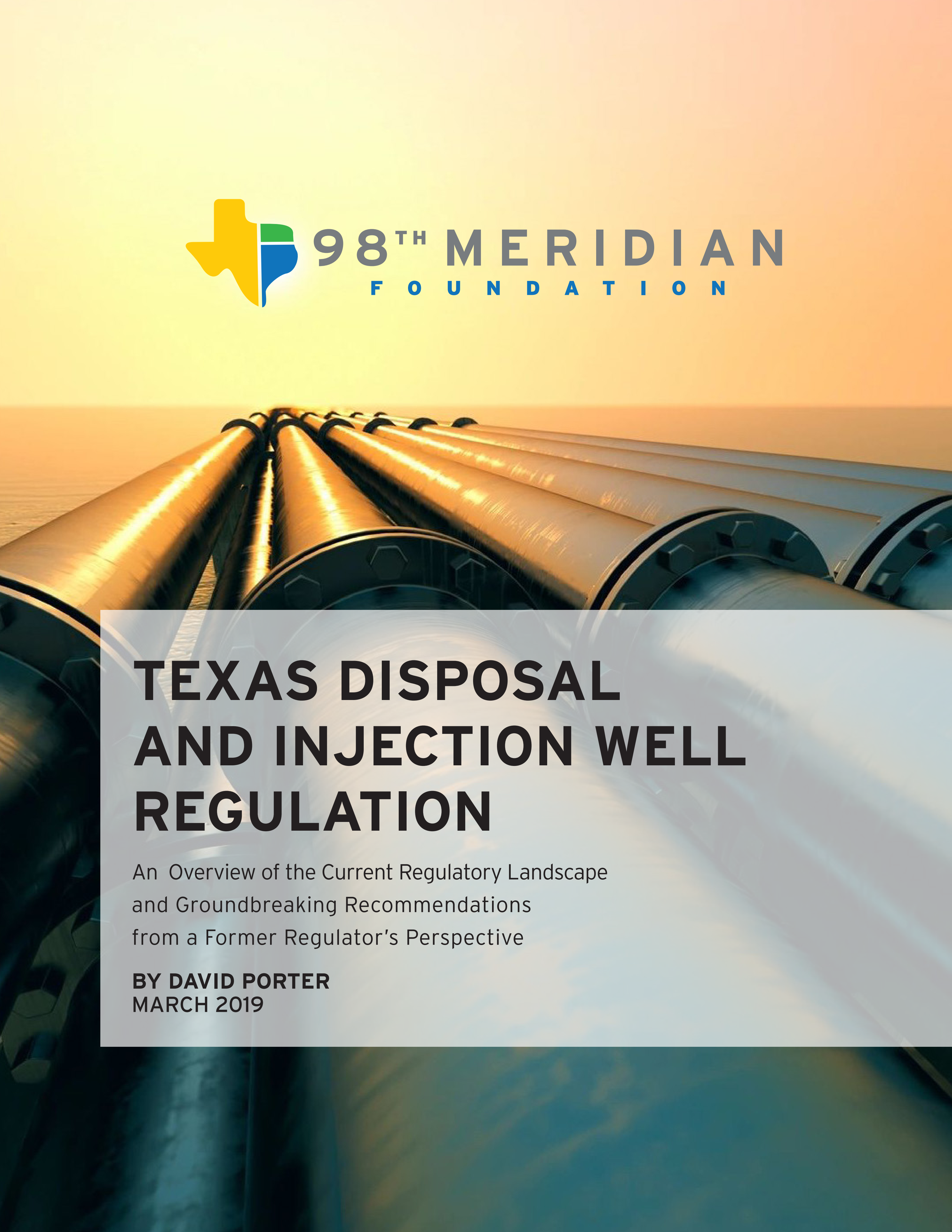


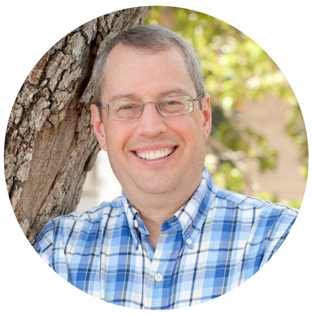
98TH MERIDIAN FOUNDATION

TEXAS DISPOSAL AND INJECTION WELL REGULATION

An Overview of the Current Regulatory Landscape and Groundbreaking Recommendations from a Former Regulator's Perspective

BY DAVID PORTER
MARCH 2019

ABOUT THE AUTHOR/FOUNDER OF 98TH MERIDIAN FOUNDATION, DAVID PORTER



David Porter served as a Texas Railroad Commissioner from 2011 to 2017. During his time on the Commission, Porter earned a reputation for being an astute, pragmatic decision-maker with a unique ability to bring together multiple stakeholders on differing sides of an issue, build consensuses and carefully craft fact-based and science-based regulation over the oil, natural gas and related industries.

After leaving office, Porter had a strong desire to continue the vital work he performed at the Commission and maintain involvement in the important issues that impact our state. He founded 98th Meridian Foundation, a nonprofit organization, which aims to study, educate and initiate high-level dialogue around issues in order to bring forth reasonable solutions. These issues all seemed to fall within three general areas: water, land and energy. They are of great importance to all Texans, our economy and, indeed, life itself.

ABOUT THE 98TH MERIDIAN FOUNDATION

The 98th meridian, which runs through the heart of Texas, is the longitude line separating east and west, arid and humid climates. Just as the 98th meridian represents a demarcation where the landscape changes, the 98th Meridian Foundation represents a new frontier of thinking about how to solve the problems surrounding these issues in bold, innovative ways.

Because of the close nexus of these issues, we must examine how potential solutions affect land, water and energy production individually and collectively. Land, water and energy are the three legs holding up the metaphorical stool of Texas life, and we must see that all three legs are strong and in good repair.

The 98th Meridian Foundation is dedicated to working on solutions to problems that take into account the big picture and attempt to preserve and improve what makes Texas great. The Foundation will approach problems with a long-term vision, looking through a free market-oriented lens in an attempt to strengthen the traditional communities of Texas, especially rural communities.

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EXECUTIVE SUMMARY

Texas has long been a top producer of oil and natural gas, a legacy which dates back to the early 20th century and has provided vast economic and societal benefits.

Oil and natural gas play a fundamental role in our lives, contributing to important, everyday products like transportation and heating fuel, plastics and synthetic materials, lifesaving pharmaceuticals and electric generation — in addition to providing more than $14 billion to the Texas economy in the form of taxes and royalty payments and hundreds of thousands of jobs last year alone.

The historic gusher at Spindletop in 1901 ushered in the beginning of Texas' oil era; and nearly a century later, Texas was the birthplace for a new combination of techniques which would revolutionize the industry. Hydraulic fracturing combined with horizontal drilling allows for the increased production of oil and gas trapped within shale rock, once thought unattainable. However, this process also requires an increase in water used to produce those hydrocarbons. The water used to produce a well which flows back to the surface post-production, flowback water, and the water naturally occurring within a geologic formation, or produced water, are now significant byproducts of oil and gas production. The proper management of such water is not an option — it is a necessity.

The most popular form of produced water management is to dispose of the fluid through injection into disposal wells. These wells are governed by strict federal and state regulations. The Railroad Commission of Texas is the state authority with regulatory oversight of disposal and injection wells in Texas, with Statewide Rules 9 and 46 being the principal rules governing these wells. Although these rules were recently updated in 2014 in light of a series of seismic events, this paper puts forth even greater recommendations on potential amendments to SWR 9 and 46.

The proposed recommendations specifically revolve around the concept of bifurcating rules to create two different levels of well categorization — high-volume/high-pressure wells, and low-volume/low-pressure wells. In order to greater account for risk profiles of each well, all high-volume disposal wells (HVDWs) should be subject to heightened standards from a permitting and regulatory perspective.

For HVDWs, recommendations include expanding the area of review from 1/4 mile radius to 1/2 mile radius; increasing the permitting fees; and prohibiting the conversion of a producing well to a HVDW.

Additionally, the paper suggests increased beneficial reuse of produced water in lieu of disposing the fluid and removing it from the hydraulic cycle. Beneficial reuses of produced water include, but are not limited to: use in hydraulic fracturing fluid and other wellbore uses; mining; power generation, such as cooling ponds; irrigation of nonedible crops and large-scale watering operations; irrigation of consumable crops; and potentially even drinking water.

