned lands.[84] At least three of those instances of contamination have happened since 2008.[85]
- There are eight active groundwater remediation projects under way on university-owned lands, addressing contamination by oil and related pollutants.[86]

The spills reported are from a variety of causes, including equipment breakdowns, corroded pipes, electrical power outages, excess well pressure, weather (such as lightning strikes and freezing temperatures), and vandalism.[87]

Fracking on University Land Contributes to Global Warming

Fracking emits methane – a potent global warming pollutant – to the atmosphere. How much methane comes from fracking wells is a matter of great debate, with estimates that vary depending on who is doing the measuring, which wells are being measured, and which steps of the fracking process are included in the estimate.

Two types of estimates – one based on the number of wells completed, and the other based on gas production amounts – show the potential for significant methane emissions.

The process of "completing" a well – preparing it to produce oil or natural gas, including through the use of hydraulic fracturing – can be particularly emissions intensive. A 2010 study by researchers at MIT estimated that the average fracked shale gas well produced an estimated 110,000 pounds of methane during the first nine days of operation, an estimate that, if applied to both oil and gas wells fracked on university lands since 2005, would imply emissions of 7 million metric tons of carbon dioxide equivalent – greater than the total emissions by 1.5 million cars in a year – for those wells.[88]

Other estimates of emissions from completions are far lower. A 2013 study led by University of Texas researchers that measured emissions at a small number of wells selected in cooperation with the oil and gas industry found that the process of well completion took between five hours and two weeks, and produced an average of approximately 3,800 pounds of methane per well, implying emissions for wells on UT lands of 244,000 metric tons of carbon dioxide equivalent.[89] Even this dramatically smaller amount of emissions exceeds the amount of carbon dioxide produced by 50,000 cars in a year.[90]

Estimates based on well completions, however, ignore the methane leakage that can occur from other parts of the process of producing, processing and transporting fossil fuels from fracked wells. Using two sets of estimates – one from the University of Texas study noted above and another from researchers at Cornell University – suggests that emissions from fracking on university-owned lands between 2005 and 2015 most likely amounted to between 4 million and 8.7 million metric tons of carbon dioxide equivalent, when estimated on a production basis.[91]

The data on methane emissions from fracking wells lead to two conclusions. First, fracking is at least a significant – and perhaps a major – source of methane emissions that are altering the climate. Second, far better tracking and monitoring of methane emissions from fracking are needed to enable citizens and decision-makers to better understand the threat.

Fracking on University Land Puts Livestock at Risk

Much university-owned land is leased for grazing of livestock. Across the nation, fracking sites have harmed livestock. In 2014, a Dallas jury awarded a north Texas ranching family $3 million from a natural gas company whose fracking operations had released emissions that caused birth defects in calves, as well as killing pets and sickening family members.[92]

Research has linked fracking fluid, fracking air emissions and water pollution from fracking sites to illness, birth defects and deaths of livestock in Texas, Colorado, Louisiana, New York, Ohio and Pennsylvania.[93]

Fracking on University Land Endangers Vulnerable Wildlife

The university-owned land on which fracking occurs provides habitat for wildlife, and is surrounded by other lands that do the same. Counties in which fracking occurs on university-owned land are home to:

- 13 species on the federal endangered list, including the ocelot, gray wolf, red wolf, whooping crane and the Pecos gambusia fish.[94]
- 1 species on the state endangered list: the Pecos assiminea snail.[95]
- 3 species on the federally threatened list: the Mexican spotted owl, the bunched cory cactus and the Pecos/puzzle sunflower.[96]
- 24 species on the state threatened list, including the bald eagle, peregrine falcon, the common black hawk, the gray hawk, the zone-tailed hawk, the reddish egret, the Proserpine shiner fish, the bluntnose shiner fish, the black bear, the Texas hornshell mussel, the Texas horned lizard and the Texas tortoise.[97]

These creatures and their habitats are important to the ecology and environment of West Texas and should be protected.

