Induced Seismicity from Oil and Gas Wastewater Injection

A Comparison of State and Federal Law Regarding Class II Underground Injection Control (UIC) Wells

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See the Collaboratory at https://www.colorado.edu/research/induced-seismicity/
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The LawAtlas Induced Seismicity dataset, which is the basis of this document, is available on the Policy Surveillance Program website.
See http://lawatlas.org/datasets/IS-oil-gas-wastewater
Or go to http://lawatlas.org/topics (choose Environmental Health, then "Induced Seismicity from Oil and Gas Wastewater Injection")

Information on the Colorado Collaboratory for Induced Seismicity and its project: Hazards SEES: The Risk Landscape of Earthquakes Induced by Deep Wastewater Injection, is available at: https://www.colorado.edu/research/induced-seismicity/

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Executive Summary

This document compares the laws and regulations of seven states and the federal government to control the disposal of oil and gas wastewater into Class II Underground Injection Control (UIC) wells. The basis of this comparison is a compilation of applicable statutes and regulations into a publicly available, on-line, free-access dataset on LawAtlas.org, hosted by the Policy Surveillance Program at the Center for Public Health Law Research at Temple University's Beasley School of Law. Most of the federal and state law displayed in the LawAtlas dataset and additional materials gleaned from state agencies were designed to protect underground sources of drinking water (USDWs), although some are specific to controlling induced seismicity. The focus of the dataset and this comparison is to highlight which jurisdictions have regulatory tools to address the hazards and risks of induced seismicity.

The regulatory tools, cited in answering 16 LawAtlas questions (Qs), address:

(1) Regulatory Authority (Q1-Q3)
(2) Well Permitting and Siting (Q4-Q5)
(3) Well Construction and Operation (Q6-Q11)
(4) Public Participation, Financial Assurances, and Liability (Q12-16)

Most of the law discussed in the first three sections addresses the potential hazards of induced seismicity. The law discussed in the fourth and final section is more applicable to ameliorating or at least redirecting risk away from the public and internalizing it to the oil and gas industry.

(1) Regulatory Authority: All jurisdictions surveyed allow oil and gas developments to dispose of wastewater by injection (see Q1). Six of the seven states surveyed have primary responsibility (primacy) for regulating underground disposal of wastewater (see Q2). Four states have regulations specific to commercial disposal wells.

(2) Well Permitting and Siting: All of the jurisdictions require oil and gas fluid injection wells to be permitted and all require the applicant to submit information on subsurface features with their permit application (see Q4). While multiple regulations require applicants to submit information during the permitting process, only a few regulatory provisions explicitly prohibit or severely restrict the siting of a well based on specific criteria (see Q5). Some of these restrictions are specific to protecting water quality of USDWs; others could be more generally applicable.

(3) Well Construction and Operations: Beyond establishing siting restrictions, all jurisdictions with primacy for Class II wells regulate by specifying well construction requirements and/or restricting the operation of the well. All jurisdictions require casing and cementing of Class II injection wells (see Q6) and require mechanical integrity testing both before injection operations begin and throughout the life of the injection well (see Q7). All jurisdictions regulate the fluid injection process, including injection pressure. Some regulate the volume or rate of injection (see Q8). All of the jurisdictions also require monitoring, record keeping, and reporting to verify compliance with permit requirements and identify potential problems (see Q10), although only one state has specific regulations regarding operator monitoring for seismicity (see Q9). All

jurisdictions have authority to require corrective action under certain circumstances (see Q11). These actions include modifying permits or shutting in wells.

(4) Public Participation, Financial Assurances, Fees and Liability: Although none of the jurisdictions surveyed have public notice/comment/hearing regulatory requirements specific to seismic events, all of them require public notice and opportunities for public hearings regarding Class II well permit applications. Public participation opportunities are, however, more limited once injection wells are operating (see Q12). All jurisdictions require the operator to post financial assurances, generally surety bonds, for injection wells, although the purpose and amount of these instruments varies (see Q13). The states also charge various combinations of permit processing fees and annual operating (licensure) fees (see Q14) that can offset the costs of regulation. Most of the jurisdictions do not directly address liability or burden of proof regarding either the cause of seismicity or for damages caused by induced seismicity (see Q15). Only two of the seven states require operators to hold liability insurance (Q16).

Introduction

Hazardous waste injection into deep wells at the Rocky Mountain Arsenal near Denver, CO was recognized as the cause of earthquakes in the early 1960s,[1] but very little induced seismicity has been attributed to oil and gas wastewater disposal until recently.[2] In the last decade, however, disposal of oil and gas production wastewater by injection into deep wells has been implicated in hundreds of small earthquakes and several, larger damaging earthquakes in several states.[3] This document is a comparison of the laws and regulations available to states and the federal government to control the disposal of oil and gas wastewater into Class II Underground Injection Control (UIC) wells. The basis of this comparison is a compilation of applicable statutes and regulations into a publicly available, on-line, free-access dataset on LawAtlas.org, hosted by the Policy Surveillance Program at the Center for Public Health Law Research at Temple University's Beasley School of Law.[4]

Wastewater disposal by injection was largely unregulated until the passage of the Safe Drinking Water Act (SDWA) in 1974.[5] While the SDWA and most of the state law that controls Class II UIC wells is intended to protect underground sources of drinking water (USDWs) from contamination,[6] our dataset provides a cross-sectional comparison of the state and federal laws that might also be used to manage induced seismicity. The dataset is current as of August 16, 2019 for regulations of the U.S. Environmental Protection Agency (EPA) that implement the SDWA and statutes and regulations of seven states with significant oil and gas development. Of the seven states – Arkansas

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[1] David M. Evans, The Denver Area Earthquakes & The Rocky Mountain Arsenal Disposal Well, 3 The Mountain Geologist. 23 (1966), available at: https://scits.stanford.edu/sites/default/files/evans_0.pdf

[2] See, National Research Council, Induced Seismicity Potential in Energy Technologies, 2013 (NRC, 2013), at 88 and Appendix C (listing induced events as of 2011), available at: https://www.nap.edu/read/13355/chapter/1.

[3] See, Ground Water Protection Council and Interstate Oil and Gas Compact Commission, Potential Injection-Induced Seismicity Associated with Oil & Gas Development: A Primer on Technical and Regulatory Considerations Informing Risk Management and Mitigation. Second Edition, 2017 (GWPC IS Primer), at 3 and 23, available at: http://www.gwpc.org/sites/default/files/ISWG%20Primer%20Second%20Edition%20Final%2011-17-2017.pdf

[4] The LawAtlas Induced Seismicity dataset is available at: http://lawatlas.org/datasets/IS-oil-gas-wastewater Or see http://lawatlas.org/topics (choose Environmental Health, then "Induced Seismicity from Oil and Gas Wastewater Injection". See also https://monqcle.com/ for information on the database platform.

[5] Safe Drinking Water Act of 1974, 42 U.S.C. § 300h (2016); https://www.govinfo.gov/content/pkg/USCODE-2010-title42/pdf/USCODE-2010-title42-chap6A-subchapXII.pdf. See also, L. Warner, Deep-Well Injection of Liquid Waste: A Review of Existing Knowledge and an Evaluation of Research Needs, U.S. Dept. of Health, Education, and Welfare. 36-37 (1965), available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=94003ZVN.PDFlso

[6] NRC, 2013, at 118.

(AR), Colorado (CO), Kansas (KS), Ohio (OH), Oklahoma (OK), Pennsylvania (PA), and Texas (TX), only PA[7] has not experienced induced seismicity.[8] The law of three states, AR, CO and OK, can also be viewed over time (longitudinally) including law changes in 2019.

LawAtlas.org organizes the applicable Class II UIC well regulations in a series of 16 questions (Qs) and answers (As) with answer selection (coding) based solely on statutory or regulatory language that is interpreted literally. Rather than inferring how a regulation might be interpreted by the agency, only explicit language of a law or regulation is coded as a requirement in that jurisdiction.[9] Similarly, a state's broad authority regarding an issue, e.g., to take necessary action to abate a problem, is not coded to include the individual options for action, e.g., shutting in a well. Where there is ambiguity in an answer, the answer choice or applicable law text is explained or qualified with caution flags.

While each jurisdiction has rules specific to disposal wells,[10] EPA, CO, OH, KS, and PA have additional oil and gas regulations that apply more broadly. These additional regulations apply to injection/disposal wells because "injection well" or "disposal well" is included in the jurisdiction's definition of "well".[11] In contrast, AR, OK and TX do not have inclusive definitions of "well," but may define well types individually.[12] The dataset focuses on regulations of the jurisdiction's oil and gas regulatory agency, e.g., the CO Oil and Gas Conservation Commission, with a few regulations or

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[7] See, Pennsylvania Department of Environmental Protection, Injection Wells for Enhanced Recovery and Disposal (Apr. 2018) (PA DEP, 2018) ("no induced seismic events have been observed in Pennsylvania in association with injection wells at the time of this publication."), at 2, available at: http://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=1419032&DocName=INJECTION%20WELLS%20FOR%20ENHANCED%20RECOVERY%20AND%20DISPOSAL.PDF%20%20%3cspan%20style%3D%22color:blue%3b%22%3e%3c/span%3e%2011/15/2020

[8] In this document, the seven states surveyed are referred to as "the states"; when EPA is included, the eight entities are referred to as "the jurisdictions".

[9] For example, neither a regulation that requires the permit applicant to report the maximum volume of water expected to be injected (e.g., CO), nor a regulation requiring the operator to report the amount injected (all states) is interpreted as the jurisdiction "restricting" the volume injected.

[10] For example, 2 Colo. Code Regs. § 404-1-325 UNDERGROUND DISPOSAL OF WATER.

[11] For example, CO defines "well" as: "WELL when used alone in these Rules and Regulations, shall mean an oil or gas well, a hole drilled for the purpose of producing oil or gas, *a well into which fluids are injected*, a stratigraphic well, a gas storage well, or a well used for the purpose of monitoring or observing a reservoir." 2 Colo. Code. Regs. § 404-1-100 DEFINITIONS (italics added)

[12] For example, TX defines "gas well", "oil well", "exploratory well," etc. in their Administrative Code (16 Tex. Admin. Code § 3.79 Definitions**)** and "disposal well" and "injection well" in their Water Code (2 Tex. Water Code Ann. § 27.002 [Injection Wells] Definitions). AR distinguishes between Class II Disposal Wells (a.k.a. private or non-commercial wells), Class II Commercial Disposal Wells, and, as of 2019, has added the definition of a "high volume disposal system" based on on-site storage capacity of greater than 1000 barrels of Class II fluids. (Ark. Code R. RULE H-1 (a)(1), (8), and (11))

comments of other state environmental agencies, e.g., the AR Department of Environmental Quality (AR DEQ) that regulates surface facilities of both commercial and high volume, non-commercial disposal wells.

The focus of this summary is to compare management of oil and gas wastewater injection based on the answers to the dataset questions (e.g., Q1 – Q16) and the text of the statutes and regulations included in the LawAtlas dataset.[13] While only requirements specified in these statutes and regulation are used to select answers to dataset questions, this summary also includes disposal well regulation reflected in (1) agency forms, (2) agency actions and policies, and (3) a few legislative and regulatory proposals. For example:

(1) Some jurisdictions have requirements in permitting or reporting forms, not explicitly included in regulations, that operators must use to apply for a permit and/or operate an injection well. These forms are identified in the dataset through caution flags and included in this summary with parenthetical references in the text (e.g., Form 2).
(2) Jurisdictions also request or require information or use agency discretion in evaluating permit applications or to impose conditions of approval for operating injection wells. This summary includes examples of these agency actions and policy statements, e.g., orders, directives, permit conditions, protocols, and guidance documents, that add nuance to the states' regulation of Class II UIC wells. The sources of these actions and policies are cited in footnotes.
(3) And finally, this summary outlines, at the end of each applicable section, a few pertinent legislative proposals and agency proposed rules or rule recommendations considered, but rejected, by KS legislators and the TX Railroad Commission in the last few years (see the "*REJECTED LEGISLATION/RULES"* boxes).

While this summary provides very little analysis and comment on the law, it provides easy access to the pertinent provisions of each jurisdiction, and our hope is that this stimulates evaluation and discussion of the various jurisdictions' approaches to Class II UIC well management as it relates to induced seismicity. The project team welcomes other researchers, regulators, industry and individuals to utilize the dataset in its current form, to update it, or to expand it to include additional states or to address additional issues.[14]

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[13] The full text of applicable statutes and regulations are included in the LawAtlas dataset as citations. Specific citation to these statutes and regulations are not included in this summary unless the discussion includes a quoted passage. See the LawAtlas.org dataset for individual citations, available at: http://lawatlas.org/datasets/IS-oil-gas-wastewater

[14] For comments, corrections or questions contact Kathryn Mutz, Natural Resources, LLC at kathryn.mutz@colorado.edu or gvmutz@gmail.com.

Regulating for Induced Seismicity

Both state and federal law can promote reduction in both the hazard and the risk[15] of earthquakes induced by fluid injection by regulating wastewater injection in a number of ways. Ways in which induced seismicity *hazard* can be reduced or avoided include:

- *Siting disposal wells* to avoid areas susceptible to earthquakes, that is areas with site specific earthquake triggering features, e.g., faults. Siting decisions include both the areal location of the well and the location of the fluid disposal zone. Avoidance of problematic locations can be through either a blanket moratorium or well-by-well siting decisions.
- *Constructing disposal wells* to operate as designed, i.e., injecting and keeping fluids in the target formation.
- *Operating disposal wells* to maintain the constructed safeguards and to identify any unexpected problems. Essential components of proper operations are monitoring and reporting of operating parameters, including injection volume/rate and pressure, and maintaining mechanical integrity of the well.
- *Implementing adaptive management strategies*, i.e., requiring changes to either the well site (depth of well and injection formation), or operational parameters in response to area seismicity.

In addition to these means of reducing hazard, induced seismicity *risk* can be ameliorated or redirected by:

- *Siting disposal wells* to avoid population areas or sensitive structures;
- *Involving the affected public* in siting, construction and operations decision making;
- *Internalizing the full cost* of agency (i.e., taxpayer) costs in permitting, monitoring and regulating disposal wells; and
- *Compensating impacted individuals* for damages from induced earthquakes.

The federal and state laws displayed in the LawAtlas dataset are compared in this summary to highlight which jurisdictions have regulatory tools – whether they be designed to protect USDWs or specific to induced seismicity – to address these hazards and risks of seismic events.

The regulatory tools, cited in answering 16 LawAtlas questions, address:

1. Regulatory Authority (Q1-Q3)
2. Well Permitting and Siting (Q4-Q5)
3. Well Construction and Operation (Q6-Q11)

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[15] See, GWPC IS Primer, at 38 (A hazard is any source of potential damage, harm, or adverse impact on something or someone. A risk is the chance or probability that a person or property will be harmed if exposed to a hazard.).

4. Public Participation, Financial Assurances, and Liability (Q12-16)

Appendix A lists the laws and regulation that are the basis of this summary and are cited in the dataset.

Appendix B lists the issues or questions (Qs) addressed in the dataset and their potential answers (As).

Appendix C provides a Statistical report, generated by the LawAtlas dataset, that summarizes the questions and answers for EPA and the seven states.

Appendix D provides a Standard report, generated by the LawAtlas dataset, that includes the answers to the questions, supporting citations, and the text of any caution flags.

1. Regulatory Authority (Q1 - Q3)

All jurisdictions surveyed allow oil and gas developments to dispose of wastewater by injection (see Q1). Four states (AR, CO, OK, and TX) have regulations specific to commercial disposal wells, and the EPA defines commercial disposal wells in its permitting process (Form 7520-06) (see Q3). These jurisdictions all define a commercial well as (1) accepting fluids from multiple oil or gas well operators (third parties) and (2) charging a fee for disposal. OK[16] and TX include the additional criterion that the operator's or well's primary business objective is to provide these services.[17]

Disposal wells for oil and gas development are classified as Class II injection wells under the Federal Underground Injection Control (UIC) program implementing the Federal Safe Drinking Water Act.[18] Six of the seven states surveyed have primary responsibility (primacy) for regulating this underground disposal of wastewater (see Q2). Of the states surveyed, only PA has not applied for primacy and depends on EPA to regulate the permitting and operation of these wells, although PA has state regulations that also apply to UIC Class II wells. When PA law is displayed in the dataset and described in this summary, it refers to PA provisions of law and regulation and a few

[16] In August 2019, OK proposed to change its definition of "commercial disposal well" to remove this additional criterion. See, OKLAHOMA CORPORATION COMMISSION, DRAFT AMENDMENTS AS OF AUGUST 15, 2019, TITLE 165. CORPORATION COMMISSION, CHAPTER 10. OIL & GAS CONSERVATION, available at: https://content.govdelivery.com/attachments/OKOCC/2019/09/11/file_attachments/1283601/Ch10DraftProposals8-15-19.pdf

[17] The dataset highlights distinctions between requirements for commercial and non-commercial disposal wells. Regulatory provisions for both commercial and non-commercial wells are included throughout the dataset, e.g., regarding MITs (Q9) or specific reporting requirements (Q7). Additional commercial well regulatory provisions, i.e., not specific to other questions, are cited in answer to Q3. These include additional permitting, well construction, surface facility, and monitoring/reporting requirements.