The specific quantities suggested in the recommendations are largely conceptual, intended begin a dialogue around implementing such thresholds. As with all regulations, much input should be received from industry and other stakeholders, and consultation with academia should occur to ensure a solid basis in science and fact before solidifying a new numerical standard in rule.

Contents

I. INTRODUCTION

The injection of fluid into subsurface geologic formations as a method of disposal is a practice that has existed for many decades, most notably commercialized by and associated with — although not exclusive to — the petroleum industry.

Injection can be used in the oilfield for multiple reasons. Fluid is often injected into underground formations in order to increase pressure and force remaining hydrocarbons within the geologic feature to the surface in older-producing fields. Injection can also be used to store certain hydrocarbons or natural resources, as well as dispose of produced or flowback water, which occurs during the production of an oil or gas well.

In most hydrocarbon-bearing formations, water is present in the rock along with the oil and/or gas. In certain formations, as hydrocarbons are brought to the surface during the production of a well, the naturally occurring water is also brought to the surface, known as produced water. Additionally, specifically in hydraulic fracturing operations, a portion of the fluid injected into the wellbore in order to fracture the rock will also return to the surface, which is referred to as flowback water. In most cases, this water is disposed of through method of injection.

The U.S. Environmental Protection Agency (EPA) governs all injection wells, defined as wells used to place fluid — including water, wastewater, brine (salt water), or water mixed with chemicals — underground into porous geologic formations, ranging from deep sandstone or limestone to a shallow soil layer.[1] The agency classifies injection wells into six categories, with Class II pertaining to oil and gas related injection.[2]

The EPA regulates disposal wells on the federal level, but certain regulatory enforcement responsibility, also known as primacy, can be granted to individual states, territories and/or tribal agencies through the EPA's Underground Injection Control (UIC) program.

The Railroad Commission of Texas (RRC) is the state agency with primary jurisdiction over oil and gas activities in Texas. The RRC was granted primacy over disposal and injection well regulations by the EPA in 1982, and administers the federally delegated authority through the Commission's Technical Permitting Section – Underground Injection Control (UIC) Program.[3]

The RRC further delineates injection from disposal wells:

> "**Disposal** wells may be used to inject mineralized water produced with oil and gas into underground zones for the purpose of safely and efficiently disposing of the fluid… **Injection** wells inject fluids into a reservoir for the purpose of enhanced oil recovery from the reservoir."[4] (emphasis added)

For the purposes of this paper, "disposal well" refers to Class II Disposal and will serve as the primary focus of the research, discussion and recommendations.

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1 "Underground Injection Control: General Information About Injection Wells," *U.S. Environmental Protection Agency*, accessed January 2, 2018, https://www.epa.gov/uic/general-information-about-injection-wells.

2 "UIC: General Information," *U.S. Environmental Protection Agency*.

3 "Oil & Gas FAQs: Injection and Disposal Wells," *Railroad Commission of Texas*, accessed January 1, 2018, http://www.rrc.state.tx.us/about-us/resource-center/faqs/oil-gas-faqs/faq-injection-and-disposal-wells/.

4 Ibid.

BACKGROUND

OIL PRODUCTION
NATURAL GAS PRODUCTION
HYDRAULIC FRACTURING
PRODUCED & FLOWBACK WATER
DISPOSAL TECHNIQUES FOR PRODUCED WATER

II. BACKGROUND

Oil Production

Texas is the number one producer of oil in the country, and has maintained a top ranking since it began production in the 1800s. The first producing oil well in Texas was drilled in Nacogdoches County in 1866,[5] and the historic gusher at Spindletop outside of Beaumont in 1901 put Texas petroleum on the map.[6]

Throughout the 20th century, Texas continued to stake its claim in the energy industry. Like the rest of the industry, however, Texas oil and gas producers are susceptible to the volatile commodities market and have experienced multiple "boom-and-bust" cycles.

Naturally, prices are largely driven by basic supply and demand principles. As such, oil production has correspondingly fluctuated over the past century based on economics, but also due to advancements in technology and drilling techniques.

From 1966 through 1978, Texas produced more than 1 billion bbls per year. In 1980, slightly over 930 million bbls were produced, and output gradually decreased during the next two decades to just under 646 million bbls by 1990, and had fallen to 399 million bbls by 2000.[7]

Output remained in the 300 million bbls range throughout the 2000s and didn't increase until the early 2010s, when it jumped up to 600 million bbls in 2012, shortly after the combination of hydraulic fracturing and horizontal drilling began to revolutionize the oil and gas industry.

By 2014, production had once again reached the 1 billion bbls mark for the first time since the 1970s, although an oversupply issue on the global market caused a precipitous drop in oil prices beginning in mid to late 2014. As a result, production growth slowed, but Texas still maintained an average of roughly 1 billion bbls in 2016 and 2017, and produced just over 1.1 billion bbls in 2018.[8]

Natural Gas Production

Like petroleum, Texas natural gas production and pricing have varied greatly over time. Commercial natural gas production began in Texas during the late 1930s, with Texas producing 575 million cubic feet (MCF) in 1936.[9] Production steadily rose throughout the next several decades, reaching 1 trillion cubic feet (TCF) by 1940; more than 2 TCF in 1945; 4 TCF by 1955; 6 TFC by 1965 and 7 TCF by 1970. Shortly after, however, output began to fall and remained between 4 and 5 TCF for most of the 1980s, 1990s and early 2000s.[10]

During the next decade, natural gas production experienced a slight comeback, as the widespread usage of hydraulic

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5 "History of the Railroad Commission 1866 – 1939: Chronological Listing of Key Events in the History of the Railroad Commission of Texas (1866-1939)," *Railroad Commission of Texas*, February 29, 2016, http://www.rrc.state.tx.us/about-us/history/history-1866-1939/.

6 Mary G. Ramos, "Oil and Texas: A Cultural History," *Texas State Historical Association*, accessed January 1, 2018, http://texasalmanac.com/topics/business/oil-and-texas-cultural-history.

7 "Crude Oil Production and Wells Counts (Since 1935): History of Texas Initial Crude Oil, Annual Production and Producing Wells," *Railroad Commission of Texas*, February 28, 2018, http://www.rrc.state.tx.us/oil-gas/research-and-statistics/production-data/historical-production-data/crude-oil-production-and-well-counts-since-1935/.

8 "Texas Monthly Oil & Gas Production," *Railroad Commission of Texas*, February 22, 2019, https://www.rrc.state.tx.us/oil-gas/research-and-statistics/production-data/texas-monthly-oil-gas-production/

9 "Natural Gas Production and Well Counts (since 1935): History of Texas Initial Natural Gas, Annual Production and Producing Wells," *Railroad Commission of Texas*, March 16, 2018, http://www.rrc.state.tx.us/oil-gas/research-and-statistics/production-data/historical-production-data/natural-gas-production-and-well-counts-since-1935/.

10 Ibid.

fracturing and horizontal drilling granted operators access to hydrocarbon reserves trapped deep within solid rock formations that were previously considered unattainable or had not yet been discovered. In 2009, natural gas output surpassed 6.8 TCF but fell again to approximately 5.7 TCF in 2016, just under 5.5 TCF in 2017, and down to roughly 5.03 TCF in 2018. [11]

Hydraulic Fracturing

In the 1990s, a new process was perfected by oilman George Mitchell, initially developed and employed in the gas-rich Barnett Shale in Northeast Texas, which combined two existing techniques – hydraulic fracturing and horizontal directional drilling. [12]

Hydraulic fracturing is a well stimulation treatment in which fluid is injected into a wellbore under high pressures in order to create small cracks or fissures in the underground rock formation, known as shale, releasing the hydrocarbons trapped inside.[14] The hydraulic fracturing fluid is composed of primarily water and sand, which together account for roughly 98 percent to 99.5 percent of the mixture, in addition to a small amount of chemical additives,[15] such as corrosion inhibitors, friction reducers, crosslinker, gellant and iron control formulas.[16]

The practice had previously been employed in Texas for more than 60 years, but gained commercial success when used in conjunction with horizontal directional drilling, as more surface area of a given geologic interval can be accessed and produced, thus increasing the amount of oil or natural gas produced from a single wellbore.