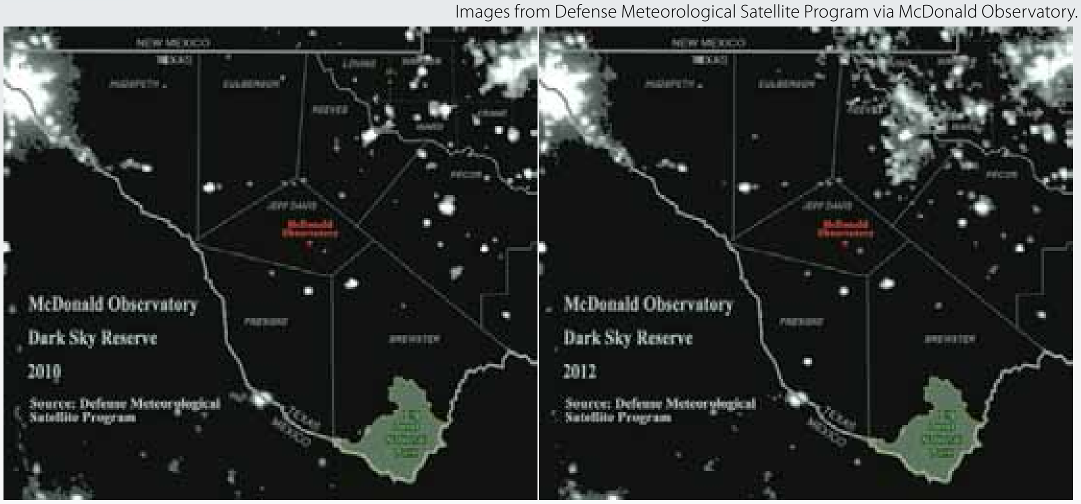
Fracking Interferes with University Research

Fracking operations in West Texas create light pollution that threatens scientific research at the McDonald Observatory in central Jeff Davis County.[98]

The university-run observatory, founded in 1932, is home to the world's fourth-largest telescope detecting visible light.[99] It touts itself as having "the darkest night skies of any professional observatory in the continental United States."[100] The observatory is also a public asset, hosting 75,000 visitors a year for educational and recreational stargazing events.[101]

Since 2010, the observatory's clear views of the night sky have become increasingly endangered by encroaching light pollution from round-the-clock oil and gas drilling, even at faraway sites.[102]

Images from Defense Meteorological Satellite Program via McDonald Observatory.



From 2010 to 2012, light pollution from oil fields encroached on the McDonald Observatory's view of the sky.

Light pollution related to fracking can come from artificial lights used to illuminate buildings and outdoor workspaces at well sites, and from flaring off of natural gas that is not able to be captured for sale.[103] As much as half the light emitted at well sites shines upward rather than down toward the ground, where it is intended to go.[104] All that light in the sky "poses an imminent threat to astronomical research at McDonald Observatory," according to a 2015 report written jointly by an observatory spokesman and an oil company executive.[105]

Local petroleum industry leaders have urged drillers to reduce their light pollution.[106] The challenge is significant: There are nearly 500 companies involved in drilling operations in the Permian Basin whose lighting equipment and practices would need to change.[107]

Operators on university-owned land in the region surrounding the observatory would be among those affected, particularly in Culberson and Pecos counties, which neighbor Jeff Davis County.[108]

Starting in 1978, state, county and local governments created a massive, 28,000-square-mile dark-sky preserve around the observatory, where outdoor lighting is strictly regulated to prevent obstructing night sky viewing.[109] In 2011, the state legislature made many restrictions mandatory in the seven counties the reserve spans, including Culberson and Pecos counties.[110]

But enforcement is lax, particularly at petroleum industry locations, an observatory spokesman told the *Texas Observer* in 2014.[111]

The university should require users of its land to comply with existing light restrictions, and consider tightening the requirements, if appropriate, to support and protect the university's own research.

Fracking on a UT Campus

This study analyzes fracking on land set aside to generate revenue for Texas' public universities. But fracking is not happening just on that university-owned land in remote areas of the state.

For example, as a result of a 2007 lease agreement, a well pad was installed on the University of Texas Arlington campus, just 400 feet from an on-campus YWCA child-care facility.[112] The well pad is still in operation.[113] In exchange, the university received an initial lease payment of nearly $800,000 plus millions in royalty payments and donations from the drilling company, Carrizo Oil and Gas, a major fracking company.[114] The child-care facility later moved across campus, to a new building paid for mostly by Carrizo.[115]

Photo by John Darling.