[18] Safe Drinking Water Act of 1974, 42 U.S.C. § 300h (2016); https://www.govinfo.gov/content/pkg/USCODE-2010-title42/pdf/USCODE-2010-title42-chap6A-subchapXII.pdf

PA-specific EPA regulations. To understand the complete regulatory regime for Class II UIC wells in PA requires adding the cited PA law to the requirements and restrictions of EPA UIC regulations.[19]

To qualify for primacy under SDWA § 1422, a state must show it:

> (i) has adopted after reasonable notice and public hearings, and will implement, an underground injection control program which meets the requirements of regulations in effect under section 1421; and
>
> (ii) will keep such records and make such reports with respect to its activities under its underground injection control program as the Administrator may require by regulation. SDWA Sec. 1422(b)(1)(A).[20]

While many states received primacy for Class II wells under § 1422, all of our surveyed states (excluding Pennsylvania) obtained primacy under SDWA § 1425.[21] This section was added to the SDWA by a 1980 amendment for the purpose of allowing states with pre-existing UIC regulatory programs to continue their programs without the additional burdens of federal requirements so long as the state program fulfills the purpose and meets the requirements of the SDWA.[22] § 1425 provides, in lieu of the § 1422 showings, that:

> the State may demonstrate that such portion of the State program meets the requirements of subparagraphs (A) through (D) of section 1421(b)(1)[23] and represents an effective

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[19] An example of a PA-specific EPA regulation is 40 CFR § 147.1951 EPA-administered program, that states that "The UIC program for the State of Pennsylvania, including all Indian lands, is administered by EPA." General EPA UIC regulations include all of the EPA regulations that define the UIC program, i.e., 40 CFR parts 124, 144, 145, 146, and 148.

[20] If for one of several reasons, the Administrator disapproves all or part of a State's program, the Administrator may (SDWA § 1422 (c): ". . . prescribe (and may from time to time by regulation revise) a program applicable to such State meeting the requirements of section 1421(b). Such program may not include requirements which interfere with or impede—

(1) the underground injection of brine or other fluids which are brought to the surface in connection with oil or natural gas production or natural gas storage operations, or

(2) any underground injection for the secondary or tertiary recovery of oil or natural gas, unless such requirements are essential to assure that underground sources of drinking water will not be endangered by such injection."

[21] See States' Tribes' and Territories' Responsibility for the UIC Program, available at: https://www.epa.gov/sites/production/files/2019-04/documents/primacy_status_revised_april17_2019_508c.pdf

[22] H.R. Rep No. 96-1348, at 5 (1980)

[23] SDWA § 1421 (b)(1): Regulations under subsection (a) for State underground injection programs shall contain minimum requirements for effective programs to prevent underground injection which endangers

program (including adequate recordkeeping and reporting) to prevent underground injection which endangers drinking water sources. SDWA § 1425 (a).

Consequently, the seven states considered in this summary were not required to adopt statutory or regulatory provisions identical to the EPA's. Rather they were required to demonstrate provisions as effective as the federal standards. AR is an example of a state who's pre-SDWA underground injection control program laws and regulations were adopted for the federal primacy program.[24] Some states, see e.g., OH, have rules that preclude their oil and gas rules from being more stringent

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drinking water sources within the meaning of subsection (d)(2). Such regulations shall require that a State program, in order to be approved under section 1422—

(A) shall prohibit, effective on the date on which the applicable underground injection control program takes effect, any underground injection in such State which is not authorized by a permit issued by the State (except that the regulations may permit a State to authorize underground injection by rule);

(B) shall require (i) in the case of a program which provides for authorization of underground injection by permit, that the applicant for the permit to inject must satisfy the State that the underground injection will not endanger drinking water sources, and (ii) in the case of a program which provides for such an authorization by rule, that no rule may be promulgated which authorizes any underground injection which endangers drinking water sources;

(C) shall include inspection, monitoring, recordkeeping, and reporting requirements; and

(D) shall apply (i) as prescribed by section 1447(b) 1, to underground injections by Federal agencies, and (ii) to underground injections by any other person whether or not occurring on property owned or leased by the United States.

[24] See Arkansas Oil and Gas Commission; Underground Injection Control; Program Approval at 49 Fed. Reg. 11179.

than the federal rules[25] or at least require the agency to evaluate and justify a more stringent rule (e.g., OH,[26] PA[27] and OK[28]).[29]

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[25] Ohio Rev. Code § 1509.22 Storage or disposal of brine, crude oil, natural gas, or other fluids

(D)(5): This division and rules, orders, and terms and conditions of permits adopted or issued under it shall be construed to be no more stringent than required for compliance with the Safe Drinking Water Act unless essential to ensure that underground sources of drinking water will not be endangered.

[26] Ohio Rev. Code Ann. § 121.39 Identifying documentation that is basis for legislation dealing with environmental protection. [applicable to rules after 3-5-1996]

. . .

(B) Except as otherwise provided in division (E) of this section, when proposed legislation dealing with environmental protection or containing a component dealing with environmental protection is referred to a committee of the general assembly. . . , the sponsor . . . shall submit to the members of the committee a written statement identifying either the documentation that is the basis of the legislation or the federal requirement or requirements with which the legislation is intended to comply. If the legislation is not based on documentation or has not been introduced to comply with a federal requirement or requirements, the written statement from the sponsor shall so indicate.

. . .

(D) Except as otherwise provided in division (E) of this section, prior to adopting a rule or an amendment proposed to a rule dealing with environmental protection or containing a component dealing with environmental protection, a state agency shall do all of the following:

(1) Consult with organizations that represent political subdivisions, environmental interests, business interests, and other persons affected by the proposed rule or amendment;

(2) Consider documentation relevant to the need for, the environmental benefits or consequences of, other benefits of, and the technological feasibility of the proposed rule or amendment;

(3) Specifically identify whether the proposed rule or amendment is being adopted or amended to enable the state to obtain or maintain approval to administer and enforce a federal environmental law or to participate in a federal environmental program, whether the proposed rule or amendment is more stringent than its federal counterpart, and, if the proposed rule or amendment is more stringent, the rationale for not incorporating its federal counterpart;

(4) Include with the proposed rule or amendment and the rule summary and fiscal analysis [information from (D)(2) and /or (D)(3), as applicable]

. . . Division (D) of this section does not apply to any emergency rule adopted under division (B)(2) of section 111.15 or division (G) of section 119.03 of the Revised Code, but does apply to any such rule that subsequently is adopted as a nonemergency rule under either of those divisions.

[27] 4 Pa. Admin. Code § 1.371 General requirements

2. Well Permitting and Siting (Q4 – Q5)

Well Permitting (Q4)

All of the jurisdictions require oil and gas fluid injection wells to be permitted[30] and all require the applicant to submit information on subsurface features with the permit application (see Q4).

- All jurisdictions require the potential permittee to provide information on aquifers and geologic strata at the proposed well location and to identify the location of nearby wells. In 2019, OK increased the area of review for identifying the location of existing wells near proposed high-volume, non-commercial disposal wells (wells injecting 20,000 barrels per day or greater) from one-quarter to one-half mile. This brought OK's area of review criterion for high volume, non-commercial wells up to the standard for commercial wells, which is one-half mile regardless of injection volume. In December 2019, OK proposed additional changes to rules on identifying the location of wells and notifying surface owners and operators. If promulgated, these changes would require comparable information for commercial and non-commercial wells and only distinguish between wells of less than or greater than 5,000 barrels per day. The proposed rule would expand the required area of review to two miles for all wells of greater than the 5,000 barrels per day volume.[31]

In the drafting and promulgating of new regulations and the application and review of existing regulations, agencies shall adhere to the following principles:

. . .

(5) If Federal regulations exist, regulations of the Commonwealth may not exceed Federal standards unless justified by a compelling and articulable Pennsylvania interest or required by State law.

[28] Okla. Stat. tit. § 27A, 1-1-206. Economic impact and environmental benefit statements

A. Each state environmental agency [Corporation Commission included in definition in Okla. Stat. tit.§27A, 1-1-201] in promulgation of permanent rules within its areas of environmental jurisdiction, prior to the submittal to public comment and review of any rule that is more stringent than corresponding federal requirements, unless such stringency is specifically authorized by state statute, shall duly determine the economic impact and the environmental benefit of such rule on the people of the State of Oklahoma including those entities that will be subject to the rule.

[29] The environmental agencies of CO (CO Department of Public Health and Environment) and TX (TX Commission on Environmental Quality) have similar qualified restrictions regarding water pollution control regulations. Colo. Rev. Stat. § 25-8- 202(8)(a)(Duties of commission—rules) and Tex. Water Code Ann. § 26.017(5) (Cooperation).

[30] Jurisdictions may allow temporary injection without a permit. For example, Ohio's regulations allow the chief to authorize temporary injection (48 hours) without a permit in order to evaluate potential for injection. (Ohio Admin. Code § 1501:9-3-06 (A))

[31] See, OKLAHOMA CORPORATION COMMISSION, REVISED DRAFT AMENDMENTS AS OF DECEMBER 2, 2019, TITLE 165. CORPORATION COMMISSION, CHAPTER 10. OIL & GAS CONSERVATION (OK 12-2-19 Draft Chapter 10 Amendments), at 60, available at:

- Half of the jurisdictions (AR, OH, TX, and EPA) specifically require identification of area faults. But only TX regulations require UIC well applicants to submit information on historic earthquakes.[32]
- Variation among the jurisdictions regarding submittal of subsurface feature information includes:
    - EPA regulations do not require a review of area seismicity, but their UIC Class II Permit Application, Form 7520-6, does. PA relies on EPA's permit information requirements and PA performs a review that includes a geologic analysis based on disposal wells functioning as a pollution abatement process.[33]
    - While CO and OK regulations do not require fault location or historic seismicity information from UIC well applicants, CO[34] and OK's[35] agency staff review permit applications for proximity of proposed wells to faults and potential area seismicity. OK requires special permitting if a well is proposed within three miles of a stressed fault, even in the absence of historic seismicity.[36]
    - TX is the only jurisdiction with regulations requiring information on bedrock/basement rock, although EPA's permit application form also requires this information (Form

https://content.govdelivery.com/attachments/OKOCC/2019/12/03/file_attachments/1335811/Ch10DraftProposals12-2-19.pdf

[32] A TX disposal well application must include a USGS Earth Archive search, beginning as far back as 1973, within 100 square miles (a circular area with a radius of 9.08 kilometers) of the proposed well site. See 16 Tex. Admin. Code § 3.9 (3)(B). In addition, TX regulations not only authorize, but require the Texas Railroad Commission to require applicants to submit any information it considers necessary to discharge its duties.

[33] See, PA DEP, 2018, at 2 citing 25 Pa. Code § 91.5.

[34] Colorado Oil And Gas Conservation Commission (COGCC) 2017 Annual Report, (COGCC 2017 Annual Report) available at: https://cogcc.state.co.us/documents/library/technical/wqcc_wqcd annual reports/2017 annual report wqcc_final_12302017.pdf (COGCC's staff geologic experts review UIC permits for site specific matters, such as the occurrence of faults and potential seismic issues.)

[35] Earthquakes in Oklahoma, Oklahoma Corporation Commission at http://earthquakes.ok.gov/what-we-are-doing/oklahoma-corporation-commission/ (The Commission has adopted a "traffic light" system . . . which directs staff to review disposal well permits for proximity to faults, seismicity in the area and other factors. All proposed disposal wells, regardless of location, now undergo a seismicity review.)

[36] OK Media Advisory– Ongoing OCC Earthquake Response, March 25, 2015 (OK Media Advisory, 3/25/15), available at: http://www.occeweb.com/News/2015/03-25-15%20Media%20Advisory%20-%20TL%20and%20related%20documents.pdf

7520-6).[37] and CO's permit review process considers the proximity of injection into basement rocks.[38] In areas of historic earthquakes or faulting, OH looks at whether the injection well is drilled deep enough to have a path of communication with the fault in the crystalline bedrock.[39]

- All states have additional regulatory requirements for providing results of downhole tests that may aid in identifying faults and characterizing potential problems (e.g., electric, resistivity, and conductivity logs).

These provisions are generally intended to minimize the potential for USDW contamination by evaluating the location of aquifers, suitability of confining layers, and the potential for existing faults and wells to conduct contaminated fluids beyond their intended injection zone.[40] Zone of Endangering Influence (ZEI)[41] tests also provide information for evaluating the volume of waste fluids that a formation is expected to safely accept (based on formation pressure) as well as the injection pressure that will not cause fractures (based on fracture gradient). While these tests may be intended to protect USDWs, the information they provide can also be useful in making well siting decisions and developing operating conditions to avoid or minimize inducing seismicity.

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[37]EPA, Instructions for Form 7520-6 Underground Injection Control Permit Application for a Class II Well, available at: https://www.epa.gov/sites/production/files/2019-05/documents/owner_or_operator_permit_application_for_a_class_ii_well_form_7520-6_class_11.pdf .

[38] Colorado Oil and Gas Commission, Engineering Unit Seismicity Review For Class II Underground Injection Control Wells, Governor's Task Force Summary (CO Governor's Task Force, 2014), available at http://cogcc.state.co.us/documents/about/tf_summaries/govtaskforcesummary_sesimicity_review_for_class_ii_underground_injection_control_wells.pdf.

[39] Preliminary Report on the Nortstar I Class II Injection Well and Seismic Events in the Youngstown, Ohio, Area, available at: http://oilandgas.ohiodnr.gov/portals/oilgas/downloads/northstar/reports/northstar-preliminary_report.pdf

[40] NRC, 2013 at 118 ("UIC regulations requiring information on locating and describing faults in the area of a proposed disposal well are concerned with containment of the injected fluid, not the possibility of induced seismicity.").

[41] J. Daniel Arthur et al., Class II Disposal Well Best Management Practices Workshop, GWPC.org (2016), available at: http://www.gwpc.org/sites/default/files/event-sessions/Tomastik_Tom_ClassIIWorkshop.pdf .

REJECTED LEGISLATION/RULES:

Kansas: In 2018, a bill before the KS legislature (HB 2672[42]) would have required permit applicants to provide information regarding potential seismic concerns and a risk assessment of the potential for induced seismicity based on the proposed location, depth of the well, and proposed daily injection volume.

Texas: In 2014, TX proposed requiring calculation of the estimated five pounds per square inch (psi), 10-year pressure front boundary and use of that area for evaluating historic seismic activity.[43] They opted instead to have all operators use a 100 square mile search area although an industry group recommended a smaller search area for all operators and an even smaller search areas for small volume disposal wells (< 5000 barrels per day). In addition to this change, the Railroad Commission included the calculation of pressure front boundaries in the list of additional information that they could require an applicant to provide if they determined that there were complex geology, proximity of the injection interval to the basement rock, presence of transmissive faults, and/or a history of seismic events.

One group of commenters recommended more stringent requirements: suggesting that the rule state that the Commission "will" rather than "may" request additional information and would have required an applicant to avoid any pressure development near a major fault system that is active or appears critically stressed and to require annual measurement and reporting of bottom hole shut-in pressure to determine if injected fluids are having far-reaching effects on subsurface stress. Another commenter recommended more discussion in the regulations on the types of information needed for permitting, including but not limited to a discussion of radioactive tracer or spinner surveys, well logs, and geological investigation of potential faulting. Other commenters recommended more Commission flexibility such that the Commission require different actions in different areas of the state or address seismicity in field rules rather than through statewide rulemakings since seismicity appears to be concentrated in certain areas of the state.

Well Siting (Q5)

While multiple regulations require applicants to submit information for the permitting process, only a few regulatory provisions explicitly prohibit (i.e., would cause an agency to reject a permit application for a specific injection well location) or severely restrict the siting of a well (either its surface location or the injection formation), based on specific criteria (see Q5). Some of these

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[42] House Bill No. 2672 (2018) (HB 2672), available at: http://kslegislature.org/li_2018/b2017_18/measures/documents/hb2672_00_0000.pdf .