After achieving initial success in the Barnett Shale, the technique quickly gained widespread popularity in the industry. From 2005 to 2008, the estimated number of hydraulic fracturing jobs in Texas jumped from just over 2,500 to more than 6,600.[17] By 2010, data indicates that 13,000 wells were hydraulically fractured, equal to 85 percent of drilling permits issued that year by the Railroad Commission of Texas.[18] Some estimates project that nationwide, 60 to 80 percent of all wells drilled domestically from 2010 to 2020 will utilize hydraulic fracturing.[19]

With the increase in hydraulically fractured wells has been a corresponding increase in the amount of water used during oil and gas production operations. The RRC estimates the amount of water used in an average hydraulic fracturing job can range from 70,000 bbls for a vertical well to 90,000 bbls in a horizontal well[20], while the USGS reports median hydraulic fracturing water use at roughly 130,000 bbls for an oil well and 163,000 bbls for a gas well in 2014.[21]

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11 "Texas Monthly Oil & Gas Production," *Railroad Commission of Texas,* February 22, 2019, https://www.rrc.state.tx.us/oil-gas/research-and-statistics/production-data/texas-monthly-oil-gas-production/

12 Scott W. Tinker, "Current and Projected Water Use in the Texas Mining and Oil and Gas Industry," *Texas Water Development Board* (June 2011): 79, http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/0904830939_MiningWaterUse.pdf.

13 "What is fracking and why is it controversial," *BBC News,* October 15, 2018, http://www.bbc.com/news/uk-14432401.

14 "Oil & Gas FAQs: Hydraulic Fracturing," *Railroad Commission of Texas*, accessed January 1, 2018, http://www.rrc.state.tx.us/about-us/resource-center/faqs/oil-gas-faqs/faq-hydraulic-fracturing/.

15 "Hydraulic Fracturing: The Process," *FracFocus* (June 20, 2010), https://fracfocus.org/hydraulic-fracturing-how-it-works/hydraulic-fracturing-process.

16 "Chemical Use in Hydraulic Fracturing," *FracFocus,* accessed January 1, 2018, https://fracfocus.org/water-protection/drilling-usage.

17 Tinker, Scott W. "Current and Projected Water Use," 57.

18 Anthony B. Cavendar, "Texas Law Requires Disclosure of Hydraulic Fracturing Chemicals as of February 1, 2012," *Pillsbury Winthrop Shaw Pittman LLP* (December 21, 2011), https://www.pillsburylaw.com/en/news-and-insights/texas-law-requires-disclosure-of-hydraulic-fracturing-chemicals.html.

19 "Hydraulic Fracturing: The Process," *FracFocus.*

20 "Oil & Gas FAQs: Water Use in Association with Oil and Gas Activities," *Railroad Commission of Texas,* accessed January 1, 2018, http://www.rrc.state.tx.us/about-us/resource-center/faqs/oil-gas-faqs/faq-water-use-in-association-with-oil-and-gas-activities/.

21 Dittrick, Paula, "Water constraints drive recycle, reuse technology" *Oil and Gas Journal*, August 7, 2017. https://www.ogj.com/articles/print/volume-115/issue-8/drilling-production/water-constraints-drive-recycle-reuse-technology.html

The amount necessary to hydraulically fracturing a well varies greatly from well to well, and within each unique formation. In the Wolfcamp Shale in West Texas, for example, one operator reports using upwards of 340,000 bbls of water per well.[22]

According to the Texas Water Development Board, overall oil and gas water use, included in the "mining" category, represented less than one percent of statewide water uses in 2016, [23] and water use specifically for hydraulic fracturing is expected to account for less than one percent of statewide water use from 2020 to 2070.[24]

60 TO 80 PERCENT OF ALL WELLS DRILLED DOMESTICALLY FROM 2010 TO 2020 WILL UTILIZE HYDRAULIC FRACTURING

Produced and Flowback Water

During the process of extracting hydrocarbons from a formation, two extraneous fluids are generally produced alongside the oil or gas – produced water and flowback water.

As previously discussed, during the hydraulic fracturing process large amounts of fluid containing water, proppant and other chemicals are injected at high pressures down a wellbore in order to create fractures in the rock and release the oil and/or gas. Following this process, some of the hydraulic fracturing fluid injected flows back up to the surface. This fluid is referred to as flowback water.[25]

Produced water, also known as "brine" or "saltwater," is water brought to the surface with the oil and gas as it is being produced, and can either be naturally occurring within the rock formation or have been previously injected as part of an enhanced recovery project, such as water flooding.[26]

Characteristics of flowback and produced water obviously depend largely on the chemical compounds used in the hydraulic fracturing fluid and the properties found within each unique rock formation; however, in general it contains: salt; oil and grease; inorganic and organic toxic compounds introduced as chemical additives in the fracturing fluid; and naturally occurring radioactive material (NORM).[27]

In wells that have undergone hydraulic fracturing, the majority of water initially returning to the surface is flowback, and over time the remaining fluid return is primarily produced water. In most shale oil and gas wells, the initial flowback rate is high but the volume typically diminishes over time.[28] In conventional oil and gas wells, the initial volume of produced water generated is low

22 Jackie Benton, "Recycling Fracking Water: Drillers Reuse, Repeat," *Fiscal Notes - Texas Comptroller of Public Accounts,* October 2015: 11, https://comptroller.texas.gov/economy/fiscal-notes/2015/october/fracking.php.

23 "Texas Water Use Estimates," *Texas Water Development Board,* Updated February 19, 2019, https://www.twdb.texas.gov/waterplanning/wateruse-survey/estimates/data/2016TexasWaterUseEstimatesSummary.pdf?d=12286.100000012084

24 "2017 State Water Plan – Water for Texas," *Texas Water Development Board*, Updated February 2019, https://www.twdb.texas.gov/waterplanning/swp/2017/doc/SWP17-Water-for-Texas.pdf

25 John. Veil, "U.S. Produced Water Volumes and Management Practices in 2012," *Groundwater Protection Council* (April 2015): 7, http://www.gwpc.org/sites/default/files/Producedpercent20Waterpercent20Reportpercent202014-GWPC_0.pdf.

26 Ibid, 12.

27 Ibid, 17.

28 Ibid, 15.

and increases over time, with a high lifespan of producing water.[29]

The water-to-oil return ratio varies significantly between formations with differing geologic characteristics and compositions. For example, in the Permian Basin, it is reported that more than 6.5 bbls of water are produced per every one bbl of oil, whereas the ratio in the Eagle Ford Shale is closer to 0.9 bbl of water per one bbl of oil.[30]

Nationwide, the total amount of produced water from oil and gas operations in 2012 is estimated to be about 21.2 billion bbls, with onshore production accounting for just under 20.56 billion bbls.[31] That year, Texas produced 7.4 billion bbls, or 35 percent of the national total.[32] More recent estimates, however, suggest that closer to 24 million bbls of water were produced from oil and gas operations nationwide in 2017, with Texas accounting for a third of water production.[33]

Disposal Techniques for Produced Water

There are three basic options for disposing of the produced water once it has been treated and separated out from the hydrocarbons: recycling/reuse; discharge; and disposal by injection.

RECYCLE/REUSE

Recycling and reusing produced water in oilfield operations has become increasingly widespread within the last decade, most likely in response to the increased water usage for hydraulic fracturing operations and heightened public scrutiny over such increased usage.

In 2013, the Railroad Commission of Texas amended rules governing produced water recycling and beneficial reuse to encourage water conservation and eliminate existing regulatory barriers to advancements in the field. For example, a permit is no longer required to reuse treated fluid in the same wellbore.

There is no standard for officially reporting or quantifying the exact amount of produced and flowback water reused or recycled currently, and discrepancies exist between various estimates, but one report notes the RRC estimated that in 2012, approximately 15 percent to 20 percent of Texas flowback water was reused.[34]

DISCHARGE

Discharge of oil and gas waste into surface waters is highly regulated and generally rare. Both a federal and a state permit are necessary for discharge.[35]

The Clean Water Act (CWA) requires the EPA to regulate point sources that discharge pollutants into surface waters — including streams, rivers, lakes, bays and oceans — in an effort to address water pollution.[36] In 1972, the National Pollutant Discharge Elimination System (NPDES) permit program was created by the CWA, under which two types of permits are issued: an individual permit, which is unique to individual facilities, and a general permit, which includes a group of dischargers or multiple facilities in a single

29 Ibid.

30 Tsvetana Paraskova, "U.S. Shale: Water is the New Oil," *OilPrice.com,* September 21, 2017, https://oilprice.com/Energy/Crude-Oil/US-Shale-Water-Is-the-New-Oil.html.

