U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

September 23, 2014

Congressional Requesters

Drinking Water: Characterization of Injected Fluids Associated with Oil and Gas Production

Every day in the United States, at least 2 billion gallons of fluids are injected into underground formations to enhance oil and gas production, or to dispose of fluids brought to the surface during the extraction of oil and gas resources.[1] Wells used for injecting fluids associated with the extraction of oil and gas resources are known as class II injection wells.[2] The majority of fluids injected into class II wells consist largely of brine and may contain pollutants such as chlorides, hydrocarbons, and naturally occurring radioactive materials. The fluids are injected deep underground into porous rock formations, such as sandstone, that are generally below aquifers that can, or do, supply drinking water. Because a significant percentage of the population gets its drinking water from underground aquifers, these wells have raised concerns about the safety of the nation's drinking water.

Domestic production of oil and gas has increased dramatically in the last several years, with corresponding increases in wastewater resulting from production processes.[3] Specifically, hydraulic fracturing combined with horizontal drilling has increased domestic production from unconventional sources such as shales, tight sandstones, and coalbed formations. Hydraulic fracturing involves the injection of fluids underground, and fluids that are produced from formations during oil and gas production, including fluids from hydraulic fracturing activities that flow back out of the well, must be disposed of or reused. Oil and gas operations that inject fluids underground for disposal or enhanced recovery are regulated by the Environmental Protection Agency (EPA) under the class II Underground Injection Control (UIC) program. However, the Energy Policy Act of 2005 exempted the process of injecting fluids into a well to hydraulically

[1] Environmental Protection Agency (EPA), *Class II Wells – Oil and Gas Related Injection Wells*, accessed September 08, 2014, http://water.epa.gov/type/groundwater/uic/class2/index.cfm.

[2]EPA regulates six classes of underground injection wells. Class II wells are used to inject brines and other fluids associated with oil and gas production, as well as hydrocarbons for storage, and are the focus of this report. Additionally, class I wells are used to inject hazardous wastes, industrial non-hazardous liquids, or municipal wastewater beneath the lowermost underground drinking water sources; class III wells are used to inject fluids associated with solution mining of minerals beneath the lowermost underground drinking water source; class IV wells are used to inject hazardous or radioactive wastes into or above underground drinking water sources (these wells are banned unless authorized under a federal or state groundwater remediation project); class V wells, in general, are used to inject nonhazardous fluids into or above underground drinking water sources, and are typically shallow, on-site disposal systems; class VI wells are used to inject carbon dioxide for long-term storage.

[3]GAO, *Oil and Gas: Information on Shale Resources, Development, and Environmental and Public Health Risks*, GAO-12-732 (Washington, D.C.: Sept. 5, 2012).

fracture formations for oil and gas production activities from regulation under the Safe Drinking Water Act.[4]

You requested that we describe what information EPA and states collect from class II well operators on the characteristics of injected fluids. This report describes information that EPA and selected states require injection well operators to provide on the characteristics of fluids injected into class II wells.

To respond to the objective, we reviewed and summarized requirements for operators to provide information about the characteristics of fluids injected into class II wells for the class II program in each of eight selected states. These are outlined in federal regulations, state regulations, guidance, and related program documents for class II programs. To clarify our understanding of the state and federal requirements for class II wells, we interviewed officials in EPA and in each of the selected eight states. We reviewed the same states chosen for our June 27, 2014, review of EPA's class II program: California, Colorado, Kentucky, North Dakota, Ohio, Oklahoma, Pennsylvania, and Texas.[5] These states represent a nongeneralizable sample, selected on the basis of the location of current shale oil- and gas-bearing formations across the country, the number of class II wells in each state, and whether the class II program was managed by the state or EPA regions. To identify current shale oil- and gas-bearing formations across the country, we used Energy Information Administration regions that are organized around national shale oil and shale gas resources.[6] These regions represent diverse geography and geologic formations, as well as different oil and gas and wastewater operations. We selected at least one state in each of the six regions identified by the Energy Information Administration. We also selected states that had higher numbers of class II wells to ensure our sample represented increased class II activity. Finally, we selected states that had both state (California, Colorado, North Dakota, Ohio, Oklahoma, Texas) and EPA-managed programs (Kentucky, Pennsylvania).[7]

We conducted this performance audit from July 2014 to September 2014 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objective. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objective.