[43] Christina Self, General Counsel to the Railroad Commission of Texas, 16 TAC Chapter 3--Oil and Gas Division, review by legal counsel of the agency's legal authority to adopt amendments to §3.9 and §3.46 August 29, 2014 (TX Legal Counsel Review, 2014), available at: https://www.rrc.state.tx.us/media/24613/adopt-amend-3-9and3-46-seismic-activity-102814-sig.pdf

restrictions are specific to protecting water quality of USDWs; others could be more generally applicable.

EPA siting rules are specific to protecting USDW water quality. EPA rules restrict siting Class II UIC wells near faults, but only if the confining zone between the proposed injection formation and a USDW has an open fault or fracture. Health is another EPA siting criterion, but only to the extent that health would be adversely affected by contamination of USDWs. AR, KS, OK, and TX all have restrictions related to the injection formation and its confining layers in order to protect fresh water resources. Beyond these injection formation restrictions, states also have specific siting criteria to protect USDWs. For example, OK regulations prohibit commercial disposal wells in a designated wellhead protection area (for public water supply wells).

Other state restrictions allow agency discretion in water-related circumstances.

- OK operators can site a non-commercial disposal well within half mile of a municipal water supply if they provide "substantial evidence" that the disposal well will not pollute the water supply well. OK regulations also have siting restrictions based on thickness of overlying strata, although the agency has discretion regarding thickness of the confining layer that protects USDWs from pollution for wells injecting less than 10,000 barrels per day or equivalent. In 2019, however, an OK rule change specified an increase in the thickness of a confining layer (from 500 to 3000 feet) considered sufficient to protect fresh water from wells injecting at 10,000 barrels per day or more equivalent rate. This rule change effectively removed agency discretion on waivers for wells with these higher injection rates.
- CO's can site a E&P Waste Management Facility, that could include disposal by injection, in a "sensitive area" if there will be "adequate measures and controls" to protect the area during operations.

A few states have regulations that explicitly go beyond USDWs with either specific, non-water related regulations or with more general or comprehensive regulations that could be applied to minimize potential for induced seismicity.

- In a moratorium area related to the Guy-Greenbrier Earthquake Swarm, AR restricts siting based on proximity to faults, other injection wells, and seismic events that define the moratorium area. These restrictions on both commercial and non-commercial injection wells can all be waived by the Commission after notice and hearing.

- OH regulations require a setback from certain structures – the state does not allow UIC wells within designated distances from various categories of buildings and transportation infrastructure. While intended to protect public safety, these short setback distances (50 – 100 feet) would fall short of protecting individuals and their property from induced seismicity impacts which may be felt many miles from a problematic injection well.

- More generally, CO regulations allow UIC permit denial if the Director has "reasonable cause to believe that the proposed disposal well could result in a significant adverse impact on the environment or public health, safety and welfare."[44]

REJECTED LEGISLATION/RULES: In 2018, a bill before the KS legislature (HB 2672[45]) proposed prohibiting Class II disposal wells within 10 miles of any known or suspected fault line.

Beyond regulation, a few jurisdictions have policies, guidelines or recommendations, or have issued specific orders/directives for restricting the siting of UIC wells that can help reduce induced seismicity.

- EPA has a decision-tree model for well permitting which recommends restricting well siting if the potential for induced seismicity is found and there are no suitable mitigation measures available. Seismic potential is determined by presence of deep-seated transmissive faults that intersect the proposed injection zone.[46]
- CO staff review permit applications for site specific matters, such as faults and potential seismic issues. If historic seismicity is identified in the vicinity of a proposed Class II UIC well, the CO Oil and Gas Conservation Commission (COGCC) requires the operator to characterize the seismic potential with respect to the proximity of injection into basement rocks and known faults.[47]
- KS had not, as of early 2017, eliminated existing, nor prohibited new wells in the Arbuckle Formation, but has restricted siting of new high volume wells within ¼ mile of existing high volume injection wells in order to restrict the total volume injected in an area.[48]

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[44] 2 Colo. Code Regs. 404-1-325(b) - Underground Disposal of Water – Withholding approval of underground disposal of water.

[45] HB 2672.

[46] EPA, Underground Injection Control National Technical Workgroup, Recommended Decision-Tree Model, Minimizing And Managing Potential Impacts Of Injection-Induced Seismicity From Class II Disposal Wells: Practical Approaches (2014), available at: https://www.epa.gov/sites/production/files/2015-08/documents/induced-seismicity-201502.pdf

[47] CO Governor's Task Force, 2014.

[48] Kansas Corporation Commission. Report and Recommendation, Conservation Division, RE: Staff Recommendation Docket No. 15-CONS-770-CMSC. 3 31 17, available at: http://estar.kcc.ks.gov/estar/ViewFile.aspx/20170331164547.pdf?Id=cffb006f-cb05-4cbf-9a20-35db76d8ce46 (limited injection due to earthquakes linked to disposal into the Arbuckle Foundation; analysis of large volume wells within ¼ mile of new large volume well permit applications).

- OH policy is to prohibit all injection into the Precambrian basement to avoid drilling near any possible fault lines in the crystalline rock[49] and avoid areas with historic earthquakes.[50] More recently, OH reportedly prevents use of the Mount Simon (basal sand near the basement) in eastern Ohio.[51]

- As of early 2016, OK had not prohibited the siting of new disposal wells in the Arbuckle Formation, but new wells into this formation could no longer be administratively approved. Applications require "full court process" and approval granted by a majority vote by Commissioners. The resulting permit is limited to six months, has requirements for seismicity monitoring, and the well can be shut-in without a court hearing. In addition, all existing wells found to be in contact or communication with the crystalline basement rock were ordered to be plugged back.[52]

- TX has administrative guidelines that indicate how the Railroad Commission evaluates information in the permitting process. Current guidelines indicate that a well permit will not be approved if there are faults, fractures, structure, or other geologic factors that indicate that isolation of the disposal zone is jeopardized. While this provision is apparently intended to prevent water quality contamination of USDWs, it could also serve to avoid siting wells where slippage of faults may trigger earthquakes.[53]

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[49] Ohio notes this new well siting restriction in its response to induced Earthquakes in Youngstown. See ODNR Division of Oil and Gas Resources, Class II Disposal Well Reforms/Youngstown Seismic Activity Questions and Answers (no date) (Youngstown FAQs), available at: http://oilandgas.ohiodnr.gov/portals/oilgas/pdf/YoungstownFAQ.pdf .

[50] Denial of a Permit to Inject Brine or Other Waste Substances pursuant to Ohio Revised Code 1509.22, Order No. 2014-421, available at: http://www.frackfreeamerica.org/uploads/1/2/4/0/12404661/2014_421_r.e._disposal_llc_denial_of_permit_to_inject.pdf

[51] Groundwater Protection Council, State of Ohio Class II UIC Program Peer Review, January, 2017 (OH Peer Review), available at: http://www.gwpc.org/sites/default/files/2017OhioClassIIPeerReviewFinal_0.pdf

[52] OK Media Advisory – Regional Earthquake Response Plan for Central Oklahoma and Expansion of the Area of Interest, March 7, 2016 (OK Media Advisory, 3/7/16), available at: http://www.occeweb.com/News/2016/03-07-16ADVISORY-AOI,%20VOLUME%20REDUCTION.pdf

[53] Railroad Commission of Texas, Injection/Disposal Well Permitting, Testing, and Monitoring Manual, Chapter III – Standards and Procedures for Class II Wells, available at: https://www.rrc.state.tx.us/oil-gas/publications-and-notices/manuals/injectiondisposal-well-manual/chapter-iii/ . But see, Oil and Gas Docket No. 08-0297874; Application of Primexx operating corporation . . . for a commercial permit to dispose of oil and gas waste by injection into a porous formation not productive of oil or gas.; Proposal for Decision, 2016 (Primexx Permit Application, 2016) (Examiners in 2016 approved siting of a disposal well in an area of recent (2011 and 2015) seismic activity, against the objections of an adjacent landowner who feared degradation of his farm's water.), available at: https://www.rrc.texas.gov/media/34222/08-97874-r9p-pfd.pdf. See Q16 discussion for further discussion of this permit.

3. Well Construction and Operation (Q6 – Q11)

Beyond establishing siting restrictions, all jurisdictions with primacy for Class II wells regulate by specifying well construction requirements (see e.g., casing and cementing at Q6), and/or restricting the operation of the well (see e.g., setting fluid volume or pressure limits at Q8). The dataset captures regulations on five aspects of well construction and operation:

- Casing and cementing;
- Mechanical integrity testing;
- Fluid injection processes, specifically injection pressure and volume;
- Monitoring, record keeping, and reporting on operations; and
- Adaptive management in response to seismicity.

Casing and Cementing (Q6)

All jurisdictions require casing and cementing of Class II injection wells (see Q6). This well construction technique is primarily intended to keep injected fluids in their intended disposal formation in order to protect the quality of USDWs. Most jurisdictions have casing/cementing provisions for both new UIC wells and for conversion of existing wells to injection wells (AR, KS, OH, OK,[54] CO and EPA).

Mechanical Integrity (Q7)

Similarly, all jurisdictions require mechanical integrity testing (MIT) to test the integrity of the well construction both before injection operations begin and throughout the life of the injection well (see Q7). While poor mechanical integrity may not cause an induced seismic event, routine MITs could ensure that a well is not exceeding its permitted injection pressure.

- All jurisdictions require both an initial test (after well completion as an injection well, conversion of an existing well to an injection well, or transfer of ownership) and routine testing at least once every 5 years. PA requires reporting on mechanical integrity on an annual basis and OK requires annual testing or continuous pressure monitoring on wells injecting greater than 20,000 barrels per day.

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[54] OK is the only jurisdiction we noted to have different casing and cementing regulations for annular injection wells, where fluids are injected between the upper surface casings and the lower injection casings, usually at lower pressures and volumes. See Okla. Admin. Code § 165:10-3-4(c)(4) (if operator intends to dispose of fluids by annular injection, operator shall comply with 165:10-5-13 which requires surface casing string to be set not less than 200 ft below base of treatable water.) Annular injection wells are not likely to cause seismicity, but it is not impossible. They inject above the bedrock, and are usually much more stringently controlled although, there is a much higher chance of contaminating drinking waters. Different jurisdictions allow for injection pressures ranging from gravity to regular injection well pressure. Some only allow for the injection of fluid sourced from the same well it is being injected into. Alaska, on one end of the spectrum, defines it as "incidental to the drilling of a well" and not a disposal operation in itself. Ohio, severely limits it. See also, Joseph Willi Friedman, Fracking: Formulation of Appropriate State Regulation of Waste Disposal, University of Michigan: Department of Earth and Environmental Sciences. 27 (2013), available at: https://deepblue.lib.umich.edu/bitstream/handle/2027.42/97755/Friedmann_Joey_MS_2013.pdf?seq

- AR, CO, and OK specify MITs following various well maintenance operations which involve resetting or moving the packer or tubing. CO also requires an MIT after casing repairs and TX requires one after every workover of the well.

- AR, OK, PA, and EPA specify MITs following problems with the well, although no jurisdiction defines seismic events related to the well as such a "problem." Identified problems include:

    - AR – When the Director has reason to believe a disposal well is leaking or improperly constructed;

    - OK[55] – When a measurable positive pressure is not being maintained at the casing valve;

    - PA – When there are any signs of equipment deterioration; and

    - EPA – When there is not a sufficient showing by the operator that there is no fluid movement into or between USDWs.

Fluid Injection Processes (Q8)

In addition to these essential requirements for properly constructing a well and verifying its integrity, all jurisdictions regulate the fluid injection process. All jurisdictions have restrictions on injection pressure based on fracture gradient of the underlying rock, and a few address the volume or rate of injection (see Q8).

Injection Pressure

Restrictions on injection pressure vary by jurisdiction:

- Federal primacy regulations provide maximum pressure formulas for CO and PA. EPA's requirement of maximum injection pressure is specific to protecting USDWs. It's formula creates a maximum injection pressure, specific to each well, to assure that the pressure during injection does not initiate new fractures or propagate existing fractures in the confining zone adjacent to the USDWs. To comply with the SDWA, injection pressure may not cause the movement of injection or formation fluids into a USDW. In addition, the federal regulation approving CO's primacy regarding Class II wells includes criteria and a formula for calculating the maximum injection pressure, with the purpose of keeping the maximum pressure below the fracture gradient of the formation.

- AR provides formulae for calculating the maximum injection pressure for specific areas of the state based on 90% of a maximum fracture gradient which varies by location and formation.

- CO regulations provide that the Director will set a maximum injection pressure. CO will grant a default fracture gradient of 0.6psi/ft, or allow an operator to use a step-rate test to

[55] 2019 revisions to OK regulations require that a well with a mechanical failure or down-hole problem must be "brought into compliance within ninety days after discovery of the problem". Okla. Admin. Code § 165:10-5-7 (f)(1)(C).

determine if there is a higher fracture gradient than the default and apply for a higher injection pressure.[56] The maximum pressure allowed is reported in the approval section of Form 33, CO's Injection Well Permit Application. For simultaneous injection wells in CO, there is no specification for how the maximum injection pressure will be determined, only a requirement that the maximum discharge pressure be calculated.

- KS regulations do not provide a formula for maximum pressure at all injection wells, but KS specifies a maximum injection pressure of less than the fracture gradient for simultaneous injection wells. In KS, an injection well permit application must include the estimated maximum injection pressure. The conservation division then considers, among other factors, maximum surface pressure, formation pressure, and pressure at the formation face.

- OH specifies a formula for determining the maximum, but will also evaluate a formula or test proposed by the injection well permit applicant and may implement graduated maximum allowable injection pressure requirements. OH regulations require additional controls on injection pressure by requiring an automatic shut-off valve to trigger if the maximum allowed is exceeded.

- OK will not permit commercial disposal wells whose injection pressure even approaches the demonstrated fracture gradient of the injection zones and the state specifies a maximum injection pressure of less than the fracture gradient for simultaneous injection wells. An OK rule change in 2019 specifies that "The maximum permitted surface injection pressure will be the pressure requested in the application or 0.5psi per foot of depth to the top of the injection/disposal interval, whichever is less, unless the results of a fracture pressure step-rate test support a higher pressure."[57] A proposed rule change in 2019 would eliminate this 0.5psi per foot-provision and allow the UIC Department to request a fracture pressure step-rate test.[58]

- TX does not have a maximum pressure formulae, but existence of maximum limits can be inferred from state rules that require testing based on the maximum pressure or reporting of the maximum authorized pressure. TX also controls injection pressure through permitting. TX has a default maximum injection pressure of 0.5psi per foot of depth, though

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[56] Colorado Oil and Gas Commission, Step Rate/Injectivity Test Documentation, COGCC Form 31 Attachment Guidance (2015), available at: http://cogcc.state.co.us/documents/reg/forms/instructions/attachment_guidance/form_31/step%20rate-injectivity%20test%20documentation.pdf

[57] Okla. Admin. Code § 165:10-5-5 (b)(5).

[58] OK 12-2-19 Draft Chapter 10 Amendments, at 62.

an operator can request an increased injection pressure if a step-rate test shows a higher pressure will not exceed the fracture gradient of the formation.[59]

REJECTED LEGISLATION/REGULATIONS: In comments on a 2014 rulemaking[60] in TX, one commenter recommended including in the rule the right of the Commission to implement graduated maximum allowable injection pressure.

Injection Volume

Regulatory restriction on the volume of fluid injection is much more limited. None of the jurisdictions' regulations explicitly limit the total injection volume for disposal wells, nor do they provide a formula for making a maximum volume determination (see Q8). Nevertheless, all of the jurisdictions consider maximum volume or injection rate (volume per time period) in their permitting.

- The AR Oil and Gas Commission requires a proposed daily injection rate (Form 36). Additionally, though the AR DEQ does not regulate the UIC program for Class II wells, it regulates the surface facilities for injection wells and requires maximum daily injection volume information in its permitting for the surface structures of an injection well (Notice of Intent, General Discharge Permit 0000-WG-SW).

- While CO regulations do not specify a maximum volume, it is determined during the permitting process based on zone-thickness, reservoir height, and porosity with the purpose of constraining the life of the well.[61] Porosity is a contributing factor to induced seismicity as it affects the amount of fluid needed to increase the pore pressure of a rock, and high pressure fluid in a fault zone can reduce the frictional strength of a fault and cause slippage.[62] The state requires that the maximum injection rate for normal operations be reported on the permit application (Form 31) and the approval section of the Injection Well Permit Application (Form 33) specifies a maximum injection volume limit.