31 John Veil, "U.S. Produced Water Volumes and Management Practices," 8.

32 Ibid.

33 Benjamin Reed, "Predicting the Future: Why the Upstream Water Management Industry Needs a Water Marketplace", *SourceWater*, February 25, 2017, https://www.sourcewater.com/water-marketplace/

34 John Veil, "U.S. Produced Water Volumes and Management Practices," 99.

35 "Applications and Permits: Discharges," *Railroad Commission of Texas*, May 18 2016, http://www.rrc.state.tx.us/oil-gas/applications-and-permits/environmental-permit-types-information/discharges/.

36 "Summary of the Clean Water Act," *U.S. Environmental Protection Agency*, accessed January 1, 2018, https://www.epa.gov/laws-regulations/summary-clean-water-act.

location.[37] Texas was granted the authority to implement the NPDES program, although EPA retains oversight responsibilities and the ability to review permits. [38]

On the state level, according to the Railroad Commission of Texas website:

> Section 26.131(b) of the Texas Water Code prohibits the Railroad Commission from issuing a permit for a discharge that will cause a violation of the Surface Water Quality Standards adopted by the Texas Commission on Environmental Quality (TCEQ). The federal Clean Water Act requires the TCEQ to revise these standards at least once every three years. These standards include numerical criteria for 35 toxic pollutants. The 35 toxic pollutants consist almost entirely of herbicides, pesticides, and metals. The metals are of prime importance in oil and gas discharges, as water produced from oil and gas formations may contain trace amounts of various metals. An applicant for a discharge permit may be required to submit information to demonstrate that the proposed discharge will not cause a violation of the standards. Although the Commission has the jurisdiction to regulate the disposal of all oil and gas wastes, very few such wastes are discharged to surface water in the state.[39]

The Commission identifies three types of discharge over which it has jurisdiction: discharge of hydrostatic test water; gas plant discharge; and produced water.[40] No general application form is available for produced water discharge; an applicant must submit a written request for a permit application. In general, discharge into "bays, estuaries and tidal areas with the exception of the Gulf of Mexico," is prohibited.[41]

INJECTION

Injection into a subsurface disposal well is the most common form of produced water management employed in Texas — in 2012, an estimated 37 percent of all produced water in Texas was injected into a non-commercial disposal well, roughly 2.9 billion bbls; and another 10 percent of all produced water that year, or 795 million bbls, was injected into an offsite commercial disposal well.[42]

Nationwide in 2012, 38.9 percent of produced water was injected into non-commercial disposal wells, and almost 7 percent was injected offsite at a commercial disposal facility or sold to a third party for commercial disposal.[43]

According to the Railroad Commission of Texas, there are more than 8,000 active disposal wells in Texas as of July 2015.[44] Nationally, EPA estimates there are 180,000 Class II injection and disposal wells, with disposal wells accounting for 20 percent, or 36,000, of total Class II wells.[45] These wells are governed by strict regulations at both the state and federal levels.

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37 "National Pollutant Discharge System (NPDES): About NPDES," *U.S. Environmental Protection Agency*, accessed January 1, 2018, https://www.epa.gov/npdes/about-npdes.

38 John Veil, et al. "A White Paper Describing Produced Water from Production of Crude Oil, Natural Gas, and Boal Bed Methane," *Prepared for the U.S. Department of Energy*, (January 2004): 25. https://publications.anl.gov/anlpubs/2004/02/49109.pdf.

39 "Applications and Permits: Discharges," *Railroad Commission of Texas.*

40 Ibid.

41 Ibid.

42 John Veil, "U.S. Produced Water Volumes and Management Practices," 100.

43 Ibid, 45.

44 "Oil & Gas FAQs: Injection and Disposal Wells," *Railroad Commission of Texas.*

45 "Underground Injection Control: Class II Oil and Gas Related Injection Wells," *U.S. Environmental Protection Agency*, accessed January 2, 2018, https://www.epa.gov/uic/class-ii-oil-and-gas-related-injection-wells.

REGULATIONS

FEDERAL REGUALTIONS
TEXAS REGULATIONS

III. REGULATIONS

Federal Regulations

The Environmental Protection Agency has primary enforcement authority over all injection wells, which are categorized into six classes:

- Class I – Industrial and municipal waste disposal wells
- Class II – Oil and gas-related injection wells
- Class III – Solution mining wells
- Class IV – Shallow hazardous and radioactive waste injection wells
- Class V – Wells that inject non-hazardous fluids into or above underground sources of drinking water
- Class VI – Geologic sequestration wells.[46]

Class II wells are further divided into three categories:

- Disposal wells
- Enhanced oil recovery wells
- Hydrocarbon storage wells[47]

In 1974, Congress passed the Safe Drinking Water Act (SDWA), which directed EPA to implement a set of requirements for injection wells in order to protect underground sources of drinking water (USDW), which became known as the Underground Injection Control (UIC) program.[48] States have the opportunity to request primacy over injection wells within their jurisdiction under Section 1422 or Section 1425 of the SDWA.[49]

General requirements in Section 1422 and 1425 govern areas such as: construction, operation, monitoring and testing, reporting, closure requirements, permitting, inspections, and record-keeping.

The following charts include relevant federal regulation sections and a brief description of what is addressed. [50]

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46 "Underground Injection Control: Underground Injection Control Well Classes," *U.S. Environmental Protection Agency,* accessed January 2, 2018, https://www.epa.gov/uic/underground-injection-control-well-classes.

47 "Underground Injection Control: Class II Oil and Gas Related Injection Wells" *U.S. Environmental Protection Agency*, accessed January 2, 2018, https://www.epa.gov/uic/class-ii-oil-and-gas-related-injection-wells.

48 Rick McCurdy, "Underground Injection Wells for Produced Water Disposal," *U.S. Environmental Protection Agency:* 1, accessed January 2, 2018, https://www.epa.gov/sites/production/files/documents/21_McCurdy_-_UIC_Disposal_508.pdf.

49 "UIC: Class II Wells," *U.S. Environmental Protection Agency.*

50 "Underground Injection Control: Underground Injection Control Regulations and Safe Drinking Water Act Provisions," *U.S. Environmental Protection Agency*, accessed January 2, 2018, https://www.epa.gov/uic/underground-injection-control-regulations-and-safe-drinking-water-act-provisions.

Federal UIC Regulations

PART 144 Underground Injection Control Program – provides minimum requirements for the UIC program promulgated under the SDWA.

PART 145 State UIC Program Requirements – outlines the procedures for EPA to approve, revise, and withdraw UIC Programs that have been delegated to the states.

PART 146 Underground Injection Control Program: Criteria and Standards - Includes technical standards for various classes of injection wells.

PART 147 State Underground Injection Control Programs – outlines the applicable UIC Programs for each state.

PART 148 Hazardous Waste Injection Restrictions – describes the requirements for Class I hazardous waste injection wells.

Sections of Safe Water Drinking Act that Address UIC

1421 Identifies the minimum requirements states must meet to be granted primary enforcement authority (primacy) for the UIC Program. This section also adresses how underground injection can endanger USDWs.

1422 Outlines the process for state primacy applications. This section provides application timelines and public participation requirements for states seeking primacy. If a state does not assume primacy, EPA runs the UIC program in that state. This section also specifies how tribes may apply for primacy.

1423 Sets forth enforcement of the UIC program. This section describes civil and criminal actions, including the amount of penalty levied.

1425 Sets forth enforcement of the UIC program. This section describes civil and criminal actions, including the amount of penalty levied. Describes optional demonstrations a state may make for the portion of the UIC program relating to oil and natural gas operations. This section allows EPA to approve existing state Class II (oil and gas) programs if the state can show that the program is effective in preventing endangerment of USDWs.

1426 Requires the EPA Administration to determine the applicability of monitoring methods and to submit a report to Congress on Class V wells. The Report to Congresss includes information on Class V well inventory, well types, design and construction recommendations, and risks associated with discharged wastes.