---

[4]In 2005, the Energy Policy Act amended the Safe Drinking Water Act to exempt the underground injection of fluids associated with hydraulic fracturing operations related to oil, gas, or geothermal production activities from regulation under class II programs, except in cases where diesel fuels are used in the fracturing process.

[5]For additional information on the state selection methodology, see GAO, *Drinking Water: EPA Program to Protect Underground Sources from Injection of Fluids Associated With Oil and Gas Production Needs Improvement*, GAO-14-555 (Washington, D.C.: June 27, 2014).

[6]Energy Information Administration, *Review of Emerging Resources: U.S. Shale Oil and Shale Gas Plays* (July 2011).

[7]States request approval from EPA to manage the UIC programs within their respective borders, including the class II programs. Under the Safe Drinking Water Act, the EPA Administrator approves state programs for one or more classes of wells through a rulemaking process, with public notice and comment, and EPA updates federal regulations to reflect the approved program. Once EPA has approved a state's program, the state has primary management and enforcement responsibility for its UIC program, known as primacy. In states that do not have approval to manage their programs, EPA regional offices manage the programs in the state directly. Twenty-five states with class II wells manage their class II programs and regulate over 95 percent of the class II wells nationwide. Eight states with class II wells have programs managed by EPA regional offices. The remaining 17 states have no class II wells.

Background

To protect underground sources of drinking water from contamination, class II injection wells are subject to regulation by the UIC program overseen by EPA under the Safe Drinking Water Act.[8] The UIC program regulates three types of class II wells associated with oil and gas production: (1) enhanced recovery wells into which brine, water, steam, carbon dioxide, or other fluids and gases are injected to increase the recovery of oil and gas from oil- or gas-bearing formations; (2) disposal wells into which brines and other fluids brought to the surface during oil and gas production activities are injected for disposal; and (3) storage wells into which liquid petroleum products are injected, generally as part of the U.S. Strategic Petroleum Reserve.[9] The number of class II wells grew from approximately 144,000 in fiscal year 2005 to over 172,000 in fiscal year 2012.[10]

EPA oversees and regulates all classes of injection wells, including class II wells associated with oil and gas production. Under the Safe Drinking Water Act, states may request approval from EPA to manage the UIC programs in their respective borders. Under the act, the EPA Administrator approves states' programs for one or more classes of wells through a rulemaking process, with public notice and comment, and EPA updates federal regulations to reflect the approved program. To gain EPA approval, a state must adopt and implement a program that meets the minimum requirements established in EPA regulations,[11] or, specifically for class II programs, a state may adopt and implement a program that it demonstrates to be as effective as federal regulations in preventing the contamination of underground sources of drinking water.[12] Once EPA has approved a state's program, the state has primary management and enforcement responsibility for its UIC program, known as primacy. In states that do not have approval to manage their programs, EPA regional offices manage the programs in the states directly.[13] EPA has approved 39 states, either through the conventional or alternative process, to manage their own class II programs, while EPA manages the class II programs in 11 states.

EPA developed safeguards to protect underground drinking water sources in the 1980s with the purpose of preventing fluids that are injected into underground formations from endangering underground drinking water sources.[14] These safeguards require well operators to, among other

[8]An underground source of drinking water as defined in 40 C.F.R. § 144.3 is any nonexempt aquifer or part of such an aquifer which: supplies any public water system; or which contains a sufficient quantity of groundwater to supply a public water system, and (1) currently supplies drinking water for human consumption; or (2) contains fewer than 10,000 milligrams/liter of total dissolved solids.

[9]The U.S. Strategic Petroleum Reserve is an emergency stock of oil maintained by the U.S. Department of Energy.

[10]Approximately 18,000 wells were not newly drilled wells, but were incorporated into the class II program as a result of the reclassification of some wells in California.

[11]Section 1422 of the Safe Drinking Water Act authorizes EPA to grant primary enforcement authority to states for all classes of UIC wells.