- In KS, an injection well permit application must include the average daily rate of injection in barrels per day and regulations imply that a maximum injection rate is determined because

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[59] Railroad Commission of Texas, Injection/Disposal Well Technical Review, Injection Pressure Requirements, available at: https://www.rrc.state.tx.us/oil-gas/publications-and-notices/manuals/injectiondisposal-well-manual/summary-of-standards-and-procedures/technical-review/

[60] TX Legal Counsel Review, 2014

[61] COGCC Underground Injection Control and Seismicity in Colorado, January 19, 2011, available at: http://cogcc.state.co.us/documents/library/Technical/Induced%20Seismicity/Underground%20Injection%20Control%20and%20Seismicity.pdf ;

[62]The National Academy of Sciences, Induced Seismicity Potential in Energy Technologies: Chapter 2, Types and Cause of Induced Seismicity, 48, available at: https://www.nap.edu/read/13355/chapter/5#48

KS charges a fee for changing the maximum rate. KS had not, as of early 2017, eliminated existing, nor prohibited new wells in the Arbuckle Formation, but has restricted injection volumes for wells and restricted siting of new high volume wells within ¼ mile of existing high volume injection wells in order to restrict the total volume injected in an area.[63]

- OH does not specify a maximum disposal volume for all wells, but permitting requirements (the sizes of the area of review) differ for injection wells with average daily volumes of less than and greater than two hundred barrels per day. OH requires a proposed daily average and maximum volume for saltwater injection wells (Form 210), but allows only 10 barrels per day in certain annular disposal wells. Following seismic activity connected to disposal wells in the Youngstown, OH area, all OH disposal well operators are required to install an electronic recording system to effectively track all fluids brought to the site.[64]

- OK regulations do not specify a maximum volume or injection rate, but adjust other permitting or operational requirements to various expected injection volumes. See, for example, well permitting information (Q4) and thickness of geologic strata required in siting decisions (Q5). OK has also declared by directive several ad hoc injection volume reductions in order to reduce the occurrence of seismicity (Q11).

- PA requires a proposed maximum and average daily volume in the permitting process. These can be determined based on either historical injection volume into the relevant geologic formation or the injection rate used to determine the fracture gradient of the formation.[65]

- In their permitting processes, TX (Form H1-A) and EPA (Form 7520-B) require operators to propose an average and maximum daily fluid volume to be injected, though it is unclear whether a permit would be denied based on this factor.

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[63] Kansas Corporation Commission. Report and Recommendation, Conservation Division, RE: Staff Recommendation Docket No. 15-CONS-770-CMSC. 3 31 17, available at: http://estar.kcc.ks.gov/estar/ViewFile.aspx/20170331164547.pdf?Id=cffb006f-cb05-4cbf-9a20-35db76d8ce46 (limited injection due to earthquakes linked to disposal into the Arbuckle Foundation; analysis of large volume wells within ¼ mile of new large volume well permit applications)

[64] Youngstown FAQs.

[65] Pennsylvania Department of Environmental Protection, Assessment of the Mechanical Integrity, for drilling a new underground injection well, by Windfall Oil & Gas Inc. (2017), Operation Data, available at: http://files.dep.state.pa.us/RegionalResources/SWRO/SWROPortalFiles/Windfall%20Injection%20Well%20Permit%20Documents/Permit/FINAL%20Zelman%20Mechanical%20Integrity%20Review.pdf

REJECTED LEGISLATION/RULES: In 2018, two bills before the KS legislature (HB 2641[66] and HB 2672[67]) proposed prohibiting injection of more than 8,000 barrels of saltwater or other fluid per day into any Class II injection disposal well.

Monitoring, Record Keeping, and Reporting (Q9 – Q10)

All of the jurisdictions require some type(s) of monitoring, record keeping, and reporting to verify their compliance with permit requirements and identify potential problems. These data can provide agencies with valuable information for managing induced seismicity. The types of processes or events monitored varies among the jurisdictions.

Seismicity Monitoring

Perhaps most pertinent to limiting or responding to induced seismicity is the monitoring of earthquakes during injection. Yet of all the jurisdictions reviewed, only OH has a specific regulation on seismicity monitoring (see Q9). Some other jurisdictions administratively require operators to monitor for earthquakes; others request voluntary seismic monitoring.

Operator Seismicity Monitoring

OH may require operators, on a case-by-case basis, to prepare a "plan for monitoring seismic activity" near wells, based on geology and proximity of the injection zone to the Precambrium basement rock.[68] And, according to Groundwater Protection Council peer reviewers, OH can also require additional seismic monitoring based on their regulation authorizing geological investigations to identify potential faulting.[69]

The following are examples of operator required monitoring not specified in regulation:

- AR has required an operator, through permit conditions, to install a seismic monitoring array and share all acquired data with the Commission.[70]

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[66] House Bill No. 2641 (2018) (HB 2641), available at: http://kslegislature.org/li_2018/b2017_18/measures/documents/hb2641_00_0000.pdf

[67] HB 2672.

[68] Ohio Admin. Code § 1501:9-3-06 (C)(3); see GWPC IS Primer.

[69] OH Peer Review, at 36 (2017), citing Ohio Admin. Code § 1501:9-3-06 (C)(2) (regarding geological investigations of potential faulting).

[70] The research team has not attempted to determine if this is an anomalous requirement or standard practice. See, Arkansas Oil and Gas Commission, Order No. 63-2008-01, Commission Review of Applicant's Request (Feb. 2008) (AR Order 63-2008-01), available at: http://www.aogc2.state.ar.us/Hearing%20Orders/2008/Feb/63-2008-01.pdf

- CO, through the use of permit conditions, requires the installation of seismic monitoring at proposed commercial wells and all well sites which plan on injecting over 10,000 barrels per day.

- OK, through agency action, required proposed wells that did not rise to their "red light" standards, but were still of concern, to have seismometers on location in order to be permitted.[71]

- PA can require injection well operators, through special permit conditions, to develop and implement a comprehensive seismic monitoring program. If the geologic review conducted of the area uncovers seismicity potential, the Department of Environmental Protection (PA DEP) will impose a seismic monitoring program on operators through special permit conditions. The plan requires the installation of seismic monitoring equipment, and the immediate notification of all seismic events recorded to better understand and mitigate all induced events.[72]

Federal/State Seismicity Monitoring

In addition to the minimal operator seismic monitoring, all of the states have agencies that conduct, to a greater or lesser extent, state-wide or targeted seismic monitoring for natural and induced seismicity.

- AR has a small network of nine permanent broadband seismic stations strategically placed within selected state parks across Arkansas. This Arkansas Seismic Network (ASN)[73] was established to achieve better and more uniform earthquake detection outside of the New Madrid seismic zone. The network, installed in spring of 2010, is integrated with the regional and national seismic networks. It is operated and maintained in cooperation with the Arkansas Geological Survey, Center for Earthquake Research and Information at the University of Memphis and Arkansas State Parks.

- CO has a seismometer network, but relies heavily upon USGS seismic observations to supplement operator seismic monitoring[74] and to "actively manage" injection operations in

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[71] See OK Directive August 3, 2015. http://www.occeweb.com/News/08-03-15VOLUME%20ADVISORY%20RELEASE.pdf

[72] See, e.g., Pennsylvania Department of Environmental Protection, Seneca Resources Corporation, Class II Disposal Well Seismic Monitoring and Mitigation Plan (Mar. 2017)(Seneca Mitigation Plan), available at: http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/Underground%20Injection%20Wells/Seneca/Class%20II%20Disposal%20Well%20Seismic%20Monitoring%20Plan%20and%20Mitigation%20Plan.pdf

[73] Arkansas Seismic Network, Arkansas Geological Survey, available at: https://www.geology.arkansas.gov/geohazards/arkansas-seismic-network.html

[74] CO Governor's Task Force, 2014. See also, Colorado Geological Survey, Seismometer Networks, available at: http://coloradogeologicalsurvey.org/geologic-hazards/earthquakes/seismometer-networks/

areas of the state (Raton Basin and Weld County) that have experienced seismicity thought to be related to wastewater injection.[75]

- KS -- The Kansas Geological Survey (KGS) monitors seismic activity with both a permanent, regional network and temporary monitoring stations currently focused on the seismically active south-central area of the state. Network installation, part of a state Seismic Action Plan, began in 2014, prompted by escalation of earthquake activity in 2013. The KGS can recommend deploying portable seismic arrays in the areas of high interest disposal wells based on physical attributes of the wells and injection well data provided by the Kansas Corporation Commission.
- Monitoring required of injection well operators is complemented in OH by the Division of Geological Survey OhioSeis monitoring network.[76]
- The OK Geological Survey operates a seismic monitoring system throughout the seismically active regions of the state.[77]
- PA has its own seismic network – nearly tripled in size to 30 stations in 2016 – and also uses data from nearby states to provide fairly even data coverage across PA.[78]
- TX – The Bureau of Economic Geology operates the TexNet seismic monitoring program focused on locating and determining the origins of earthquakes within the state. The program of monitoring and research, created in 2016 and operated with state funding, is also supported by multiple industry sponsors. [79]
- EPA does not monitor for seismicity related to Class II wells, but the U.S. Geological Survey operates a national seismic monitoring array and may deploy temporary seismic stations to better understand earthquakes that may be induced by human activity, including oil and gas development.[80]

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[75] COGCC 2017 Annual Report.

[76] Ohio Department of Natural Resources Division of Geological Survey, OhioSeis: Ohio's earthquake monitoring network, available at: http://geosurvey.ohiodnr.gov/earthquakes-ohioseis/ohioseis-home

[77] See, Oklahoma Geological Survey, Seismic Monitoring Program, available at: http://www.ou.edu/ogs/research/earthquakes/seismicstations

[78] The Pennsylvania State Seismic Network, available at: http://paseis.geosc.psu.edu/about.html

[79] Bureau of Economic Geology, TexNet Seismic Monitoring Program, available at: https://www.beg.utexas.edu/texnet-cisr/texnet; see also 2018 Biennial Report on Seismic Monitoring and Research in Texas, November 28, 2018, available at: https://www.beg.utexas.edu/files/texnet/docs/TexNet_Biennial%20Report2018.pdf

[80] See Induced Earthquakes: Observational Studies and related webpages at: https://earthquake.usgs.gov/research/induced/studies.php

REJECTED LEGISLATION/REGULATION: In comments on a 2014 rulemaking in TX,[81] one commenter generally suggested reducing the burden on applicants and operators of injection wells regarding information to justify issuance of a permit or to better understand seismicity issues and, instead, solicit funding from the legislature to fund studies. Alternatively, another commenter recommended requiring a seismic monitoring plan, such as pre- and post-monitoring of the region for earthquakes and requiring monitoring before injection and testing and recording of original bottom hole injection interval pressure. This commenter suggested that seismic monitoring plans should assess induced seismicity for existing permits as well.

Operational Parameters Monitoring

Aside from monitoring seismic activity near injection wells, all of the jurisdictions require monitoring, record keeping, and reporting of various parameters related to well operations (see Q10). All jurisdictions require monitoring/reporting of fluid volumes or injection rate. Some states (e.g., AR and OK) have special rules for seismically active areas or commercial disposal wells.

Fluid Volumes

- In AR, operators must report, on a quarterly basis, maximum monthly fluid volumes (Form 14), while operators within lands associated with the Guy-Greenbrier Earthquake Swarm, must measure injection volume at least daily (Form 14B). Commercial wells are required to file monthly reports with maximum daily injection rates, daily volumes injected, and cumulative volumes injected since the commencement of operations (Form 14A).

- In CO, operators must report volume of produced water (Form 7) and other Class II fluids (Form 14) injected into the well monthly, within 45 days of the end of the month. CO rules specify the manner in which volumes are measured, computed and reported.

- In KS, operators must report on a yearly basis the total volume of fluid injected (Form U3C).

- In OH, saltwater injection well operators must monitor injection volumes on a daily basis and annually report the total volume injected (Form 204). Annular disposal wells must annually report the total volume of fluid injected (Form 205).

- In OK, monitoring and reporting requirements have evolved during the period of increased seismic activity associated with wastewater disposal. Several changes were instituted for specific areas through OK Corporation Commission directives followed by formal rulemakings. Currently, operators of non-commercial wells must monitor injection rate and annually report total fluid volume injected as well as monthly subtotals (Form 1012); commercial wells report semi-annually (Form 1012C). Operators of Arbuckle formation disposal wells must record the daily fluid volume injected and report it upon the Commission's request. If requested by the Pollution Abatement Department, operators of wells within seismicity areas of interest must monitor volumes on a daily basis and report

[81] TX Legal Counsel Review, 2014.

at least weekly (Form 1012D). Areas of interest (AOI) in OK have also evolved and expanded over the last several years. An AOI was defined as a 10 kilometer (about 122 square miles) area surrounding a 4.0 magnitude earthquake,[82] and then the center mass of an earthquake "cluster" (August, 2015).[83] By early 2016, the areas of interest in central and western OK covered more than 10,000 square miles[84] and in May, 2018, 15,000 square miles.[85] As of March, 2016 all wells in AOIs were requested by directive to monitor daily and report weekly.[86]

- Operators in PA must submit a copy of the EPA annual monitoring report to the PA DEP.
- In TX, operators must monitor injection rate on a monthly basis. Annually, operators must report the total volume of liquid and/or gas injected for each month (Form H-10).
- EPA regulations require observation of flow rate and cumulative volume weekly for fluid disposal. These observations must be recorded every 30 days, though operators are only required to report, at a minimum, annually the average total volume injected (Form 7520-11). However, there are quarterly reporting forms (7520-8) for the minimum, maximum, and average injection rate for each month and cumulative monthly total volume injected.

Injection Pressure
All jurisdictions also require monitoring/reporting of injection pressure (see Q10).

- AR operators must report on a quarterly basis[87] the maximum daily injection pressure required to inject water into the formation each month (Form 14); commercial wells (Form 14A) and wells situated in areas associated with the Guy-Greenbriar earthquake swarm (Form 14B) file monthly reports of daily recorded, daily maximum well pressures.
- CO rules do not specify measuring and reporting of injection pressure, but the required monthly reporting form (Form 7) includes surface injection pressure (psig) for tubing and/or casing.

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[82] OK Media Advisory, 3/25/15 (change expected to more than double the number of disposal wells in the AOI).

[83] OK Media Advisory – Oil and Gas Disposal Well Volume Reduction Plan, August 3, 2015 (OK Media Advisory, 8/3/15). http://www.occeweb.com/News/08-03-15VOLUME%20ADVISORY%20RELEASE.pdf

[84] OK Media Advisory, 3/7/16.

[85] OK Media Advisory – Medford area earthquake, May 17, 2019, available at: http://www.occeweb.com/News/2019/05-17-19-Medford_EQ_Advisory.pdf

[86] OK Media Advisory, 3/7/16.

[87] While the regulation Ark. Code R. RULE H-3 (n) indicates quarterly filing, AR Form 14 is a monthly form to be filed no later than the 15th of the month following the month covered in the report.

- KS operators must annually report the monthly average injection pressure and maximum injection pressure of that year (Form U3C).

- OH saltwater injection well operators must monitor injection pressures on a daily basis. Annually, operators must report the maximum injection pressure and average daily injection pressure (Form 204).

- OK has regulations for both "required" and "requested" monitoring parameters. All disposal well operators must monitor surface injection pressure and annually report their monthly data on daily average pressure rates (Form 1012); commercial wells report semi-annually (Form 1012C). Operators of commercial saltwater disposal wells and operators of Arbuckle formation disposal wells must record the daily casing tubing annulus pressure and surface injection pressure and report them upon the Commission's request. If requested by the Pollution Abatement Department, operators of wells within seismicity areas of interest must monitor pressures on a daily basis and report at least weekly (Form 1012D) and supply the Department with bottom hole pressure data.[88] Further, operators with "yellow light" permits in the Commission's traffic light system are required to shut down wells every 60 days for bottom hole pressure readings.[89]

- Operators in PA must submit a copy of the EPA annual monitoring report to the PA DEP.

- TX operators must monitor injection pressure on a monthly basis. Annually, operators must report the average and maximum pressures (Form H-10).

- EPA regulations require operators to observe injection pressure and record the average injection pressure monthly. EPA's Quarterly Injection Monitoring Report (Form 7520-8) requires operators to report the minimum, maximum, and average injection pressure that occurred each month during the quarter. Operators are only required to report annually the average injection pressure and have the option to report the minimum and maximum pressures from each month (Form 7520-11). Injection pressure must be observed weekly for fluid disposal wells. These observations must be recorded every 30 days.