1431 Authorizes emergency powers for EPA. Under this section, EPA may take action to protect public health if substantial endangerment of USDWs is imminent.

1442 Gives EPA authority to conduct research, studies, training, and demonstrations. This section addresses ways to identify improved methods for protecting USDWs.

1443 Establishes grants for primacy programs. Each year, states receive EPA funding under this section to help them implement their UIC programs.

Texas Regulations

Texas was granted primacy over oil and gas injection wells in 1982, and administers the UIC program through the RRC's Technical Permitting Section.

Under the UIC program, Class II disposal wells in Texas are regulated in Title 16 of the Texas Administrative Code (TAC) by the following statewide rules:

1. Statewide Rule 9 (§3.9): Disposal Wells
2. Statewide Rule 46 (§3.46): Fluid Injection into Productive Reservoirs
3. Statewide Rule 81 (§3.81): Brine Mining Injection Wells
4. Statewide Rule 95 (§3.95): Underground Storage of Liquid or Liquefied Hydrocarbons in Salt Formations
5. Statewide Rule 96 (§3.96): Underground Storage of Gas in Productive or Depleted Reservoirs
6. Statewide Rule 97 (§3.97): Underground Storage of Gas in Salt Formations
7. Statewide Rule 13 (§3.13): Casing, Cementing, Drilling, and Completion Requirements[51]

Statewide Rules (SWR) 9 and 46 are the primary regulations referenced in discussion on disposal wells rules. SWR 9 governs disposal of "saltwater or other oil and gas waste by injection into a porous formation not productive of oil, gas, or geothermal resources."[52] while SWR 46 governs "fluid injection operations in reservoirs productive of oil, gas, or geothermal resources."[53]

The rules include, but are not limited to, the following requirements summarized from SWR 9 and 46: [54]

LETTER FROM GROUNDWATER ADVISORY UNIT - RRC OIL AND GAS DIVISION 3.9(2)

For a permit to dispose of waste by injection into a nonproductive formation, the applicant must prove that "the formations are separated from freshwater formations by impervious beds which will give adequate protection to such freshwater formations" by submitting a certified letter from the RRC's Groundwater Advisory Unit confirming the well will not endanger freshwater.

PERMIT APPLICATION 3.9(3) & 3.46(b)(1)

Along with a permit application, an applicant must also submit documentation, such as a printed copy or screenshot, of the results of a search on the United States Geologic Survey (USGS) website containing locations of historic seismic activity within a circular area of 100 square miles – a circle with a radius of 9.08 kilometers (km) — centered around the proposed disposal well location.

The Commission may also require additional information such as logs, geologic cross-sections, pressure front boundary calculations, and/or structure maps to ensure that fluid will be confined to its injection interval.

COMMERCIAL DISPOSAL WELLS 3.9(4), 3.9(5)(B) & 3.46(b)(2), 3.46(c)(2)

This section defines commercial disposal well as "a well whose owner or operator receives compensation from others for the disposal of oilfield fluids or oil and gas wastes that are wholly or partially trucked or hauled to the well, and the primary business purpose for the well is to provide these services for compensation." An applicant for a commercial disposal well must clearly indicate such on the application and in the published public notice of application. Furthermore, applicants must give notice to affected parties, as dictated in 3.9(a)(5) & 3.46(c), plus

51 "Injection/Disposal Well Permitting, Testing, and Monitoring Manual," *Railroad Commission of Texas* (June 21, 2015), http://www.rrc.state.tx.us/oil-gas/publications-and-notices/manuals/injectiondisposal-well-manual/.

52 Texas Administrative Code, Title 16: Economic Regulations, Part 1: Railroad Commission of Texas, Chapter 3: Oil and Gas Division, Section 9: Disposal Wells, *eLaws*, 2019, http://txrules.elaws.us/rule/title16_chapter3_sec.3.9.

53 Texas Administrative Code, Title 16: Economic Regulations, Part 1: Railroad Commission of Texas, Chapter 3: Oil and Gas Division, Section 46: Fluid Injection into Productive Reservoirs, *eLaws*, 2019, http://txrules.elaws.us/rule/title16_chapter3_sec.3.46.

54 Texas Administrative Code, Title 16: Economic Regulations, Part 1: Railroad Commission of Texas, Chapter 3: Oil and Gas Division, *eLaws*, 2019, http://txrules.elaws.us/rule/title16_chapter3.

owners of record of each surface tract that adjoins the proposed disposal or injection tract.

NOTICE OF APPLICATION 3.9(5) & 3.46(c)

An applicant must provide a copy of the application to affected persons, which include: the owner of the surface tract; each operator within one-half mile of the proposed well; the county clerk; and the city clerk if located within municipal boundaries. Notice of the application must also be published in the appropriate county's newspaper or approved circulation.

PROTESTED APPLICATIONS 3.9(5)(E) & 3.46(c)(5)

An affected party has 15 days to protest. This provision defines an affected person to be "a person who has suffered or will suffer actual injury or economic damage other than as a member of the general public or as a competitor, and includes surface owners of property on which the well is located and Commission-designated operators of wells located within one-half mile of the proposed disposal well."

PERMIT APPROVAL 3.9(5)(F) & 3.46(c)(6)

If no affected parties protest, the permit may be administratively approved. If denied administrative approval, the applicant can request a hearing, after which the examiner makes a recommendation for final action to the Commissioners.

PERMIT MODIFICATION, SUSPENSION OR TERMINATION BY COMMISSION 3.9(6) & 3.46(d)

The RRC can modify, suspend or terminate a permit with just cause and an opportunity for a hearing in the instance of: a material change in the conditions or information originally provided; potential water pollution; substantial violations of the permit; misrepresentation of material facts during the permitting process; fluids escaping the disposal zone; injection contributing to seismic activity; and/or waste of resources due to injection.

AREA OF REVIEW 3.9(7) & 3.46(e)

The applicant must review data for all wells that penetrate the proposed disposal zone within a $^1/_4$ mile radius of the proposed disposal well, and identify any wells that appear unplugged or improperly plugged, to avoid movement of fluids from the disposal zone into freshwater strata.

A variance from the area of review may be granted upon proof that it will not increase the risk of fluid migration into freshwater strata or to the surface. Further requirements are set forth.

AREA PERMIT 3.46(k)

An applicant for injection into a producing formation may apply for an area permit to cover injection into new or converted wells within a permit area. Once the area permit is approved, the operator may apply to inject into individual wells. The application for an area permit must include: an application for at least one injection well; the maximum number of injection wells that will be operating in the area; the depth(s) of usable quality water, as dictated by the Groundwater Advisory Unit; the type of fluid to be injected in any well within the area; the depths from the top to bottom of the injection interval; the maximum surface injection pressure for any well within the area; the maximum amount of fluid to be injected daily in each well, as well as the maximum cumulative amount of fluid to be injected daily in the permit area. The applicant must also provide a wellbore diagram(s) showing the type(s) of completion(s) that will be used for newly drilled injection wells, which include casing and liner sizes and depths, as well as a statement indicating that such wells will be cemented in accordance with the cementing requirements of Statewide Rule 13: Casing, Cementing, Drilling, and Completion Requirements.

The area of review for an area permit includes review of the entire permit area and the area $^1/_4$ mile beyond the outer boundary of the area for wells that may have been improperly plugged or left unplugged. The applicant must include the date of plugging for each abandoned well identified within the area. A map showing the location of each existing well that may be converted into an injection well and the location of each well the applicant intends to drill must be provided.

For existing wells in the permit area that will be converted into injection wells, a diagram must be provided which indicates the casing and liner sizes and depths, packer setting depth, types and volumes of cement, and the cement tops for the well.

An applicant must give notice as prescribed above for the area permit, but does not need to provide notice for each individual well drilled within the permit area; however, the operator does still need to file an application for each well to be drilled.

CASING 3.9(8) & 3.46(f)

Disposal or injection wells are subject to compliance with Statewide Rule 13: Casing, Cementing, Drilling and Completion Requirements.

SPECIAL EQUIPMENT 3.9(9) & 3.46(g)

For injection into nonproductive formations, wells must have tubing set on a mechanical packer, no higher than 100 feet above the top of the permitted interval, and a pressure observation valve on the tubing as well as each annulus of the well.