The gate to a drill pad, home to several fracked wells, on the University of Texas Arlington campus.

Policy Recommendations

Fracking is so dangerous to the environment and human health that it should not occur anywhere. New York and Maryland have banned fracking because of its inherent risks, including to public health.[116] The National Governors Association's Center for Best Practices has called for significant effort to protect water quality from the hazards of fracking.[117]

The University of Texas has a responsibility to ensure that its operations do not threaten the public or the environment. If the University of Texas continues to allow fracking on its land, the university should at least end the worst practices and take immediate steps to protect the public.

The university should protect Texas's natural heritage by prohibiting drilling on lands with special environmental value, such as Diablo Plateau, the Pecos River watershed, and all land that is habitat for migratory birds and endangered or threatened species. The university's existing policies require it to reduce greenhouse gas emissions; the university should step up those efforts regarding use of land it owns.[118]

The university should write strong environmental protections into the agreements it signs with oil and gas companies. Leases and the accompanying field manual of required operating procedures should:

- Reduce the risks of pollution by banning toxic chemicals and strictly limiting emissions at well, storage and transmission sites, including wastewater holding locations.
- Adopt best practices to prevent surface, groundwater, air and light pollution. Examples include:
    - Colorado's air pollution rules, which require companies to establish a leak detection and repair program, as well as install equipment to eliminate 95 percent of methane and other hydrocarbon emissions from fracking sites and related equipment.[119]
    - North Dakota's flaring rules, which set a statewide target for the amount of natural gas burned off as waste, require companies to detail plans to meet the limit, and empower regulators to cut companies' production if they do not comply.[120]
    - Pioneer Energy Services' recommendations for aiming and shielding both existing and new light fixtures, and installation of appropriate LED fixtures, which reduce light pollution and simultaneously reduce glare, improve visibility and save energy.[121]
- Codify the university's verbal commitment to protect Texas's valuable water resources by requiring fracking companies use to non-potable water in fracking on university land – and more narrowly define "non-potable water" as water that cannot be made safe for human consumption.[122] The university should also require operators to meet aggressive water use reduction goals and to recycle wastewater. Companies would still need to collect and properly dispose of contaminated wastewater.

- Reduce earthquake risk by restricting fracking operations in known areas of seismic activity, as Ohio has done, and establishing pre- and post-monitoring testing for seismic activity;[123]

- Require advance notice of any new wells or fracking operations be provided to local landowners, groundwater districts, and municipal and county officials;

- Require annual reporting on the disposal of produced water, flowback, drill cuttings and any other liquid or solid waste associated with wells fracked on university-owned lands, to be compiled into a university-issued annual report on waste from fracking on university-owned lands;

- Require pre- and post-drilling monitoring of groundwater and nearby surface waters to identify contaminants and their sources.

In addition, the university should, in keeping with its mission as an educational institution, collect and make available to the public more complete data on fracking, including water usage and chemicals involved, enabling Texans to understand the full extent of the harm that fracking causes to our environment and health.

Methodology

Identifying Wells

Data on wells drilled on university-owned land was received as the result of a public records request. Wells were identified by American Petroleum Institute (API) number from a list provided by Roger Starkey, Associate Vice Chancellor for State and Federal Relations, University of Texas System, correspondence with Huey Fisher in the office of Texas Representative Eddie Rodriguez, 12 March 2015. Additional clarifying information was provided on 12 May 2015. There were 4,350 well API numbers provided.

Assembling the Data

FracFocus.org offers the most comprehensive database of wells that have been fracked, chemicals used in those frack jobs, and related information. The website is run by the Groundwater Protection Council, a non-profit association of state regulators of oil and gas drilling, and the Interstate Oil and Gas Compact Commission, a multi-state association.[124] The site itself is funded by the oil and gas industry.[125] Disclosure requirements are either set by states, some of which have mandatory disclosure rules, or by individual companies that choose to disclose in states without rules.