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[88] See also, OK Media Advisory, 3/7/16 (All operators were requested in a directive to do so).

[89] OK Media Advisory, 8/3/15 (including other conditions for proposed wells not meeting "red light" (stop) standards, but still of concern). The traffic light system has evolved in OK, but in 2015, yellow light permitting included special permitting for any well proposed within three miles of a stressed fault, even in the absence of seismicity and for any well proposed within six miles of an earthquake swarm or magnitude 4.0 event.

See also OK 12-2-19 Draft Chapter 10 Amendments, at 73 (A proposed rule change in 2019 would add "requested monitoring" requirements for areas of interest designated for "potential environmental or public safety impacts" and change the repository of these data to the Manager of the Induced Seismicity Department).

Water Quality

While the quality of injected wastewater has not been and is not likely to be implicated in inducing seismicity, understanding the source and/or quality of wastewater may be useful in finding disposal or reuse alternatives if underground injection needs to be severely curtailed. Only CO, KS, PA, and EPA specifically require reporting on the quality or type of injected fluids (see Q10).

- CO requires information on the type of non-produced water wastes received from transporters (e.g., groundwater recovered during a remediation project).
- KS requires reporting on the kind of fluid injected and considers it when making permitting decisions.
- PA and EPA require monitoring the nature of injected fluids and reporting any major changes in characteristics or sources.
- AR and OK regulations only require information on the generator or source of injection fluids for commercial disposal wells (AR Form 14A and OK Form 1012C). For non-commercial wells, OK operators must submit a yearly report on the type of fluid injected and the source of all freshwater fluids (OK Form 1012).
- OH operators do not have to report the quality or type of fluid, but regulators have the authority to sample injection fluids at any time during injection operations.
- Only TX lacks regulations regarding the quality or type of fluid injected, though Form H-10 requires reporting of all fluid types injected during the reporting cycle.

Other Parameters

Other requirements for reporting related to injection (See Q10) include:

- Identifying the injection interval (AR; TX on Form H-5), mechanical failures (OH; OK), any significant pressure change (TX), and accidents (PA). These and other states may require similar information on UIC permit or operation forms or, more generally, related to operation of all wells.
- KS has the potential to have the most comprehensive reporting requirement specifying that operators must report "any other performance information that may be required by the conservation division," although the report need not be filed until March of the following year.

The ability of an agency to receive injection data in a timely manner is important to effective management of induced seismicity. Requirements for data compilation and reporting vary from daily-to-annual compilation and monthly-to-annual reporting. Some states (e.g., AR and OK) have special rules for seismically active areas or commercial disposal wells, e.g., OK can require reporting 'on-demand' for data from Arbuckle formation disposal wells.

REJECTED LEGISLATION/REGULATIONS: A commenter on the 2014 rulemaking in TX[90] recommended that the Commission revise TX rules to require monthly reporting of injection volumes and pressures along with maintaining daily injection volumes and pressures that may be requested at any time.

Adaptive Management (Q11)

All jurisdictions have authority to require corrective action under certain circumstances (see Q11). These actions include modifying or preventing injection operations. At least four states have responded to induced seismicity by shutting in wells or at least temporarily reducing fluid injection volumes (CO, KS, OH, and OK). At least one state, OH, has required operators to modify injection pressures in response to suspected induced seismicity. The authority to take these corrective actions is crucial for timely response to induced events. The regulatory language allowing for corrective actions varies by jurisdiction with some actions explicitly authorized and others made possible by general authority.

Prohibit Injection – Shut-in Wells

All jurisdictions except TX specifically allow the regulatory agency to prohibit injection (e.g., suspend operations, shut-in the well), but even TX can effectively shut-in a well by revoking the operating permit (see below). Although only OK can specifically shut-in a well due to seismicity, all other jurisdictions have agency discretion when there is potential harm to the public or an emergency situation exists. Regulatory rationales for prohibiting injection, include:

- AR – If a well is leaking, if there is any fluid migration into USDWs, or if there is imminent danger to the health or safety of the public.
- CO – If the well lacks mechanical integrity or, if, by violating a rule, order, or permit requirement, a well operator creates an emergency situation.
- KS – If there is a failure in mechanical integrity, and if a well operator violates any provisions, rules, or regulations and shut-in is necessary to prevent pollution and protect water quality. Also, if damage may result if immediate remedial action is not taken, an emergency adjudicative proceeding can authorize shut-in.
- OH – If an operator's failure to comply with an order creates an imminent danger to health or safety of the public or is likely to result in immediate and substantial damage to the natural resources of the state. Additionally, a well can be shut-in if there are mechanical failures that reasonably could or actually have caused the contamination of land, surface waters, or subsurface waters.
- OK – As amended in 2017, OK regulations specify that the Conservation Division may "shut down or take other action including the issuance or execution of administrative agreements,

[90] TX Legal Counsel Review, 2014.

. . . to address matters including, but not limited to seismic activity. . . ."[91] The first Arbuckle disposal well was shut-in due to earthquake concerns in September, 2013. As of March, 2016, when OK law on Corporation Commission authority was amended, there were 27.[92]

- PA – If the well operator is engaging in unlawful conduct or conduct that causes immediate and irreparable harm to the public.

- EPA can prohibit injection if a permit or inventory information was not submitted timely, or if a well operator fails to comply with a request for information or does not provide financial assurance information, or if the well lacks mechanical integrity.

Revoke Permit

All jurisdictions except OK explicitly provide for revoking a permit, although TX is the only state that explicitly allows for revoking a permit if a well is contributing to seismic activity.

- AR can revoke a permit if the holder fails to meet permit conditions, the permit was issued in error, or the holder falsified or otherwise misstated any material information in the application form. In 2019, AR amended its regulations to explicitly state that the agency could revoke a UIC Well permit for failure to comply with the agency's operating requirements for commercial and non-commercial injection wells. Additionally, the AR DEQ can revoke a surface facilities permit for Class II wells if they determine that the activity endangers human health or the environment.[93] 2019 AR regulations specify that

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[91] Okla. Admin. Code § 165:10-5-7 (g)(1). Administrative shutdown or other action regarding a well. This regulatory addition followed a statutory change in 2016: Okla. Stat §17-52 (D) Corporation Commission - Jurisdiction, power and authority - Environmental Jurisdiction of Department of Environmental Quality, effective 4 18 16 (If a well creates an emergency situation that has "potentially critical environmental or public safety impact . . . the Commission may take whatever action is necessary, without notice and hearing, including without limitation the issuance or execution of administrative agreements by the Oil and Gas Conservation Division of the Corporation Commission, to promptly respond to the emergency.").

[92] Gov. Mary Fallin, Press Release - Gov. Fallin Says USGS Earthquake Hazard Map Shows State Regulators Are Taking Correct Action (March 28, 2016), available at: http://services.ok.gov/triton/modules/newsroom/newsroom_article.php?id=223&article_id=19739 (There are currently [as of March 2016] 27 Arbuckle disposal wells shut in as a result of OGCD actions.) See also, Mack, J., A Handy, J. Barrett, and K. Jones. 2016. Oil and Gas Industry May Face Increased Regulatory, Transactional, and Litigation Risks. Oil & Gas Journal 13(7), available at: http://www.ogfj.com/articles/print/volume-13/issue-7/features/seismicity-triggering-more-regulation.html ("Until now [2016], companies could successfully resist the OCC's directives since the traffic light system was not a part of the state's official regulations. In response, House Bill 3158 was drafted to clarify the OCC's authority to "take whatever action necessary without notice and hearing" to respond to emergency situations. HB 3158 received unanimous support in both chambers of the Oklahoma State Legislature, and it was signed into law by Governor Mary Fallin on April 18, 2016.").

[93] See A. C. A. § 8-4-101, et seq; See also, Authorization To Construct And Operate The Surface Associated With A Disposal System For Subsurface Injection Of Salt Water And Other Oil Field Wastes Under The

the AR DEQ has jurisdiction over surface facilities of both commercial Class II wells and high volume, non-commercial disposal wells.

- In CO, the Commission may revoke a permit if the holder fails to perform any required corrective action/abatement or fails to comply with a cease and desist order with regard to violation of a permit provision.
- KS can revoke a permit for just cause after a hearing.
- In OH, the chief can revoke an unused permit by order if the owner of a well has failed to comply with an order or is causing, engaging in, or maintaining a condition or activity that is an imminent danger to health or safety of the public or damage to the state's natural resources.
- PA can revoke a permit if the holder violates the Clean Streams Law, the Solid Waste Management Act, any other statute administered by the department of oil and gas and the result of such a violation is unsafe operation or environmental damage.
- TX can revoke a permit if injection is likely to be contributing to seismic activity and for several other specified reasons.[94]
- EPA can revoke a permit for noncompliance by the permittee with any condition of the permit, for failure to disclose all relevant facts/misrepresentation of any relevant facts in the application or during the permit issuance process, or if a determination finds that the permitted activity endangers human health or the environment and can only be regulated to acceptable levels by termination of the permit.

Modify Permits

State and federal regulations do not explicitly state that the agency can reduce injection pressure, injection rate, or volume of fluids, but CO, TX and EPA can effectively do so with the more general authority to modify permit terms. The justification necessary for modifying a permit varies among these jurisdictions, but, arguably, all the justifications could be used to reduce injection pressure, rates or volumes. Other states have reduced either volume or injection pressure with administrative actions.

- CO can modify a permit if the operator fails to take corrective action or abate a problem or comply with a cease and desist order regarding a permit violation, or if failure to take required action results in an emergency situation. CO uses a traffic light system as a guide

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Provisions Of The Arkansas Water And Air Pollution Control Act. Section B, Standard Permit Conditions, at 17, available at: https://www.adeq.state.ar.us/water/permits/nodischarge/pdfs/sw/0000-wg-sw.pdf

[94] Other reasons include: there is a material change to the conditions of operation or completion of a disposal well, there is a likelihood that freshwater will be polluted, any substantial violations of the permit, the permit holder has misrepresented material facts in obtaining the permit, if injected fluids are escaping the disposal zone, or there is waste of natural resources.

in managing seismicity at injection wells, which recommends at least modification of operations if a ML 2.5 earthquake is felt near the well site.[95] If an operator fails to modify operations after such an event, CO could view this as a permit violation.

- TX can modify (or suspend or terminate) a permit for just cause and after notice and opportunity for a hearing for various reasons, including, as of 2014, that injection is "likely to be or determined to be contributing to seismic activity."[96]

- EPA may modify permits for various reasons including obtaining information that would have justified a different permit condition at the time of permit issuance.

Modify Operations

Other states use administrative authority without explicitly changing permit terms:

- While AR does not have explicit regulatory authority to modify permits, it has asserted this authority on a case-by-case basis as a UIC well permit condition.[97]
- While a "change in permit" was not explicitly addressed, in 2017, the Court of Common Pleas, Franklin County, OH, adopted a plan of the Division of Oil and Gas Resources Management to allow the AWMS #2 well to resume operations of its injection well. The plan included a schedule for starting with reduced injection pressure and volume and increasing both pressure and volume dependent on results of seismicity monitoring.[98]

[95]CO Governor's Task Force, 2014.

[96] See 16 Tex. Admin. Code § 3.46 (d)(1)(F); Railroad Commission of Texas, Railroad Commission Adopts Disposal Well Rule Amendments Today, 10/28/2014 (TX Disposal Rule Amendments, 2014) (Rule amendment in 2014 clarifies "Commission's staff authority to modify or suspend or terminate a disposal well permit, including modifying disposal volumes and pressures or shutting in a well, if scientific data indicates a disposal well is likely to be or determined to be contributing to seismic activity), available at: https://rrc.texas.gov/all-news/102814b/

[97] AR Order 63-2008-01 ("That the Director shall issue a permit . . .subject to the following conditions: . . .b. That the Director shall have ongoing authority to amend, revoke, or otherwise modify any aspect of the injection permit as deemed necessary. . .")

[98] See, American Water Management Services, LLC v. Division of Oil and Gas Resources Management, PM-16CV006218OD423-R87, available at: https://vindy.media.clients.ellingtoncms.com/news/documents/2017/01/25/16-CV-006218.pdf

REJECTED LEGISLATION/REGULATIONS: In considering the TX Commission's authority to modify permit terms, the original language of the proposed 2014 rule gave the Commission authority to modify the permit "if injection is *suspected of or shown to be* causing seismic activity"[99] (emphasis added). Two commenters recommended requiring that injection should be "demonstrated by reliable scientific and engineering data" to be causing seismic activity before a permit is modified, suspended or terminated for seismic activity.

Broad Authority

Besides authorization to take specific actions, some jurisdictions have broad authority to take corrective actions either in an emergency or when necessary to protect the public or the environment. For example, KS and OK agencies can take "other actions" in certain emergency situations.

- The KS code provides that the commission, on the basis of emergency adjudicative proceedings, "may authorize its agents to enter upon the land where the well is located and take such remedial action necessary . . . ." if damage may result if immediate remedial action is not taken.[100]

- In addition to shutting-in wells, OK regulations specify that the Conservation Division may ". . . take other action including the issuance or execution of administrative agreements, . . . to address matters including, but not limited to seismic activity. . . ."[101] Both before and after this regulation was formalized, OK has required, by directive, the plugging back of wells to above basement rock and many injection volume reductions, ranging from significant percentage reductions by multiple wells[102] to a 70 percent reduction by an individual well.[103]

- PA can create a mandatory preliminary injunction if it finds that a well operator is engaging in "conduct causing immediate and irreparable harm to the public." PA also uses a traffic light system to mitigate induced seismicity from injection wells. In one example mitigation plan, if a well in a red-light area records a magnitude 2 or greater earthquake within 2 miles

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[99] TX Legal Counsel Review, 2014), at 2.

[100] Kan. Stat. § 55-162 (b). Finding reasonable cause to believe that person has violated act or rules and regulations; hearing; procedure; order; immediate remedial action; reconsideration and judicial review; investigations; sealing of well; removal of seal, penalty.

[101] Okla. Admin. Code § 165:10-5-7 (g)(1). Administrative shutdown or other action regarding a well).

[102] See OK Directives and Media Advisories 2015-2019, available in OCC News at: http://www.occeweb.com/News/news.htm . For example, OK Media Advisory, 3/25/15 (Over 300 wells, over one-third of wells in the Arbuckle formation, must be plugged back to shallower depth or reduce injection volumes by 50%).

[103] See OK Directive, April 9, 2018 – Directive for disposal well in Covington area to reduce volume by 70 percent; available at: http://www.occeweb.com/News/2018/04-09-18ADVISORY.pdf

of the well, PA DEP will order injection operations to cease until it authorizes injection. In a yellow-light area, PA DEP will order the injection rate to be reduced by 50% until otherwise authorized whenever three or more consecutive seismic events between magnitude 1 and 2 are felt within 2 miles and within a 7-day period.[104]

- In TX, the commission need only find that an emergency exists to create an order without notice or hearing to protect public health, safety, or welfare in the case of an emergency, though that emergency order can only remain in force for 15 days from its effective date.

- EPA regulations require state programs (authorized under SDWA § 1422) to have specific remedies, including restraining unauthorized activity "endangering or causing damage to public health or environment." But none of the states in this survey were awarded Class II well primacy under SDWA § 1422.

4. Public Participation, Financial Assurances, Fees, and Liability (Q12 - Q16)

Most of the law discussed in the previous sections addresses the potential hazards of induced seismicity. The law discussed in this final section is more applicable to ameliorating or at least redirecting risk. The dataset presents four types of regulations that could engage the public in helping to manage wastewater injection or help to ensure that the industry internalizes more of the costs of induced seismicity:

- Q12 compares regulations that require giving notice, seeking public comments, or offering public hearings on injection well permits and operation of wells;
- Q13 addresses the types and amounts of financial assurances that operators are required to post to permit and operate a disposal well;
- Q14 reports administrative fees charged by the jurisdictions either for permitting or annual operations of disposal wells; and
- Q15 and Q16 address the manner in which jurisdictions address liability issues related to injection wells.

Public Participation (Q12)

Requirements for public participation, including providing the public with notice, opportunity to comment on or protest a proposed permission or action, or opportunity to observe or participate in administrative hearings can occur both during an injection well permitting process or while a permitted well is operating.[105] Requirements for providing public participation opportunities can apply to either the management agency itself or to permit applicants / well operators.

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[104] See, e.g., Seneca Mitigation Plan.