For injection into producing formations, wells must have tubing set on a mechanical packer no higher than 200 feet below the known top of cement behind the long string casing and at least 150 feet below the base of usable quality water, and a pressure observation valve on the tubing as well as on each annulus of the well.

WELL RECORD 3.9(10) & 3.46(h)

An operator must file the appropriate completion form within 30 days of completing or converting a disposal or injection well.

MONITORING AND REPORTING 3.9(11) & 3.46(i)

Operators must monitor the injection pressure and injection rate of each well at least once a month and report the results annually to the Commission. The operator must keep these records for at least five years, and is required to report any significant pressure changes or other data indicating leaks within 24 hours to the appropriate RRC District Office.

TESTING 3.9(12) & 3.46(j)

A disposal or injection well completed with surface casing set and cemented through the entire interval of protected usable quality water must be tested for mechanical integrity at least once every five years and after every workover of the well. A disposal or injection well without surface casing set and cemented through the entire interval of protected usable quality groundwater must be tested at the frequency dictated by the permit.

Pressure Tests: For wells that dispose or inject through tubing and packer, the test pressure must equal the maximum authorized injection pressure or 500 pounds per square inch (psi), whichever is less, but at least 200 psi. For wells that dispose or inject through casing, the test pressure must equal the maximum permitted injection pressure or 200 psi, whichever is greater. The test pressure must stabilize within 10 percent of the required test pressure before starting the test, and a pressure differential of at least 200 pounds per square inch gauge (psig) must be maintained between the test pressure on the tubing-casing annulus and the tubing pressure. It must last for 30 minutes for liquid or 60 minutes for air or gas. A pressure recorder must be used.

The tubing-casing annulus fluid used in a pressure test must be fluid for wells that inject fluid and cannot contain additives that may reduce the effectiveness of the test. As an alternative, the tubing-casing annulus pressure may be monitored and included on the annual monitoring report if authorized by the Commission.

PLUGGING 3.9(13) & 3.46(m)

Disposal wells must be plugged when operations are completed according to SWR 14: Plugging.

PENALTIES 3.9(14) & 3.46(n)

The Commission has the authority to sever, or revoke, an operator's ability to sell their product, and thus do business, in the Texas oil and gas industry upon violations.

Please refer to the 16 Texas Administrative Code Chapter 3 for complete text. For an itemized checklist of requirements used in the Railroad Commission's technical review of a disposal permit, please view the Technical Review Section of the RRC's Injection/Disposal Well Manual.

Although not specified in rule, within the RRC's Injection/Disposal Well Manual are further requirements for commercial facilities, excerpt below:

- Prior to beginning operation, all collecting pits, skimming pits, or washout pits must be permitted under the requirements of Statewide Rule 8.
- Prior to beginning operation, a catch basin constructed of concrete, steel, or fiberglass must be installed to catch oil and gas waste which may spill as a result of connecting and disconnecting hoses or other apparatus while transferring oil and gas waste from tank trucks to the disposal facility.
- Prior to beginning operation, all fabricated waste storage and pretreatment facilities (tanks, separators, or flow lines) shall be constructed of steel, concrete, fiberglass, or other materials approved by the Assistant Director of Technical Permitting. These facilities must be maintained so as to prevent discharges of oil and gas waste.
- Prior to beginning operation, dikes shall be placed around all waste storage, pretreatment, or disposal facilities. The dikes shall be designed so as to be able to contain a volume equal to the maximum holding capacity of all such facilities. Any liquids or wastes that do accumulate in the containment area shall be removed within 24 hours and disposed of in an authorized disposal facility.
- Prior to beginning operation, the facility shall have security to prevent unauthorized access. Access shall be secured by a 24-hour attendant, a fence and locked gate when unattended, or a key-controlled access system. For a facility without a 24-hour attendant, fencing shall be required unless terrain or vegetation prevents truck access except through entrances with lockable gates.
- Prior to beginning operation, each storage tank shall be equipped with a device (visual gauge or alarm) to alert drivers when each tank is within 130 bbls from being full.
- If the facility will have staff on-site for periods of time necessitating bathroom accommodations, these accommodations must be designed, installed, and maintained by a person licensed to do so and the accommodations must comply with all applicable local, county, and State health regulations.[55]

To apply for an injection permit, an applicant must submit Forms H-1 and H-1A for injection into a producing reservoir, or Form W-14 for injection into a nonproductive formation. The fee for each disposal well permit under SWR 9 is $250, or $500 for a permit for injection under SWR 46. There is an additional fee of $375 for each exception request, and fees are nonrefundable.[56]

By 2014, the Railroad Commission had permitted more than 100,000 Class II wells throughout its history, with approximately 60,000 of those permits currently active and more than 30,000 active wells.[57] As of June 2015, Texas had roughly 34,200 active disposal and injection wells, of which 8,100 were disposal wells.[58]

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55 "Injection/Disposal Well Permitting, Testing, and Monitoring Manual: Technical Review," *Railroad Commission of Texas*, March 23, 2016, http://www.rrc.state.tx.us/oil-gas/publications-and-notices/manuals/injectiondisposal-well-manual/summary-of-standards-and-procedures/technical-review/.

56 "Oil & Gas Fee Payments and Surcharges," *Railroad Commission of Texas*, November 20, 2017, https://www.rrc.state.tx.us/oil-gas/applications-and-permits/fees-surcharges/

57 "Manual for Permitting Process Guidance Manual for Permitting Class I and Class II Wells for the Injection and Disposal of Desalination Concentrate," *Texas Water Development Board*, May 6, 2014, : 12, http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/1004831106_injectionwells.pdf

58 "Oil & Gas FAQs: Injection and Disposal Wells," *Railroad Commission of Texas.*

ISSUES AND CHALLENGES

SEISMICITY
POTENTIAL CONTAMINATION
COST

IV. ISSUES/CHALLENGES WITH DISPOSAL

Seismicity

One of the most prominent concerns regarding disposal by injection is the potential connection between disposal wells and seismic activity. Beginning in late 2008, a string of earthquakes occurred in North Texas, several of which were recorded in the vicinity of injection wells.[59] In more recent years, West Texas has also experienced an uptick in seismic events, although many of which were not large enough to feel.[60]

Since 2008, the rate of seismic occurrences with magnitudes greater than three has increased from approximately two events per year to 12 events per year.[61] From 1975 to 2016, there were 162 earthquakes recorded in Texas with magnitudes of three or greater — 94 of which, or 58 percent, occurred since 2008.[62]

Several studies have reported an association between fluid injection and seismicity. Indicators include seismicity in an area without historic seismic activity; earthquakes with epicenters near an injection well, specifically high-volume injection and near known subsurface faults; and hypocenters with focal depths at or greater than the depth of injection.[63]

A recent University of Texas study compares seismicity and subsurface disposal in the Bakken Shale, Eagle Ford Shale, Permian and in Oklahoma, noting that produced water injection volumes in the plays have doubled since 2009. The report states that "the shift in [produced water] disposal to nonproducing geologic zones related to low-permeability unconventional reservoirs is a fundamental driver of induced seismicity."[64]

In light of these seismic events, in 2014 the Railroad Commission of Texas amended the rules governing injection and disposal, which now include the requirement to search the USGS database for historic seismic activity in the area of a proposed injection well. Additionally, the RRC hired an in-house seismologist to coordinate with outside researchers and academia.[65]

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59 Frohlich, Cliff, et al. "A Historical Review of Induced Earthquakes in Texas," *Seismological Research Letters, 87, no. 4,* 2016: 1. http://www.jakewalter.net/papers/Frohlichetal2016.pdf.

60 "Earthquake monitoring is important to the Permian Basin," *Scott Tinker Bureau of Economic Geology*, February 25, 2019, lhttps://www.mrt.com/opinion/article/Earthquake-monitoring-is-important-to-the-Permian-13642680.php

61 Frohlich, Cliff, et al. "A Historical Review of Induced Earthquakes in Texas," *Seismological Research Letters, 87, no. 4,* 2016: 1. http://www.jakewalter.net/papers/Frohlichetal2016.pdf.