FracFocus.org has significant drawbacks:

- Companies enter the data themselves directly, and are not subject to verification or validation of their entries.[126]
- Companies are allowed to withhold information on chemicals used in fracking by classifying them as trade secrets.[127]
- Disclosure to the database has only been mandatory in Texas since February 1, 2012, meaning any disclosures about fracking before then were voluntary and may not provide a comprehensive picture of the industry.[128]

Nevertheless, it is the best available data. In early 2015, for the first time, FracFocus made some of its data available for bulk download.[129]

However, those data were not the full data set submitted to the site. When FracFocus launched in January 2011, disclosure forms were submitted on paper or via electronic PDF, and were neither submitted nor later entered into the system in a machine-readable format. This format was called "FracFocus 1.0."[130]

Starting in November 2012, a new format, called "FracFocus 2.0," was made available for data entry. That included chemical data in machine-readable format, but was not the mandatory submission format until May 31, 2013.[131]

Only after May 31, 2013, was "FracFocus 2.0" the sole format for submitting disclosure data.[132]

As a result, the bulk-downloadable data available from FracFocus included only header information (without chemical disclosure) for records submitted in the "FracFocus 1.0." For data submitted in "Frac-

Focus 2.0” format, the chemical disclosure data were available in the bulk download.[133]

To include in our analysis the data submitted in the “FracFocus 1.0” format required the incorporation of data released by the U.S. Environmental Protection Agency, which in March 2015 published an analysis of all the “FracFocus 1.0” data, as provided to the agency directly by FracFocus.[134]

The EPA conducted quality-assurance processes, but not real-world-comparison data validation, before releasing the data used in its analysis to the public.[135]

FracFocus.org Data

The most recently updated bulk data package was downloaded from FracFocus.org on 6 May 2015. The three data files were processed through Microsoft SQL Server software according to the instructions provided on the FracFocus website and archived at web.archive.org/web/20150520202149/http://data.fracfocus.org/DigitalDownload/FracFocus-SQLtoAccess.pdf.

The three data files were joined according to the instructions provided on the FracFocus website and archived at web.archive.org/web/20150520202248/http://fracfocus.org/data-download, with one important change. The site itself recommends a pair of “inner join” processes, but that omits any mention of the header information for the records entered in the FracFocus 1.0 format (January 2011 to May 31, 2013), as well as 2,280 records whose data indicate they were entered in the FracFocus 2.0 format but for which chemical disclosure data is missing.[136] To include those records in our analysis, we conducted “left join” processes instead of the “inner join” ones.

Then, for ease in processing, the data – which up until that point included records from every state from which operators had submitted information – were culled to only those in the state of Texas.

U.S. Environmental Protection Agency Data

The EPA-processed data from “FracFocus 1.0” format information were downloaded from www2.epa.gov/hfstudy/epa-project-database-developed-fracfocus-1-disclosures on 6 May 2015.

The “QAWell” table in the EPA data was queried for wells in Texas.

Those wells’ associated disclosure data were joined with the FracFocus Texas wells data to create the assembled data.

Determining Wells that Had Been Fracked

Searching the assembled data for the 4,350 API numbers provided by the university returned 2,194 records of fracking operations conducted at 2,049 wells.

That is far fewer than the 4,132 wells University of Texas officials had estimated have been fracked, of the wells drilled on university-owned land from 2005 to 2015, and leaves 2,083 wells’ fracking operations unaccounted for.[137] It is possible, and even likely, that some or all of those wells were fracked between 2005 and FracFocus’s launch in 2011, or between 2005 and the beginning of mandatory disclosure in Texas in February 2012.

Determining Water Use at Fracked Wells

The university supplied data that wells on university-owned land used 6.3 billion gallons of water between February 2012 and December 2014.[138] Discounting this by 5 percent, to reflect the university’s assertion that 95 percent of the wells were fracked, results in 6 billion gallons of water. As fracking wells use far more water than conventional wells, this is a conservative calculation.

Determining Chemical Use at Fracked Wells

The FracFocus and EPA data have multiple records for each frack job, detailing each chemical used in that job. In total, the data for the 2,194 frack jobs at the 2,049 wells was in 82,459 records.