[105] The dataset is focused on operation of the injection control program rather than states' acquisition of primacy. Thus the dataset does not address notice/comments/hearings related to a state's original application for and assumption of the permit program (primacy), nor does it address making changes to those

Permitting

Although none of the jurisdictions have public notice/comment/hearing regulatory requirements specific to seismic events, all jurisdictions require public notice and opportunities for public hearings regarding permit applications for Class II wells and all but AR have additional regulations regarding public comments or protests (see Q12). Notice is generally by publication in a newspaper and by mail to specific individuals, such as surface owners or identified by terms such as "affected" or "interested" individuals.

- EPA requires public notice or hearings, allowing for at least 30 days of public comment, to any individual who has requested by writing to be on the notification list. Any individual can comment on draft permits.
- AR regulations require notice in a local newspaper during the permitting process. Additionally, there are strict notice and hearing requirements for any proposed well within areas likely to contain faults or near a Moratorium Zone.
- CO regulations require notice of well permit applications to be posted in a Denver county newspaper and in any county where the affected land is situated. Additional notice is required to all surface owners within one-quarter mile of the well, and well owners producing from the injection zone within one-half mile of the well. In CO, the public can search by county for pending UIC well permits.[106]
- OH regulations require notice to permit a new well within an urbanized area to all landowners within 500 feet and to the executive authority of the township. The Ohio Oil and Gas Division is responsible for publishing notice of permit applications in a newspaper of general circulation in the county of the affected land as well as individually notifying all owners or operators of wells producing from the same formation as the injection well and within the area of review.
- In OK, the recipients of notice for disposal well permits currently varies with the type of well. Notice to the surface owner of the proposed injection well site is required. Further, operators must publish notice of proposed injection well projects in local newspapers as part of the permit application.[107] For commercial disposal wells, notice is broadened to surface owners and lessees of land adjacent and contiguous to the well site. 2019 proposed rule changes would eliminate notice to lessees, but expand notice to all surface owners

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state-operated permit programs despite the fact that advocating for changes to a program might promote changes that reduce the hazards or risk of induced seismicity.

[106] Colorado Oil and Gas Conservation Commission, Underground Injection UIC) Permits Search, available at: https://cogcc.state.co.us/permits3.html#/UIC

[107] Emery Gullickson Richards, *Finding Fault: Induced Earthquake Liability and Regulation*, Columbia Journal of Environmental Law, 24 (2015) (Finding Fault), available at: http://www.oilandgasbmps.org/docs/GEN442_InducedEarthquakeLiabilityandRegulation.pdf

within one mile of the proposed well for both commercial and non-commercial wells.[108] Notice to oil and gas well operators is also required for wells based on disposal volumes and types of wells and 2019 proposed changes would also expand these requirements.

Further, as mentioned regarding citing of injection wells in the Arbuckle Formation (see Q5), such wells cannot be administratively approved and wells in OK's AOI areas must have a public review.[109]

- PA regulations require notification of well permit applications to surface owners and water purveyors within 1000 feet of a vertical well bore. And a permit may be denied if there are "unresolved objections" to the well location, but only if those objections are by a coal mine owner or operator. A surface owner can object to a proposed well location, but only based on specific environmental and "public resource" considerations. In a more general statement about participation, PA regulations provide that "any person having a direct interest" in a relevant matter can request a conference with the department and notice will be given to all interested parties.

- TX regulations require notice to be delivered to all "affected persons" for commercial wells, including surface tract owners whose land abuts the affected land and in a newspaper in the affected area.

Operations

In most jurisdictions, public notice and opportunity to comment and access to a public hearing or conference are also available once the agency has granted a UIC permit, but it is more limited than the public participation opportunities during the permitting process. In three jurisdictions (EPA, OK, and TX) the required notice during operations is limited to issues not likely to include induced seismicity; in three others (CO, KS, and PA) notice must be provided regarding orders that could be issued during operations and relate to processes that could affect seismicity potential.[110]

- EPA regulations on public participation regarding well operations are specific to aquifer exemptions; in OK they are related to pollution complaints; and in TX they are specific to well plugging.

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[108] OK 12-2-19 Draft Chapter 10 Amendments, at 62.

[109] OK Media Advisory, 8/3/15 (Those proposed wells that do not meet "red light" (stop) standards but are still of concern . . . Must have public review).

[110]For example, CO has issued orders in regards to violations of maximum injection pressure, which occurred during the operation of wells. See COGCC, ORDER NO. 1V-329 (2008), available at: https://cogcc.state.co.us/orders/orders/1v/329.html

- AR – While not explicit in regulations, AR has cited to its permitting regulations (Rule H-1) for requiring a hearing prior to approving a permit amendment (increasing disposal volume and/or pressure) when the requested amendment is subject to objections.[111]

- CO requires notice of all orders to be given to the affected party and to be published in a Denver county newspaper, and a newspaper situated in the county where the affected land is situated. Additionally, any interested party may file a request to receive notice for up to three years when any petition is filed upon which a hearing may be held.

- KS requires operators to post notice to the landowner on whose land the subject well is located, and, if within one-half mile of the well, to other operators, owners of unleased acreage, and the owner of the mineral estate. Operators must publish public notice in the official country newspaper if they apply to change their permit per the instructions for Form U-8. If an interested party protests the application, then a hearing must be held.

- PA has the option to publicly publish notice of an order in a newspaper in circulation in Harrisburg and in the county where the affected land is situated, but can also give notice by personal service to the operator, or by U.S. mail to the operator or royalty owner affected.

While public notice in a newspaper may not be read by many, it may be the most effective method in operation in these states. And it has led to successful protests by area residents in OK at least once.[112] Notice to individuals within a short distance of an injection well is not likely to inform the entire at-risk population because earthquakes can be felt several miles from a problematic injection well. A notification system that allows interested parties to sign up with an agency to receive electronic notice might be the most effective if it were applied broadly to operator reports and agency orders.

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[111] REQUEST FOR AN ORDER APPROVING AN AMENDED CLASS II COMMERCIAL DISPOSAL WELL PERMIT; ORDER NO. 035-2-2012-01 (citing General Rule H-1 as requiring a hearing), available at: http://www.aogc2.state.ar.us/Hearing%20Orders/2012/February/035-2-2012-02.pdf

[112] Finding Fault, at 24, citing Barry Porterfield, *It's a Wrap for Disposal Well Issue*, PAULS VALLEY DEMOCRAT (Sept. 6, 2012, 9:30 AM) http://www.paulsvalleydailydemocrat.com/news/local_news/it-s-a-wrap-for-disposal-well-issue/article_e396bdc9-c178-5a23-8c47-c9611da8a34a.html (residents first hear of well permit application in legal notice).

REJECTED LEGISLATION/RULES: In 2018, a bill before the KS legislature (HB 2672[113]) would have tasked the corporation commission with providing the named surface owner, all landowners within one mile, and local governments within 15 miles of the proposed well the permit application and information on the hearing process and other public participation options. The change would have tasked the commission with providing a data repository on Class II disposal wells on their website (see §1(e)). The bill proposed creation of a citizens' injection well board to "protect the interests of Kansas citizens, businesses, counties, cities and townships in any proceedings before the state corporation commission concerning class II injection disposal wells." If passed, the board would have been able to employ a consumer counsel who could initiate actions, intervene in proceedings and complaint cases, and request rehearing or judicial review of state corporation commission orders or decisions (see §3).

Comments on the 2014 TX[114] rulemaking recommended (1) adequate public notice to elicit public comment and to engage public involvement through the permitting process, and accompanying hearing procedures, and (2) earnest appeals procedures for property owners who do not agree with or who are otherwise impacted by the Commission's permit determination in any case.

Financial Assurances (Q13)

All jurisdictions require the operator to post financial assurances, generally surety bonds, for injection wells. These bonds may be blanket bonds or on a per well basis (see Q13). States could use financial assurances to compensate the public and repair environmental damage from induced seismicity. But bonds, and especially blanket bonds, are often criticized as being insufficient to even protect the environment from the failures of disreputable operators.[115] To cover the costs of induced seismicity damage, states would likely have to change both the purpose and amounts of their required financial assurances.

In addition to bonds, various states also specify suitability of alternative financial assurances: letters of credit (all states); certificates of deposit (all but KS and TX); and cash (all but KS). All jurisdictions except AR make a general statement about the potential for "other types" of instruments to be acceptable if approved by the managing agency. Other types include escrow accounts and sinking funds (CO), liens (CO and KS); financial statements (OH); cashier's checks, bank joint custody receipts, other negotiable instruments (OK); and plugging insurance policies (TX). In KS an operator can show the requisite financial responsibility in lieu of posting a bond by demonstrating acceptable compliance with rules, regulations and orders over the previous three years and paying a nominal ($100) nonrefundable fee.

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[113] HB 2672.

[114] TX Legal Counsel Review, 2014.

[115] See e.g., Ho, Jacqueline, et al. 2016. Plugging the Gaps in Inactive Well Policy, Resources for the Future (This report is not specific to injection wells), available at: https://media.rff.org/documents/RFF-Rpt-PluggingInactiveWells.pdf

Purpose and Forfeiture

Ensuring the plugging of wells and reclamation of well sites is the principal purpose of financial assurances for all jurisdictions except KS, who's regulations do not state a specific purpose. In addition, a few jurisdictions specify other purposes of the financial assurance or occurrences that could prompt forfeiture.

- The KS financial assurance process is an operator licensure process simply to "assure financial responsibility."[116]
- CO regulations have financial assurances to ensure protection of the soil and to protect surface owners who are not parties to a lease or surface use agreement from unreasonable crop loss or land damage.
- Most states will hold a bond to more generally assure compliance with state law (AR, CO, OH, TX), commission rules (AR, OK, PA, TX), or conditions of the permit (PA, TX).
- No jurisdiction specifically requires financial assurance to compensate damage from induced seismic events.

Amount of Financial Assurance

All states also specify the amount, or provide a guideline for calculating the amount of financial assurances.

- Two states (AR, CO) and EPA have financial assurance regulations specific to injection wells:
  - AR - $25,000 for a Disposal well; $50,000 for a Commercial Disposal well.[117]
  - CO – For Class II commercial UIC well surface facilities and structures, the cost is $50,000 for each facility. For any well, the cost is $10,000/well for all wells less than three thousand feet and $20,000/well for wells greater than three thousand feet. CO has an additional financial assurance for operations with heavy equipment: $2,000/well for non-irrigated land, $5000/well for irrigated land, or a blanket assurance of $25,000.
  - While EPA does not provide a dollar amount, it specifies that the bond must cover the cost of closing, plugging, and abandonment of injection wells.
- The remainder of states (KS, OH, OK, PA, and TX) do not distinguish between financial assurances for injection and production wells. Three of these (KS, PA, and TX) require financial assurance based on the depth of wells which could, arguably, compensate for

[116] Kan. Stat. § 55-155 (d) Licensure of operators and contractors; requirements.

[117] Ark. Code R. RULE B-2: PROOF OF FINANCIAL RESPONSIBILITY REQUIRED TO BE FURNISHED (f)(4)(AR operators can supply blanket financial assurances of: 1) $25,000 for 1-25 wells; 2) $50,000 for 26-100 wells; or 3) $100,000 for 101 or more wells).

potentially greater expense in plugging deeper wells and mitigating their surface impacts. OH and OK require financial assurances on a per well or operator net worth basis.

- KS – The state does not specify an injection well financial assurance, but the general well assurance is $.75 times the total aggregate depth of all wells or a blanket performance bond where: 1-5 wells cost $7,500; 6-25 wells cost $30,000; and over 25 wells is $45,000.
- OH – Financial assurance is $5,000 per well or a statewide blanket for $15,000.
- OK – Before drilling, a $25,000 (or less, if negotiated) financial assurance or a financial statement showing the operator is worth at least $50,000 is required for both injection and production wells.
- PA – Financial assurance is based on number of wells and their depth.[118] But, for a surety bond, the price is $2,500/well or a blanket bond of $25,000.
- TX – Financial assurance is $2/foot of well depth for each well, though in no circumstances will it be less than $10,000. TX also has a blanket bond available.[119]

- States can also increase the standard amount of the financial assurance for various reasons.
  - In AR, the Director can require additional financial assurance based on: length of operation within the state, compliance history of the permit holder, environmental consideration of the well location, and other factors that may impact the cost of plugging and restoring the well site.
  - In order to demonstrate that operators are capable of fulfilling the obligations imposed by the state's oil and gas law, CO has the flexibility to increase financial assurance requirements based on an operator's pattern of non-compliance with oil and gas regulations in CO or other states, because special geologic, environmental, or operational circumstances exist which make the plugging and abandonment of particular wells more expensive, or due to other special and unique circumstances.

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[118] 58 Pa. C.S.A. Oil and Gas § 3225. Bonding (a)(1) (PA financial assurances are calculated at: Depth of less than 6,000 feet: 1) up to 50 wells is $4,000 per well; 2) 51-150 wells is $60,000 plus $4,000/well in excess of 50 wells; 2) 151-250 is $60,000 plus $4,000 for each well in excess of 150; 3) and more than 250 is $100,000 plus $4,00/well in excess of 250. For wells of depth greater than 6,000 feet the same number categories apply: 1) $10,000/well; 2) $140,000 plus $10,000/well in excess of 20; 3) $290,000 plus $10,000/well in excess of 50; 4) $430,000 plus $10,000/well in excess of 150 and 5) for 150 wells or more, $430,000 plus $10,000/well in excess of 150).

[119] 16 Tex. Admin. Code § 3.78 Fees and Financial Security Requirements (g)(1)(B) (TX blanket bonds are: 1-10 wells for $25,000; 10-100 wells for $50,000; and; 100 or more for $250,000).

- OK can require a surety in any amount greater than $25,000 and up to $100,000, after notice and hearing, that there is good cause for concern over pollution or improper plugging of wells by the operator or an affiliate.

- TX regulations do not provide specific reasons for an increase in financial assurances, but state that the amount of assurance can be greater than the amount needed to reclaim wells.

Fees (Q14)

The states charge various combinations of permit processing fees and annual operating (licensure) fees (see Q14).[120] EPA does not specify permit processing or operations fees. Both types of state fees are currently nominal, but, if sufficient, could offset the states' costs for monitoring and managing for induced seismicity.

Injection Permit Processing Fees

AR, KS, OH, OK, and TX have fixed injection well permit processing fees, ranging from $200 in KS to $1,500 in OK. Some states, for example AR, OH, and TX, charge a separate (additional) fee for drilling the well.

- OK's fees differ for commercial ($1500) and non-commercial ($250) wells.

- AR's fees include both a drilling fee ($300) for any disposal well and a separate fee to begin operating the commercial ($500) and non-commercial ($100) injection well.

- PA has a permit application fee for all wells adjusted to cover well permitting administrative costs, and the orphan and abandoned well program. PA's permit fees vary by depth of well.

Operations Fees

- AR, KS, OK, and TX have a fixed annual operation fee, ranging from $100 in AR and KS to $350 in TX.
- OK fees differ for commercial and non-commercial wells.
- OH has an operation fee calculated by volume injected and location of the source of fluids, ranging from $.05 - $.20 per barrel.
- In addition to its fixed fee, KS also has an operations fee adjusted to cover administrative costs, specifically including inspection, investigation, enforcement, and monitoring.

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[120] As of August 2019, CO fees are set to $0 for a disposal/injection well permit (Form 2), but will be reviewed in an upcoming rulemaking. See chart of applicable fees, available at: http://cogcc.state.co.us/documents/reg/Rules/LATEST/AppendixIII.pdf ; personal communications, Chris Eisinger, Colorado Oil and Gas Conservation Commission, August 23, 2019.

REJECTED LEGISLATION/RULES: In 2018, a bill before the KS legislature (HB 2672 §1(d)(2)[121]) proposed changing their permitting fee to "no less than $1000" and their $100 annual operating fee to a volume-based fee of $.01per 100 barrels of injected fluids, paid quarterly, to fund an injection well induced seismicity fund (see Q15).

A comment on the 2014 rulemaking in TX[122] recommended that the Commission increase the disposal well permit application fee to cover the additional work required of Commission staff.

Liability (Q15 – Q16)

Determining Liability

Most of the jurisdictions do not directly address liability or burden of proof regarding either the cause of seismicity or for damages caused by induced seismicity (see Q15).

Regarding whether or not a well is inducing seismicity, one state, AR, has generally addressed burden of proof standards in regulation, and another, TX, in administrative proceedings.