62 Ibid.

63 Ibid, 13.

64 Scanlon , Bridget R., et al. "Managing Basin-Scale Fluid Budgets to Reduce Injection-Induced Seismicity from the Recent U.S. Shale Oil Revolution," *Seismological Research Letters*, 2018, 90 (1): 171-182. https://doi.org/10.1785/0220180223

65 "Oil & Gas FAQs: Injection and Disposal Wells," *Railroad Commission of Texas*.

Potential Contamination

Another concern is the potential for fluid migration, spills and/or leaks — ultimately contaminating the water supplies and polluting soil.

Although the Railroad Commission's well integrity standards are among the most stringent in the country, there is always the potential for human error. For example, if an abandoned well is within the area of review for an injection well and is not properly plugged nor identified by the new disposal well operator, there is the potential for fluids to migrate.[66]

According to one analysis of EPA records, between 2008 and 2010, 70 percent of disposal wells in Texas had at least one violation, and more than 4,000 had test failures, indicating potential leaks;[67] however, violations can be issued for other less serious disruptions, and do not always imply leak or failure.

Cost

Another challenge with disposing produced water by injection is the cost. For on-lease disposal, the average cost is typically less than $0.25/bbl of fluid disposed. For commercial disposal, the average cost can vary from $0.50/bbl to $2.50/bbl.[68] However, the cost of transporting the fluid can add, on average, another $1.00/bbl/hour of transportation time to the overall cost.[69] Given that as many as 7.5 bbls of water can be produced for every one bbl of crude oil, and on average 260 bbls of water are produced for every one mcf of gas — transportation and disposal costs can quickly rise depending on the amount of production per well.[70]

It is estimated that the oil and gas industry spent nearly $6.4 billion on water management in 2014, including water supply, storage, transport, treatment and disposal. More than $4.2 billion of that overall cost, or 66 percent, was dedicated to transportation and disposal.[71]

The specific costs of disposal and transportation can vary greatly by area and is generally based on supply and demand; however, these costs can account for some of the largest expenses incurred when producing a well.

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66 Jill E. Johnston, Emily Werder, and Daniel Sebastian. "Wastewater Disposal Wells, Fracking, and Environmental Injustice in Southern Texas," *American Journal of Public Health, 106, no. 3,* 2016: 550–556. doi: 10.2105/AJPH.2015.303000.

67 Ibid.

68 Rick McCurdy, "Underground Injection Wells for Produced Water Disposal," *U.S. Environmental Protection Agency:* 4, accessed January 2, 2018, https://www.epa.gov/sites/production/files/documents/21_McCurdy_-_UIC_Disposal_508.pdf.

69 Ibid.

70 John Kemp, "Water is the biggest output of U.S. oil and gas wells: Kemp," *Reuters*, November 18, 2014, https://www.reuters.com/article/us-usa-shale-water-kemp/water-is-the-biggest-output-of-u-s-oil-and-gas-wells-kemp-idUSKCN0J223P20141118.

71 Jackie Benton, "Recycling Fracking Water: Drillers Reuse, Repeat," *Fiscal Notes - Texas Comptroller of Public Accounts,* October 2015: 11, https://comptroller.texas.gov/economy/fiscal-notes/2015/october/fracking.php.

IMPORTANCE OF DISPOSAL WELLS

WATER PRODUCTION INTERTWINED WITH OIL & GAS

ECONOMIC AND SOCIETAL BENEFITS OF OIL & GAS PRODUCTION

INCREASED DATA AND UNDERSTANDING OF SEISMICITY

IV. IMPORTANCE OF DISPOSAL WELLS

Water Production Intertwined with Oil & Gas Production

Produced and flowback water is an inevitable byproduct of oil and gas production, and thus, despite certain challenges, its proper management is not an option — it is a necessity.

While other options for managing produced water do exist — and many are gaining commercial viability as the technology advances and as industry shifts greater emphasis onto beneficial reuse and recycling initiatives — disposal wells are currently the most utilized management technique.[72]

Disposal wells, more often than not, present the most economical choice, in addition to being a safe, widely-accepted and well-regulated practice. Injection for the purposes of fluid waste disposal has been employed in the oilfield since the 1930s, and since the beginning of the EPA's UIC program, more than 33 trillion gallons of oilfield fluid have been injected without endangering underground sources of drinking water.[73]

Economic and Societal Benefits of Oil & Gas Production

As referenced above, produced water is an inevitable byproduct of oil and gas production, the importance of which on our economy and society cannot be overstated. On a daily basis, oil and natural gas make possible the lives and modern-day conveniences we enjoy. Petroleum is a component in everyday products used in transportation, heating and electric generation, in addition to being used as feedstock for plastics, chemicals and synthetic materials.[74] Natural gas is also used in various sectors for heating, generating electricity, transportation and as feedstock for plastics.[75]

Countless products are derived from petrochemicals, such as fertilizers, pesticides, pharmaceuticals, cleaning products, rubber, clothing, electronic equipment, furniture and more.[76] Furthermore, the oil and gas industry is a major contributor to our economy. In Texas alone, the industry paid more than $14 billion in state and local taxes, as well as state royalties in fiscal year 2018;[77] and provided upwards of 225,000 jobs last year.[78]

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72 "Fact Sheet – Underground Injection for Disposal," *U.S. Department of Energy,* accessed February 12, 2018, https://www.netl.doe.gov/research/coal/crosscutting/pwmis/tech-desc/injectdisp.

73 Rick McCurdy, "Underground Injection Wells for Produced Water Disposal," 1.

74 "What are petroleum products, and what is petroleum used for?" *US Energy Information Administration*, Updated April 6, 2018, https://www.eia.gov/tools/faqs/faq.php?id=41&t=6

75 Ibid.

76 "Petrochemical Facts," *American Fuel & Petrochemical Manufacturers,* Accessed March 2019, https://www.afpm.org/petrochemical-facts/

77 "Texas Oil and Natural Gas Industry Paid More than $14 Billion in Taxes and Royalties in 2018, Up 27% from 2017", *Texas Oil and Gas Association*, https://www.txoga.org/texas-oil-and-natural-gas-industry-paid-more-than-14-billion-in-taxes-and-royalties-in-2018-up-27-from-2017/

78 Ingram, Karr, "Texas Petro Index", *Texas Alliance of Energy Producers*, February 19, 2019, https://www.texasalliance.org/texas-petro-index

Increased Data & Understanding of Seismicity

In 2015, the 84th Texas Legislature created the TexNet program, approving $4.47 million to construct, monitor and maintain a statewide array of seismometers to better study, understand and eventually predict these geologic occurrences.[79] The Texas Bureau of Economic Geology (BEG) is responsible for the TexNet system, which entails permanent monitors strategically placed statewide and portable stations to be dispensed to areas with recent activity. In total, our state's network now contains 160 monitoring stations, including those managed by partner institutions.[80]

The BEG also manages the Center for Integrated Seismicity Research (CISR), a multidisciplinary, collaborative research center which seeks to better understand seismicity, specifically seismology, geologic characterization, reservoir modeling, seismic hazard and risk assessment, and seismic risk social science.[81] The TexNet program and CISR work alongside industry partners, which include the Bureau of Economic Geology, the Institute for Geophysics, and the Department of Petroleum and Geosystems Engineering at The University of Texas; as well as SMU's North Texas Seismicity Study Group and the Department of Petroleum Engineering at Texas A&M University.[82]

MORE THAN 33 TRILLION GALLONS OF OILFIELD FLUID HAVE BEEN INJECTED WITHOUT ENDANGERING UNDERGROUND SOURCES OF DRINKING WATER.

As a result of these programs and beneficial collaborative partnerships, the scientific community will gain greater insight and understanding into seismic events, both naturally occurring and potentially induced.

79 Sara Robberson Lentz, "Why is Texas Shaking?" *UT News,* March 30, 2017, https://news.utexas.edu/2017/03/30/why-is-texas-shaking.

80 Scott W. Tinker "Earthquake monitoring is important to the Permian Basin" *Texas Bureau of Economic Geology*, February 25, 2019, https://www.mrt.com/opinion/article/Earthquake-monitoring-is-important-to-the-Permian-13642680.php

81 "TexNet Research and the Center for Integrated Seismicity Research," *Texas Bureau of Economic Geology,* accessed February 12, 2018, http://www.beg.utexas.edu/cisr.