In Step 1, we excluded as incompletely entered the 7,363 records that listed a chemical on a frack job's reporting form but listed no ingredient concentration in the final composition of the fracking fluid.

In Steps 2 and 3, we selected data deemed most likely to be reliable for the purposes of our analysis, based on available data about ingredients' maximum concentrations in the final fracking fluid.

For Step 2, we wanted only reliable records regarding base fluid water usage. Water as a base fluid is a major component of fracking fluid. To identify water records describing base fluid concentration, we used the same method as described in the "Calculating chemical amounts" section below.

We excluded records with either too much or too little base fluid water concentration. Specifically, we excluded records from frack jobs where:

- the base fluid water maximum concentration was indicated in the data as exceeding 101 percent of the job's fracking fluid, or
- the base fluid water maximum concentration was indicated in the data as being less than 50 percent of the job's fracking fluid.

This resulted in the exclusion of 14,411 records.

In Step 3, we looked for reliable ingredient usage and reporting. FracFocus requires reporting of each ingredient's *maximum* percentage concentration in fracking fluid. If a fracking fluid's composition was significantly modified during the course of a fracking job, all the ingredients' maximum concentrations, when added together, could, therefore, exceed 100 percent. Using these numbers would likely result in overestimates of chemical amounts.

If a report was incomplete, all the disclosed ingredients' maximum concentrations, when added, could be far below 100 percent. With no way to know the concentrations of the missing ingredients, we assumed they, if reported, could potentially bring the total above 100 percent. Using these numbers, therefore, could result in overestimates of the amounts of those chemicals that were reported.

To ensure we were basing our analysis on fracking fluids whose composition was substantially completely reported and substantially uniform throughout the entire frack job, we excluded records from frack jobs where:

- the total component maximum concentration was indicated in the data as exceeding 101 percent of the job's fracking fluid,[139] or
- the total component maximum concentration was indicated in the data as being less than 95 percent of the job's fracking fluid.[140]

This resulted in the exclusion of 7,941 records.

These steps left for analysis 52,744 records from 1,542 frack jobs at 1,480 wells. Our analysis, therefore, was conducted on 64 percent of available records, describing 70 percent of frack jobs at 72 percent of wells, suggesting that the estimates of chemical use in this report likely significantly understates total chemical use at these wells.

As Table M-1 shows, 69.6 percent of the records from the FracFocus bulk download had valid data usable in this analysis. And following EPA's data quality efforts, 55.6 percent of the data downloaded from the EPA were usable.[141] This may be because the EPA's analysis depended first on converting PDF files into a machine-readable database format, a process that can easily introduce errors, such as by placing data values in incorrect fields.

Table M-1. Quantifying data validation exclusions

Source	Starting Point: All records for frack jobs at University Lands wells	Step 1: Records with nonzero ingredient concentration in HF fluid	Percent kept	Step 2: Records within reasonable water base fluid concentration limits	Percent kept from previous step	Step 3: Records within reasonable ingredient concentration limits	Percent kept from previous step	Percent kept overall
EPA – FracFocus 1.0	33,230	25,925	78.0%	23,677	91.3%	18,474	78.0%	55.6%
FracFocus bulk download (FracFocus 2.0)	49,229	49,171	99.9%	37,008	75.3%	34,270	92.6%	69.6%
Total	82,459	75,096	91.1%	60,685	80.8%	52,744	86.9%	64.0%

Calculating Chemical Amounts

To calculate the amount of each chemical used, we first calculated each frack job's total mass. The source data included both gallons of water used and the percentage by mass of water in the fracking fluid as a whole. As the mass of a gallon of water is a known quantity, this allows determination of the total mass of the fracking fluid.

Records detailing water use were those where the Chemical Abstracts Service Registry number was 7732-18-5, or where the trade name or ingredient name included the word "water" and did not mention other chemicals or substances. Many fracking jobs had multiple such records, because water is an ingredient in many fracking chemicals. For example, in 15 percent hydrochloric acid, the remaining 85 percent is water. We needed to ensure the total mass calculation was using only the water used as base fluid (sometimes also called "carrier fluid"), to correspond with the volume reported in gallons. For each job, we used the largest number reported in a "PercentHFJob" field for water records.