- AR regulations note that the Director has the burden of proof with a substantial evidence standard in abandoned well and emergency hearings. AR has used emergency hearings to shut-in wells likely to be inducing seismicity.[123]
- While burden of proof and standard of review are not explicit in TX oil and gas regulations, hearing examiners have decided individual cases approving a new permit and declining to modify an existing permit despite seismicity in the area of the wells. In a case regarding objections to a new injection well permit (Primexx, 2016[124]), Examiners did not explicitly state a burden of proof or standard of review, but noted that the operator applicant provided evidence and testimony, but the objecting adjacent landowner/farmer questioned

[121] HB 2672.

[122] TX Legal Counsel Review, 2014.

[123] See Arkansas Oil and Gas Commission, Order No. 051-2011-02 (Emergency Order), Cessation Order – Emergency Order (Mar. 2011) available at: http://www.aogc2.state.ar.us/Hearing%20Orders/2011/March%20(Special%20Hearing)/051A-2011-02%20Emergency%20Order%20-%20Final.pdf

[124] Primexx Permit Application, 2016 (With failure of the Commission to provide policy guidance or the agency staff to request additional information from the applicant or to propose any special permit conditions related to the area seismicity, and failure of the landowner to provide his own evidence, the Examiners concluded that there was no evidentiary basis to deny the injection well application. In their analysis, the Examiners noted that "evidence indicates the co-location of injection activity and seismic activity", but also that "locations of the seismic events are not accurately known because of inherent limitation of the regional seismograph network used to detect them." They also affirmed the Commission's authority to "modify, suspend or terminate a disposal permit if "injection is likely to be or determined to be contributing to seismic activity."),

the operator, but did not present his own case. In their ruling, the Examiners noted that the Commission had no specific criteria, policy or guidance on whether there was already sufficient capacity for fluid disposal (a public interest issue), nor how evidence of area seismicity should be considered in evaluating a permit application, nor did the agency request additional information from the applicant.[125] In 2015 hearings to determine if either or both of two wells had caused or contributed to recent area seismic activity, the respondent well operators (XTO Energy and EnerVest Operating) had the burden of proof to show by a preponderance of evidence (i.e., "it is more likely than not") that their wells were "[not] likely to be or determined to be contributing to seismic activity . . . (16 Tex. Admin. Code §3.9(6)(A)(vi))".[126]

More generally, three states (CO, KS, and PA) address liability for violation of regulations or negative impacts of development on the environment or the public.

- CO notes only that, initially, there is a rebuttable presumption against liability if the environmental impacts are ongoing and a result of a previous violation committed by a predecessor. This liability regulation lists types of environmental impacts (air, water, soil, and biological resources) and includes application to any rule of the Act itself. But the

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[125] See TX Legal Counsel Review, 2014), at 1 (The 2014 rulemaking added regulatory language regarding calculation of a pressure front boundary around a proposed disposal well location to be required in "limited circumstances where additional information is necessary to demonstrate that fluids will be confined if the well is to be located in an area where conditions exist that may increase the risk that fluids will not be confined to the injection interval." (citing 16 Tex. Admin. Code §3.9(3)(C) and §3.46(b)(I)(D))).

[126] Railroad Commission of Texas, Oil and Gas Docket No. 09-0296411 (XTO Reno Well), at 4, available at: https://www.rrc.texas.gov/media/31023/09-96411-sho-pfd.pdf and Oil and Gas Docket No. 09-0296410 (EverVest Briar Well), at 4 (In these hearings, examiners understood "contributing" to mean that fluid injection (the subject action) provided at least a part of the force necessary to cause or achieve seismic activity (the outcome). The examiners also required that the injection stimulus and consequent seismic activity must occur in a mechanically connected system that allows for stress to be transferred to the location of rupture.), available at: https://www.rrc.state.tx.us/media/31022/09-96410-sho-pfd.pdf ; See also, Hornback, Matthew J., et al. Causal Factors for Seismicity near Azle, Texas, Nature Communications. Nature Publishing Group. April 21, 2015 (Causal Factors report), available at: https://www.nature.com/articles/ncomms7728?iframe=true&width=100%25&height=100%25 (The EnerVest Briar Well and XTO Reno Well hearings were called by the Texas Railroad Commission (RRC) in response to the Causal Factors report that had concluded that: "On the basis of modeling results and the absence of historical earthquakes near Azle, brine production combined with wastewater disposal represented the most likely cause of recent seismicity near Azle." After hours of testimony and multiple exhibits presented by the respondent operators and no direct case presented by the RRC and no testimony by the authors of the Causal Factors report, Examiners in both cases concluded that the preponderance of the evidence "does not support a finding that the well is likely to be or determined to be contributing to seismic activity." But "evidence in the record does not support a finding of fact that [the well] is not contributing to seismic activity in the Azle-Reno area, or that the seismic activity is solely the result of natural tectonic processes.").

regulation does not specify the potential causes of these resource damages, for example, by seismicity.

- PA regulations state that a person is liable for a well control emergency and the costs incurred by the department in its response to the emergency including "providing the resources and equipment needs for the incident." PA regulations do not address burden of proof.
- KS does not address general environmental or social impacts, but addresses liability surrounding abandoned wells likely to pollute usable waters. There, if pollution is occurring, the liability falls onto the last operator, the operator who plugged the well, or an individual who tampers with well equipment. The Commission can investigate any pollution problem related to oil and gas activity and has a cause of action for the reasonable costs of plugging, replugging or repairing a well against any person legally responsible for the care and control of the well.

REJECTED LEGISLATION/RULES: In 2018, a bill before the KS legislature (HB 2672[127]) proposed creating an injection well induced seismicity fund (see Q16) supported by Class II injection disposal well application fees and a new injection volume fee (see Q14). According to the bill, the agency rules and regulations promulgated for the proposed law would have presumed damages caused by an earthquake were caused by an induced seismicity event, unless proven otherwise.

Another bill in the 2018 Kansas legislative session requiring induced seismicity liability insurance (HB 2669[128]) (see Q16), would have made an operator of a class II injection disposal well a liable party for any property damages caused by an induced seismicity event, unless the operator can prove by a preponderance of the evidence that the operator could not have caused such induced seismicity event.

Liability Insurance

Two states (CO and OH) require operators to hold liability insurance (see Q16).

- CO operators must maintain at least $1 million per occurrence in general liability insurance coverage for property damage and bodily injury to third parties.
- OH well owners must obtain liability insurance of $1 - 3 million (in urban areas) for bodily injury and property damage caused by drilling, operating or plugging of all of their OH wells. While OH requires horizontal well owners to include an environmental endorsement on their policy, this is not required for non-horizontal (including injection) wells.

[127] HB 2672.

[128] House Bill No. 2669 (2018) (HB 2669), available at: http://kslegislature.org/li_2018/b2017_18/measures/documents/hb2669_00_0000.pdf

- AR has, through permit conditions, required an operator to acquire liability insurance prior to injection.[129]

REJECTED LEGISLATION/RULES: In 2014, in response to a commenter recommending that the Commission require operators to buy earthquake insurance, the TX state legal counsel stated that it "has no statutory authority to require an operator to purchase insurance".[130]

In 2018, a bill before the KS legislature (HB 2669[131]) proposed requiring operators to provide a certificate of induced seismicity liability insurance that is reasonably sufficient to provide coverage for property damages caused by induced seismicity events as determined by the commission.

HB 2672[132] also proposed creating an injection well induced seismicity fund supported by Class II injection disposal well application fees and a new injection volume fee (see Q14). Expenditures from the fund could, have reimbursed Kansas citizens, entities, counties, cities and townships for damages from induced seismicity events and provided operational moneys for the citizens' injection well board. The Kansas legislature rejected a similar fund – an earthquake risk pool fund in 2015 (HB 2349).[133] This fund would have been limited to compensating personal injury or property damages. The bill would have established a new Class II UIC disposal well license fee and required suspending such licenses, permits and approvals in certain counties until the fund was sufficiently funded to provide adequate financial safeguards to compensate for potential personal injury or property damage.

Conclusion

This whitepaper and the LawAtlas dataset are the principal products of the Regulatory Actions group of the Colorado Collaboratory of Induced Seismicity project "Hazards SEES: The Risk Landscape of Earthquakes Induced by Deep Wastewater Injection." Our focus has been to compare management of oil and gas wastewater injection by EPA and seven states that have had significant oil and gas development as well as experience with induced earthquakes. For this comparison, we relied primarily on statutory and regulatory language captured in the LawAtlas Induced Seismicity dataset. We have supplemented this law with information from state administrative agency forms,

[129] See AR Order 63-2008-01. While it was the only order located on this issue, it is not possible to determine from the Commission order whether this is an anomalous requirement or standard practice.

[130] TX Legal Counsel Review, 2014, at 4.

[131] HB 2669.

[132] HB 2672.

[133] HB 2349 (2015), available at: http://kslegislature.org/li_2016/b2015_16/measures/documents/hb2349_00_0000.pdf

actions and policies. In order to document what has been recommended, but not yet included in statutes and regulation, we have summarized a few failed legislative and regulatory proposals.

While this summary provides very little analysis and comment on the law, it provides easy access to the pertinent provisions of each jurisdiction. Our hope is that this stimulates evaluation and discussion of the various jurisdictions' approaches to Class II UIC well management as they relate to induced seismicity. Ideally, this will lead to reduction in both the hazards and risks of induced seismicity from disposal of oil and gas production fluids by injection.

The project team welcomes other researchers, regulators, industry and individuals to utilize the dataset in its current form, to update it, or to expand it to include additional states or to address additional issues.[134]

[134] For comments, corrections or questions contact Kathryn Mutz, Natural Resources, LLC at kathryn.mutz@colorado.edu or gvmutz@gmail.com.

APPENDICES

Appendix A: Statutes and Regulations Cited in the LawAtlas Dataset

Arkansas		
Ark. Code	Powers and Duties - Rules and Regulations	§ 15-71-110 (a) and (d)
Ark. Code R.	General Hearing Procedures	RULE A-2 (c)
	Additional Requirements for Specific Types of Hearings	RULE A-3 (a)
	Enforcement Procedures	RULE A-5 (e)
	Proof of Financial Responsibility Required to Be Furnished	RULE B-2 (b-h) and (k)
	Abandoned or leaking well and well site remediation	RULE G-1 (a) and (c-f)
	Version 1: Class II Disposal and Class II Commercial Disposal Well Permit Application Procedures Version 2: Class II Disposal, Class II Commercial Disposal, Enhanced Oil Recovery Injection (EOR), and Class V Brine Disposal Well Permit Application Procedures	Version 1: RULE H-1 (a), (c-d), (h-j) and (o-s) Version 2: RULE H-1 (a), (c-d), (e-g) (j-l) and (q-u)
	Well Construction, Operating and Reporting Requirements for Class II Disposal Wells	RULE H-2 (a), (d-e) and (n-p)
	Well Construction, Operating and Reporting Requirements for Class II Commercial Disposal Wells	RULE H-3 (a-d), (f-g), (j-k), and (m-s)
40 CFR	State-administered program – Class II wells [reserved]	§ 147.201
Colorado		
Colo. Rev. Stat.	ADDITIONAL POWERS OF COMMISSION - RULES	§ 34-60-106 (13)
	Rules – hearings - process	§ 34-60-108 (3-8)
2 Colo. Code. Regs.		
DEFINITIONS (as of 2 14 19)	DEFINITIONS	§ 404-1-100

GENERAL RULES (as of 1 30 15)	EFFECTIVE SCOPE OF RULES AND REGULATIONS	§ 404-1-201
	GENERAL RULES: TESTS AND SURVEYS	§ 404-1-207 (b)
SERIES DRILLING, DEVELOPMENT, PRODUCTION AND ABANDONMENT (as of 2 14 19)	FINANCIAL ASSURANCE REQUIREMENTS	§ 404-1-304
	FORM 2 AND 2A APPLICATION PROCEDURES	§ 404-1-305 (e-f)
	SERIES DRILLING, DEVELOPMENT, PRODUCTION AND ABANDONMENT: COGCC Form 7. OPERATOR'S MONTHLY REPORT OF OPERATIONS	§ 404-1-309 (b)
	SERIES DRILLING, DEVELOPMENT, PRODUCTION AND ABANDONMENT: COGCC Form 17. BRADENHEAD TEST REPORT	§ 404-1-314
	SERIES DRILLING, DEVELOPMENT, PRODUCTION AND ABANDONMENT: COGCC Form 14. NON-PRODUCED WATER	§ 404-1-316A (b)
	MECHANICAL INTEGRITY TEST	§ 404-1-316B COGCC Form 21
	GENERAL DRILLING RULES	§ 404-1-317 (e-i)
	POLLUTION	§ 404-1-324A (e)
	EXEMPT AQUIFERS	§ 404-1-324B (b-d)
	UNDERGROUND DISPOSAL OF WATER	§ 404-1-325 (b-f) and (i-n)
	MECHANICAL INTEGRITY TESTING	§ 404-1-326 (a) and (f)
	MEASUREMENT OF PRODUCED AND INJECTED WATER	§ 404-1-330 (a-c)
RULES OF PRACTICE AND PROCEDURE (as of 2 14 19)	PROCEEDINGS NOT REQUIRING THE FILING OF AN	§ 404-1-502 (a-b)
	ALL OTHER PROCEEDINGS COMMENCED BY FILING AN APPLICATION	Version 1: § 404-1-503 (a-b) and (d) Version 2: § 404-1-503 (a-b) and (e)
	REQUIREMENT OF PUBLIC HEARING	§ 404-1-505
	NOTICE FOR HEARING	§ 404-1-507 (a)
	PROCEDURES FOR ALLEGED VIOLATIONS	§ 404-1-522 (g)
	DETERMINATION OF RESPONSIBLE PARTY	§ 404-1- 524 (a-g)
	PERMIT-RELATED PENALTIES	§ 404-1-525 (a)
FINANCIAL ASSURANCE AND OIL AND GAS CONSERVATION	GENERAL	§ 404-1-702 (a-b)
	SURFACE OWNER PROTECTION	§ 404-1-703

AND ENVIRONMENTAL RESPONSE FUND (as of 5 1 18)	SOIL PROTECTION AND PLUGGING AND ABANDONMENT.	§ 404-1-706 (a-b)
	GENERAL LIABILITY INSURANCE	§ 404-1-708
	FINANCIAL ASSURANCE	§ 404-1-709
	SURFACE FACILITIES AND STRUCTURES APPURTENANT TO CLASS II COMMERCIAL UNDERGROUND INJECTION CONTROL WELLS.	§ 404-1-712
E&P WASTE MANAGEMENT (as of 5 1 18)	E&P WASTE MANAGEMENT: INTRODUCTION	§ 404-1-901 (e-f)
	E&P WASTE MANAGEMENT: MANAGEMENT OF E & P WASTE	§ 404-1-907 (c, d and f)
40 CFR	State-administered program – Class II wells	§ 147.300
	Existing Class I, II (except enhanced recovery and hydrocarbon storage) and III wells authorized by rule	§ 147.303
Kansas		
Kan. Stat.	LICENSURE OF OPERATORS AND CONTRACTORS; REQUIREMENTS	§ 55-155 (a-e)
	Finding reasonable cause to believe that person has violated act or rules and regulations; hearing; procedure; order; immediate remedial action; reconsideration and judicial review; investigations; sealing of well; removal of seal, penalty.	§ 55-162 (a-b) and (e)
	COMMISSION'S COST ASSESSED AGAINST OPERATORS AND AGENTS; DISPOSITION OF MONEY	§ 55-176 (a)
	INVESTIGATION OF COMPLAINT BY THE COMMISSION; FINDINGS; RESPONSIBILITY FOR REMEDIAL ACTION; COSTS; HEARINGS; ORDERS	§ 55-179 (a-e)
	Testing and investigation of pollution; plugging expenses; liens.	§ 55-180 (a-d)
	Disposal of salt water; rules and regulations; assessment of costs; disposition of moneys	§ 55-901
Kan. Admin. Regs.	DEFINITIONS	§ 82-3-101 (a)
	SURFACE CASING AND CEMENT	§ 82-3-106 (a-d)
	§ 82-3-120. OPERATOR OR CONTRACTOR LICENSES: APPLICATION; FINANCIAL RESPONSIBILIITY; DENIAL OF APPLICATION; PENALTY	§ 82-3-120 (a-b), (f), (h-l)
	NOTICE OF APPLICATION	§ 82-3-135a (a-e)