82 Ibid.

RECOMMENDATIONS

1. DELINEATE RULE REQUIREMENTS FOR DISPOSAL WELLS BASED ON VOLUME AND PRESSURE; INCREASING REGULATIONS FOR HIGH-VOLUME/HIGH-PRESSURE WELLS

2. DECREASE VOLUME OF PRODUCED WATER DISPOSED BY ENCOURAGING BENEFICIAL REUSE

VI. RECOMMENDATIONS

1. Delineate Rule Requirements for Disposal Wells Based on Volume and Pressure; Increasing Regulations for High-Volume/High-Pressure Wells

Seismicity is a concern regarding disposal wells, whether viewed from a scientific or a public perception standpoint. To mitigate the risk of induced seismic events, rules regarding oil and gas wastewater disposal should contemplate requirements for wells in two bifurcated categories: high-volume, which generally correlates with higher pressure wells, and low-volume/low-pressure wells.

Numerous studies and analysis examining the relationship between seismicity and disposal wells show such events have occurred disproportionately near areas where wastewater disposal volumes are highest. For example, in the three seismic sequences that occurred in Northeast Texas from 2008 to 2013, all had epicenters within 2km of injection wells with permitted injection rates of 24,000m^3 or greater.[83] Another analysis concludes that, "areas where the largest fluid volumes were injected into the Ellenburger were also the areas where compressibility generally decreased, subsurface pressures increased, and earthquakes most often occurred."[84]

Traditionally, disposed volumes typically aligned with intended usage – commercial disposal wells would qualify as much higher volumes and on-lease disposal wells almost always handled considerably lower volumes of produced water. However, with the increased production from unconventional plays and corresponding increases in the size of contiguous leaseholds, some on-lease wells are disposing of nearly as much fluid as commercial wells – in some cases as much, if not more.

In order to differentiate between higher risk and lower risk wells, all high-volume disposal wells (HVDWs) should be subject to heightened standards from a permitting and regulatory perspective.

For purposes of this recommendation, a suggested starting point for "high-volume" classification could be in the range of 5,000 bbls to 10,000 bbls or greater. This is, however, just a conceptual quantity, intended begin a dialogue around implementing such thresholds. As with all regulations, much input should be received from industry and other stakeholders, and consultation with academia should occur to ensure a solid basis in science and fact before solidifying a new numerical standard in rule.

Increased requirements for HVDWs could include the following concepts:

EXPAND AREA OF REVIEW FOR HVDWS

Currently, in accordance with SWR 3.9(7) & 3.46(e), an applicant for a disposal well permit must review data for all wells that penetrate the proposed disposal zone within a 1/4 mile radius of the proposed disposal well, and identify any wells that appear unplugged or improperly plugged, to avoid movement of fluids from disposal zone into freshwater strata. However, in areas where disposed volumes are higher there is an increased risk of fluid migration and higher probability of geologic disturbance, especially near existing faults.

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83 Cliff Frohlich, et al., "A Historical Review of Induced Earthquakes in Texas," 13.

84 Matthew Hornbach, et al., "Ellenburger wastewater injection and seismicity in North Texas," *Physics of the Earth and Planetary Interiors, 261, part a*, 2016, 54-68, https://ac.els-cdn.com/S0031920116301133/1-s2.0-S0031920116301133-main.pdf?_tid=e6654f94-e87e-4d2e-8aa5-b2f4af3a4ec8&acdnat=1522431067_9bb09b648a5dff9d926742b44df1b4ff.

To lessen these risks, the area of review for HVDWs should be increased to a $^1/_2$ mile radius.

IMPLEMENT SPACING REQUIREMENTS FOR COMMERCIAL WELLS

There are currently no spacing or minimum acreage requirements in rule for disposal wells in Texas. Generally, a disposal well does not necessitate a large tract of land; however, if taking in large volumes of oilfield waste there should be some basic governance on spacing, both to mitigate potential over-pressurization and to mitigate the noise and disruptions to communities and neighboring residents that can be associated with larger facilities.

A 50-acre minimum spacing requirement is recommended for commercial wells, in addition to a 1,000-foot setback requirement.

INCREASE FEES FOR HVDWS

The current fee to submit a SWR 9 disposal well application is $250. However, many of these permit applications are protested, which can lengthen the process to six months or more, in some cases a year. The current fee and surcharge are completely misrepresentative and do not take into account the time and expense to the RRC staff.

Additionally, raising the fee will deter commercial disposal well "flippers" — parties who file for a commercial disposal well permit with hopes of receiving administrative approval, meaning there no protests filed against the application, in order to sell the now permitted disposal well at a premium, often thousands of dollars more than the few hundred required to obtain the permit.

Fees and surcharges associated with HVDWs should be raised to $7,500. This fee would apply each time a permit is sold to another party before disposal operations have actually commenced.

PROHIBIT CONVERSIONS FROM PRODUCING WELLS TO HVDWS

Currently the conversion of a producing well into a disposal well is allowed, although a new permit is required and additional rules may apply to such conversion. However, older wells may not be as well-constructed and/or may have suffered some loss of integrity over time. This, coupled with high-volumes of fluid being disposed at higher pressures later in the well's lifespan, presents a greater likelihood for mechanical failure which could lead to fluid migration and contamination.

By prohibiting the conversion of producing wells to HVDWs, yet still allowing conversions to low-volume disposal wells, the risk of seismic activity is mitigated and the economic vitality of marginal wells is not obstructed. While the return on marginal wells are much lower, they still account for an important share of statewide output. In 2012, Texas had more than 140,000 marginal oil wells, accounting for almost 20 percent of all statewide production that year.[85]

All HVDWs should be required to be newly drilled and newly constructed wellbores, and the conversion of producing wells to HVDWs should be prohibited.

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85 "Marginal Wells: Fuel for Economic Growth," *Interstate Oil and Gas Compact Commission: 11*, accessed March 30, 2018, http://iogcc.ok.gov/Websites/iogcc/images/MarginalWell/MW_2012_report.pdf.

2. Decrease Volume of Produced Water Disposed by Encouraging Beneficial Reuse

In addition to increasing regulatory requirements for high-volume disposal wells, industry and regulators should continue to pursue beneficial reuses of produced water in order to alleviate the amount of produced water being disposed. Rules and regulations should not be overly prescriptive, as water recycling practices and technologies are constantly evolving and are driven largely by effectiveness and economics. Furthermore, beneficial reuses should not be restricted by rule, and allow for new innovations to flourish.

Beneficial reuses of produced water include, but are not limited to: use in hydraulic fracturing fluid and other wellbore uses; mining; power generation, such as cooling ponds; irrigation, for instance in nonedible crops and large-scale watering operations; irrigation for consumable crops; and potentially even drinking water.

For example, in 2015 the Railroad Commission of Texas, Texas A&M AgriLife Research, and a handful of private companies joined together for a six-month project irrigating a cotton crop in Pecos, Texas using recycled produced water from oil and gas operations in the Delaware Basin. Irrigating the crop with a blended mixture of groundwater and produced water resulted in no reduction of cotton yield or lint quality.[86] Innovative solutions to reusing produced water, such as this, should be more widely explored and if proven safe, broadly accepted by regulatory agencies.

While significant advancements in the water recycling and reuse arena have been achieved by the oil and gas industry in recent years, more can be done by both industry and government to advance this effort.

86 "Agricultural Reuse of Treated Produced Water," *Texas A&M Agrilife Research & Energy Water Solutions*, https://www.owrb.ok.gov/2060/PWWG/Resources/Lewis_Katie.pdf

VII. Glossary

/BBLs: Barrels

CISR: Center for Integrated Seismicity Research

CWA: Clean Water Act

EPA: U.S. Environmental Protection Agency

HVDW: High-Volume Disposal Well

MCF: Million cubic feet, a unit measuring natural gas production

NORM: Naturally Occurring Radioactive Material

NPDES: National Pollutant Discharge Elimination System

PSI: Pounds per square inch

RRC: Railroad Commission of Texas

SDWA: Safe Drinking Water Act, passed by Congress in 1974

SWR: Statewide Rules

TAC: Texas Administrative Code

TCEQ: Texas Commission on Environmental Quality

TCF: Trillion cubic feet, a unit measuring natural gas production

Texas BEG: Texas Bureau of Economic Geology

UIC: Underground Injection Control

USDW: Underground Sources of Drinking Water

USGS: United States Geologic Survey

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