For each fracking job, each ingredient's percentage by mass was multiplied by the job's total mass, to arrive at a mass of that ingredient in that job.

Chemical masses were then added across fracking jobs, to arrive at a total of each chemical used in fracking on University of Texas-owned lands.

This method is the same as that used by media organizations in Texas and Ohio to determine amounts of chemicals used in fracking wells in those states.[142]

This method makes four key assumptions:

- It assumes that the number listed in the base fluid amount is, in fact, water. In FracFocus 1.0 data submissions this field had varying labels, referring to "base," "fluid" or "water," with operators asked to identify whether the base fluid was water or something else. In 93 percent of records in FracFocus 1.0, the base fluid was water.[143] The assumption that this field referred to water was used by the U.S. Environmental Protection Agency when calculating cumulative water volumes.[144]

In FracFocus 2.0 data, this distinction is clearer: One field is labeled "TotalBaseWaterVolume" and another is labeled "TotalBaseNonWaterVolume." Our analysis used the "TotalBaseWaterVolume" field for calculating the total job mass.

- It assumes the number given for the concentration of the chemical ingredient in the total hydraulic fracturing fluid in percentage by mass remained constant throughout the frack job. Companies may vary their chemical compositions over the course of a frack job. However, FracFocus only asks them to report the maximum concentration, meaning there is no way to identify periods of time when the concentration might have been below that maximum level.
- It uses only the field indicating the percentage of the chemical ingredient in the overall fracking fluid. Another field provides the percentage of the chemical ingredient in an additive – if an acid is in solution, for example, it would say the solution was 50 percent acid. The labeling on the FracFocus forms and in its documentation is clear that these two fields are unrelated and do not need to be factored together.
- It assumes the water used in fracking jobs on university-owned lands is fresh, weighing 8.33 pounds per gallon.[145] The university says it allows only "non-potable" water to be used in fracking on university-owned lands, a definition that could include fresh water.[146] Fresh water was selected because it is the most conservative assumption: If this model had assumed brackish water was used, the amounts of chemicals would have been higher, by 0.03 percent.[147]

The chemical totals we use in this report are the sums of the data reported just in the 1,542 frack jobs at the 1,480 wells with data in FracFocus and EPA databases; the results are not extrapolated to represent any additional wells.

Calculating Methane Emissions

We calculated methane emissions using two approaches. The first approach multiplied emissions per well during completion by the number of fracking wells. The second method estimated emissions as a percentage of gas produced from fracking wells.

The production-based method includes emissions from a wider range of activities involved in producing gas from fracking wells – from drilling to fracking to processing – and therefore better reflects the impact of fracking. The per-well emission factor is conservative because it is based on a narrower definition of fracking activity (it excludes production and processing). However, it may overestimate emissions from wells that were drilled but produced little to no gas.

Emissions Based on Well Completion

We estimated methane emissions by multiplying an estimate of emissions per completion of a fracking gas well by 4,132, the number of fracked wells on university-owned land.

Two recent studies – one from the Massachusetts Institute of Technology and one from the University of Texas – estimate methane emissions per well.

For the MIT calculation, we estimated average emissions of 50,000 kilograms of methane per well, per Francis O'Sullivan and Sergey Paltsev, "Shale Gas Production: Potential Versus Actual Greenhouse Gas Emissions," *Environmental Research Letters*, 7:1-6, 26 November 2012, doi: 10.1088/1748-9326/7/4/044030.

This estimate is a national average based on nearly 4,000 wells completed in 2010 and assumes 70 percent of wells undergo "green" completions in which fugitive emissions are captured. This likely overstates the green completions rate before 2010.

For the University of Texas calculation, we estimated average emissions of 1,733 kilograms of methane per well, per David T. Allen et al., "Measurements of Methane Emissions at Natural Gas Production Sites in the United States," *Proceedings of the National Academy of Sciences* 44:110, 17768-17773, 16 September 2013, doi: 10.1073/ pnas.1304880110.