	PROTESTERS	§ 82-3-135b (a-e)
	INJECTION ALLOWED ONLY BY PERMIT; PENALTY	§ 82-3-400 (a) and (b)
	APPLICATION FOR INJECTION WELL; CONTENT	§ 82-3-401 (a) and (c)
	NOTICE OF APPLICATION; OBJECTION	§ 82-3-402 (a-b)
	PERMITTING FACTORS; APPLICATION APPROVAL	§ 82-3-403 (a-c)
	CASING AND CEMENT	§ 82-3-405 (a-d)
	INJECTION WELL TUBING AND PACKER REQUIREMENTS	§ 82-3-406 (b)
	MECHANICAL INTEGRITY REQUIREMENTS; PENALTY	§ 82-3-407 (a-b), (d-e), (g)
	DURATION OF INJECTION WELL PERMITS; MODIFICATION PENALTY	§ 82-3-408 (a)
	RECORD RETENTION; ANNUAL REPORT; PENALTY	§ 82-3-409 (a-c)
	TRANSFER OF AUTHORITY TO INJECT; PENALTY	§ 82-3-410 (b)
	ASSESSMENT OF COSTS.	§ 82-3-412 (b-c)
40 CFR	State-administered program—Class II wells.	§ 147.851
Ohio		
Ohio Rev. Code	Enforcement -- injunction against violation.	§ 1509.04 (A-D)
	Application for permit to drill, reopen, convert, or plug back a well	§ 1509.06 (A
	Liability Insurance Coverage	§ 1509.07 (A-B)
	Forfeiting bond	§ 1509.071 (A)
	Storage or disposal of brine, crude oil, natural gas, or other fluids	§ 1509.22 (C-D), (H)
	Notice of Filing for permit to drill new well.	§ 1509.60
Ohio Admin. Code	Permits	§ 1501:9-1-02 (F)
	Surety Bond.	§ 1501:9-1-03 (A), (C-D), and (F)
	Construction of and conversion to saltwater injection wells	§ 1501:9-3-05 (A-C)
	Permit	§ 1501:9-3-06 (A), (C), (G-I)
	Operating, monitoring and reporting of saltwater injection wells.	§ 1501:9-3-07 (D-J)
	Annular disposal	§ 1501:9-3-11 (A), (C-G)

40 CFR	State-administered program – Class II wells	§ 147.1800 (a)
	Existing Class I and III wells authorized by rule—maximum injection pressure	§ 147.1803 (a)
Oklahoma		
Okla. Stat. tit. 17	Exclusive Jurisdiction, Power and Authority Vested in Corporation Commission and the Department of Environmental Quality	§ 139 (A) and (D)
Okla. Admin. Code	General Provisions: Fees, fines and bonds	§ 165:5-3-1 (a) and (b)
	Administration: Definitions	§ 165:10-1-2 Definitions
	Administration: Prescribed forms	§ 165:10-1-7 (b)
	Operator's agreement; Category A and Category B surety	§ 165:10-1-10 (a), (d-e)
	Financial statement as surety	§ 165:10-1-11 (a-d)
	Corporate surety bond	§ 165:10-1-12 (a)
	Irrevocable commercial letter of credit	§ 165:10-1-13 (a) and (b)
	Cashier's check, certificate of deposit, or other negotiable instrument	§ 165:10-1-14 (a) and (b)
	Required approval of notice of intent to drill, deepen, re-enter, or recomplete; Permit to Drill	§ 165:10-3-1 (g)
	Drilling, Developing, and Producing: Casing, cementing, wellhead equipment, and cementing reports	§ 165:10-3-4 (a-d), (f), (l), (n)
	Underground Injection Control: Approval of enhanced recovery injection wells or disposal wells	§ 165:10-5-2 (a) and (e)
	Underground Injection Control: Authorization for existing enhanced recovery injection wells and existing disposal wells	§ 165:10-5-3 (b)
	Underground Injection Control: Application for approval of enhanced recovery injection and disposal operations	§ 165:10-5-5 (a-c), (i-j), l)
	Underground Injection Control: Testing and monitoring requirements for enhanced recovery injection wells and disposal wells	§ 165:10-5-6 (a-f)
	Underground Injection Control: Monitoring and reporting requirements for wells covered by 165:10-5-1	§ 165:10-5-7 (a), (c-d), (f-g)
	Underground Injection Control: Transfer of authority to inject	§ 165:10-5-10 (a)

	Underground Injection Control: Application for permit for one time injection of reserve pit fluids	§ 165:10-5-13 (b)
	Underground Injection Control: Application for permit for simultaneous injection well	§ 165:10-5-15 (b)
	Administration and enforcement of rules	§ 165:10-7-2 (e)
	Pollution Abatement: Waste management practices reference chart	§ 165:10-7-24 (b), (c)
	Commercial Disposal Facilities: Commercial disposal well surface facilities	§ 165:10-9-3 (a), (c-f)
40 CFR	State-administered program - Class II wells	§ 147.1851
Pennsylvania		
58 Pa. C.S.A. Oil and Gas	Definitions	§ 3203 Well
	Well permits	§ 3211 (b) and (d)
	Bonding	§ 3225 (a-d)
	Conferences	§ 3251 (a)
	Public Nuisances	§ 3252
	Enforcement orders	§ 3253 (a-e)
	Restraining Violations	§ 3254 (a-c)
	Well control emergency response cost recovery	§ 3254.1
	Existing rights and remedies preserved and cumulative remedies authorized	§ 3257
	Unlawful conduct	§ 3259 (1-2)
	Third party liability	§ 3261
58 P.S. Oil and Gas (Oil and Gas Conservation Act)	Rules, regulations, notices, orders and hearings	§ 410 (a-f)
25 Pa. Code	Definitions	§ 78.1
	APPLICATION REQUIREMENTS.	§ 78.15 (a-b)
	PERMITS, TRANSFERS AND OBJECTIONS: Disposal and enhanced recovery well permits	§ 78.18 (a)
	Permit application fee schedule	§ 78.19 (a-e)
	Opportunity for objections and conferences; surface landowners	§ 78.21 (a)
	WELL DRILLING, OPERATION AND PLUGGING: Casing and Cementing: General Provisions	§ 78.81 (a-b)
	WELL DRILLING, OPERATION AND PLUGGING: Surface and coal protective casing and cementing procedures	§ 78.83 (c-f)

	WELL DRILLING, OPERATION AND PLUGGING: Casing and cementing plan	§ 78.83a (a)
	WELL DRILLING, OPERATION AND PLUGGING: Casing and cementing—lost circulation	§ 78.83b (a)
	WELL DRILLING, OPERATION AND PLUGGING: Intermediate and production casing	§ 78.83c (a-c)
	WELL DRILLING, OPERATION AND PLUGGING: Casing standards.	§ 78.84 (a-d)
	WELL DRILLING, OPERATION AND PLUGGING: Cement standards	§ 78.85 (a-e)
	WELL DRILLING, OPERATION AND PLUGGING: Mechanical integrity of operating wells	§ 78.88 (a-e)
	WELL REPORTING: Logs and additional data	§ 78.123 (b)
	WELL REPORTING: Disposal and enhanced recovery well reports	§ 78.125 (a-c)
	Requirements to file a bond	§ 78.302
	Form, terms and conditions of the bond	§ 78.303 (a-e)
	Terms and conditions for collateral bonds -- general	§ 78.305 (a-d)
	Collateral bonds -- letters of credit	§ 78.306 (a)
	Collateral bonds—certificates of deposit	§ 78.307 (1-5)
	Collateral bonds—negotiable bonds	§ 78.308 (1-4)
	Forfeiture determination	78.312 (a), (b)
40 CFR	Purpose and scope of part 144	§ 144.1 (a), (b)
	EPA-administered program (Subpart NN Pennsylvania)	§ 147-1951 (a) and (b)
	Existing Class I, II (except enhanced recovery and hydrocarbon storage) and III wells authorized by rule. (Subpart NN Pennsylvania)	§ 147.1953 (a) and (b)
	Requirements for wells authorized by permit. (Subpart NN Pennsylvania)	§ 147.1955 (b-c)
Texas		
Tex. Natural Resources Code	Purposes of Rules and Orders	§ 85.202 (a)
	Emergency Order	§ 85.206 (a-c)
	Persons Required to Execute Bond, Letter of Credit, or Cash Deposit	§ 91.103
	Bonds, Letters of Credit, Cash Deposits, and Well-Specific Plugging Insurance Policies	§ 91.104 (a-c)

	Individual Bond	§ 91.1041 (a) and (c)
	Blanket Bond	§ 91.1042 (a) and (c)
	Bond Conditions	§ 91.105
	Financial Security for Persons Involved in Activities Other Than Operation of Wells	§ 91.109 (a-c)
	Refund	§ 91.1091 (1-3)
	Report to the Commission	§ 91.142 (a), (e), (f), (g)
Tex. Water Code	Information Required of Applicant	§ 27.032
	Application Fee	§ 27.0321 (a) and (b)
	Railroad Commission Rules, Etc.	§ 27.034 (a)
16 Tex. Admin. Code	Disposal Wells	§ 3.9 (1-7), (12)
	Casing, Cementing, Drilling, Well Control, and Completion Requirements	§ 3.13 (a-b)
	Plugging	§ 3.14 (a)
	Fluid Injection into Productive Reservoirs	§ 3.46 (a-b), (d), (i-j)
	Fees and Financial Security Requirements	§ 3.78 (a-d), (g-h), (l)
	Permit for Injection	§ 4.617 (c) and (d)
40 CFR	State-administered program - Class II wells	§ 147.2201
Environmental Protection Agency		
Safe Drinking Water Act, Title XIV: Safety of Public Water Systems, Part C: Protection of Underground Sources of Drinking Water	Regulations for State Programs	§ 1421 (a-b)
	State primary enforcement responsibilities SDWA	§ 1422 (a-b)
	Optional Demonstration By States Relating To Oil Or Natural Gas	§ 1425 (a-c)
40 CFR	Purpose and scope.	§ 124.1 (a-c) and (e)
	Application for a permit.	§124.3 (g)
	Draft permits.	§124.6 (e)
	Public notice of permit actions and public comment period.	§124.10 (a-e)
	Public comments and requests for public hearings.	§124.11
	Public hearings.	§124.12 (a-d)
	Obligation to raise issues and provide information during the public comment period.	§124.13
	Reopening of the public comment period.	§124.14 (a-e)
	Issuance and effective date of permit.	§124.15 (a-b)

	Stays of contested permit conditions.	§124.16 (a-c)
	Response to comments.	§124.17 (a-c)
	Administrative record for final permit when EPA is the permitting authority.	§124.18 (a-e)
	Purpose and scope of part 144.	§ 144.1 (a-b) and (e-f)
	General Provisions: Identification of underground sources of drinking water and exempted aquifer	§ 144.7 (a-c)
	General Program Requirements: Prohibition of movement of fluid into underground sources of drinking water	§ 144.12 (a-b)
	Authorization of Underground Injection by Rule: Existing Class I, II (except enhanced recovery and hydrocarbon storage) and III wells	§ 144.21 (c-e)
	Authorization of Underground Injection by Rule: Requiring other information	§ 144.27 (a) and (b)
	Requirements for Class I, II, and III wells authorized by rule	§ 144.28 (d), (f-h)
	Authorization by Permit: Application for a permit; authorization by permit	§ 144.31 (a), (e)
	Authorization by Permit: Effect of a permit	§ 144.35 (a-b)
	Authorization by Permit: Modification or revocation and reissuance of permits	§ 144.39 (a)
	Authorization by Permit: Termination of permits	§ 144.40 (a)
	Permit Conditions: Conditions applicable to all permits	§ 144.51 (q)
	Permit Conditions: Establishing permit conditions	§ 144.52 (a)
	Purpose and scope	§ 145.1 (c)
	Requirements for permitting.	§ 145.11 (a-b)
	Requirements for enforcement authority	§ 145.13 (a) and (d)
	Criteria and Standards, General Provisions: Classification of Injection Wells	§ 146.5 (b)
	Criteria and Standards, General Provisions: Mechanical integrity	§ 146.8 (a-f)
	Criteria and Standards Applicable to Class II Wells: Applicability	§ 146.21
	Criteria and Standards Applicable to Class II Wells: Construction requirements	§ 146.22 (a-e)

	Criteria and Standards Applicable to Class II Wells: Operating, monitoring, and reporting requirements	§ 146.23 (a-c)
	Criteria and Standards Applicable to Class II Wells: Information to be considered by the Director	§ 146.24 (a)

Appendix B: Summary of Regulatory Issues Addressed in the LawAtlas Dataset, Qs 1 – 16.

Regulatory Authority:	Q1: Does the jurisdiction allow for the disposal of oil and gas production fluids through injection wells?
	A1: Yes; No
	Q2: Has the Environmental Protection Agency (EPA) delegated primacy of the Underground Injection Control (UIC) Program under the Safe Drinking Water Act to the jurisdiction, enabling it to regulate Class II disposal wells?
	A2: Yes; No, EPA administers the UIC program
	Q3: Does the jurisdiction distinguish between commercial and non-commercial wells when regulating Class II disposal wells?
	A3: Yes; No
Well Siting and Permitting:	Q4: What subsurface features does the jurisdiction consider when permitting a Class II disposal well?
	A4: Aquifers; Faults, Geologic strata; Bedrock/Basement rock; Historic earthquakes; Location of wells; Other
	Q5: For what reasons does the jurisdiction restrict the siting of Class II disposal wells?
	A5: Proximity to faults; Potential water contamination; Injection zone characteristics; Proximity to other injection wells; Proximity to seismic events; Public health, safety, welfare, or the environment; Other; None
Well Construction and Operations:	Q6: Must operators case and cement Class II disposal wells?
	A6: Yes; No
	Q7: When must operators demonstrate mechanical integrity of Class II disposal wells?
	A7: An initial test; On a routine schedule; Following well maintenance or problems; After seismic activity
	Q8: Does the jurisdiction restrict injection pressure, injection rate, or total volume of fluids?
	A8: Injection pressure; Injection rate; Total fluid volume
	Q9: Does the jurisdiction require the operator to monitor for seismicity near Class II disposal wells?
	A9: Yes, all Class II disposal wells; Yes, after seismic events in the area; Yes, on a case-by-case basis; No, but requires a plan for monitoring; No.
	Q10: What must operators monitor during operation of Class II disposal wells?
	A10: Fluid volume or injection rate; Injection pressure; Quality or type of injected fluids; Other

	Q11: Can the jurisdiction change requirements for Class II disposal wells after they are permitted?
	A11: Yes, by prohibiting injection; Yes, by reducing injection parameters; Yes, modifying a permit; Yes, revoking a permit; Yes, through general authority to take action; No
Public Notification, Financial Assurances, and Liability:	Q12: Does the jurisdiction require public participation opportunities for Class II disposal wells?
	A12: Yes, during the permitting process; Yes, during operation and applicable to seismic issues; Yes, during operations, but specific to non-seismic issues; Yes, specific to seismic events; No
	Q13: Does the jurisdiction require a financial assurance for Class II disposal wells?
	A13: Yes; No
	Q13.1: What type of financial assurances can be used in the jurisdiction?
	A13.1: Surety bond; Letter of credit; Certificate of deposit; Cash; Other
	Q13.2: Does the jurisdiction specify the amount of financial assurances?
	A13.2: A13.3: Yes, dollar amount; Yes, in terms of costs to be covered; No
	Q13.3: What are the stated purposes or reasons for forfeiture of the financial assurance?
	A13.3: Ensure well is plugged and site is reclaimed; Compensate third parties for impacts of development; Other specific purposes; Generally ensure compliance with state or federal law; None
	Q14: Does the jurisdiction charge a permit or operations fee for Class II disposal wells?
	A14: Permit processing fee - fixed; Permit processing fee - adjusted to cover administrative costs; Operation fee - fixed; Operation fee - adjusted by volume; Operation fee - adjusted to cover administrative costs; No fees
	Q15: Does the jurisdiction address liability issues for determining the cause of seismicity or damage from it?
	A15: Yes; No
	Q16: Does the jurisdiction require operators to carry liability insurance?
	A16: Yes; No

Appendix C: LawAtlas Dataset Statistical Report: Qs and As

Available for download from the LawAtlas Induced Seismicity Dataset at
http://lawatlas.org/datasets/IS-oil-gas-wastewater

Also available at:
https://drive.google.com/drive/folders/1NMZb74WtCK9Waw9d79bxLJqycQRW_rmx?usp=sharing

Appendix D: LawAtlas Dataset Standard Report: Answers, Supporting Citations, and Caution Flags.

Available for download from the LawAtlas Induced Seismicity Dataset at
http://lawatlas.org/datasets/IS-oil-gas-wastewater

Also available at:
https://drive.google.com/drive/folders/1NMZb74WtCK9Waw9d79bxLJqycQRW_rmx?usp=sharing