This estimate is an average based on 24 well completions in 2012 in four U.S. regions, among which 62 percent of wells had at least some fugitive emissions captured. This likely overestimates the rate of completions with captured emissions before 2010. Further research has raised questions about the accuracy of the methane emissions measurements used in that study.[148]

Our estimates based on well completions have two limitations of note. First, they do not include methane emissions from pipelines, compressor stations, and condensate tanks, or carbon dioxide emissions from equipment used to produce gas. Second, they may not accurately reflect emissions from fracked shale wells that primarily produce oil rather than gas. The data we obtained on well completions do not distinguish between wells fracked for oil versus gas production and therefore we have chosen to apply this estimate for shale gas wells to all wells. We spoke with two experts in the field who believe that, given the lack of better data on emissions from oil wells, is it reasonable to assume that fracked oil wells have substantial methane emissions. We converted methane emissions to carbon dioxide equivalents using a 100-year global warming potential of 34 times that of carbon dioxide, per Gunnar Myhre, Drew Shindell, et al., Intergovernmental Panel on Climate Change, "Anthropogenic and Natural Radiative Forcing," *Climate Change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 2013.

Emissions Based on Gas Production.

The University of Texas data provided included information on production, saying there were 511,945.6 million cubic feet of gas produced from the 4,350 wells on university-owned land that were drilled between 2005 and 2015.

We converted cubic feet of produced gas to cubic feet of methane using the assumption that 78.8 percent of gas produced from unconventional wells is methane, per Robert Howarth, et al., "Methane and the Greenhouse Gas Footprint of Natural Gas from Shale Formations," *Climatic Change* 106: 679-690, 2011.

Two recent studies – one from Cornell and one from the University of Texas – estimate rates of methane emissions as a percentage of gas production.

For the Cornell calculation, we assume that 3.3 percent of the methane produced over the life of a well is lost as fugitive emissions, per Robert Howarth, et al., "Methane and the Greenhouse Gas Footprint of Natural Gas from Shale Formations," *Climatic Change* 106: 679-690, 2011, as presented in Robert Howarth, et al., *Methane Emissions from Natural Gas Systems; Background Paper Prepared for National Climate Assessment*, 25 February 2012.

This estimate includes well-site and processing emissions from shale and tight-gas sands wells that produce gas. The estimate assumes significant venting of methane in the initial days after a well is fracked.

For the University of Texas calculation, we assume that 1.2 percent of the gross gas production over the life of a well is lost as fugitive emissions of methane, per the field production emissions number calculated in David T. Allen et al., "Measurements of Methane Emissions at Natural Gas Production Sites in the United States," *Proceedings of the National Academy of Sciences* 44:110, 17768-17773, 16 September 2013, doi: 10.1073/ pnas.1304880110, used in place of the 2011 field production emissions number in EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2011*, 12 April 2013. Further research has raised questions about the accuracy of the methane emissions measurements used in that study.[149]

The 3.3 percent pollution rate from Howarth, et al., is higher, and the 1.2 percent pollution rate from Allen, et al., is lower, than the rate reported in EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2011*, 12 April 2013.

The 3.3 percent pollution rate is in the range of one recent study that measured fugitive emissions over a gas and oil field in Colorado, finding fugitive methane emissions of 2.3 to 7.7 percent of gas produced (Gabrielle Pétron, et al., "Hydrocarbon Emissions Characterization in the Colorado Front Range: A Pilot Study," *Journal of Geophysical Research*, 117, D04304, 2012, doi:10.1029/2011JD016360, and Jeff Tollefson, "Air Sampling Reveals High Emissions from Gas Field," *Nature*, 483(7384): 139-140, 9 February 2012, doi: 10.1038/482139a).

A second recent study in the same area measured methane emissions equal to 6.2 to 11.7 percent of production (Anna Karion, et al., "Methane Emissions Estimate from Airborne Measurements over a Western United States Natural Gas Field," *Geophysical Research Letters*, 27 August 2013, doi: 10.1002/grl.50811).

As in our calculations based on well completion, we converted methane emissions to carbon dioxide equivalents using a 100-year global warming potential of 34 times that of carbon dioxide, per Gunnar Myhre, Drew Shindell, et al., Intergovernmental Panel on Climate Change, "Anthropogenic and Natural Radiative Forcing," *Climate Change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 2013.

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