[12]Section 1425 of the Safe Drinking Water Act created an alternative process for EPA to grant primary enforcement authority to states for class II wells only.

[13]For additional information on class II wells, see GAO-14-555. Some states that have been approved for primacy do not have class II wells, and the number of states with class II programs is smaller than the number with primacy approved.

[14]EPA, Office of Drinking Water, *Statement of Basis and Purpose: Underground Injection Control Regulations*, (Washington, D.C.: May 1980). In GAO-14-555, our review included a summary and comparison of the regulations and guidance that establish state and EPA-managed program safeguards, but we did not analyze the technical

things, meet technical standards for constructing, operating, testing, and monitoring injection wells. As part of these safeguards, EPA regulations require that operators "monitor the nature of the injected fluids with sufficient frequency to yield data representative of their characteristics."[15] According to EPA officials, the purpose of monitoring is to ensure that the fluids to be injected into a class II well are fluids that are allowed to be injected into a class II well and are considered nonhazardous. According to EPA documentation, information on the characteristics of injected fluids can help to provide an early warning of potential contamination of underground sources of drinking water and can help federal and state regulators understand the reasons for well failures and take appropriate corrective actions.[16]

States, and EPA regional offices that manage programs in some states, are largely responsible for the day-to-day management of the class II program. Management includes permitting wells, inspecting wells, enforcing regulations, developing and applying guidance, and collecting and reporting program data to EPA.

Information Collected by EPA and Selected States on the Characteristics of Fluids Injected into Class II Wells Varies

Class II programs in seven of the eight states we selected require that permit applicants provide some information on the characteristics of fluids injected into class II wells prior to permitting, but the specificity and frequency of the information applicants report varies from state to state. Specifically, all of the states we selected except for Ohio require that applicants provide some information on the characteristics of fluids injected into class II wells, but the specific constituents to be reported differ by state. For example, EPA Region 4, which manages the class II program in Kentucky, requests that applicants analyze the pH, total dissolved solids, and specific gravity of the fluid to be injected into a class II well, and can request that applicants provide additional data on the chemical characteristics of injected fluids. Conversely, class II programs in Colorado and North Dakota request an analysis of the fluids injected into class II wells but do not specify what information on fluid characteristics applicants are required to provide. While Ohio's regulations do not require operators to provide information on the characteristics of fluids injected, the regulations narrowly define what fluids can be injected into class II wells. In addition, according to state officials, Ohio conducted research on the characteristics of produced water in the state's oil and gas producing formations and samples fluids injected into class II wells during well inspections.

According to EPA officials, fluid characterization requirements for class II wells are designed to ensure that no chemicals are injected that could potentially damage the wells. In addition, EPA officials told us that the agency does not prescribe a set list of constituents that state and EPA-managed class II programs should monitor. Specifically, according to guidance issued by EPA on class II well monitoring, EPA cannot recommend a single set of constituents that should be monitored because injection fluids can vary widely in composition and contain different naturally occurring chemicals and fluids used in oil and gas production depending on the source of the

---

sufficiency of those safeguards. According to EPA officials, the safeguards established in EPA regulations are still sufficient.

[15]40 C.F.R. §§ 146.23(b), 144.28(g)(2).

[16]EPA, Office of Drinking Water, *Statement of Basis and Purpose: Underground Injection Control Regulations*, (Washington, D.C.: May 1980).

injection fluid. As a result, state programs and programs managed by EPA regions have discretion to monitor the injection fluid constituents that they deem critical to protect underground sources of drinking water in their respective states or regions.

In addition, five of the eight programs we selected request that well operators conduct additional analyses of fluids injected into class II wells after the well has been permitted. Of these five programs, in Kentucky, EPA Region 4 requests that operators provide updated information on fluids injected into class II wells annually, and Colorado requests updated reporting every 5 years. Texas and California request updated information on fluids injected when the source of the injected fluids changes. EPA Region 3, which manages the program in Pennsylvania, requests that operators provide updated information on fluids injected into commercial class II wells every year and fluids injected into private wells every 2 years. Of the remaining states, North Dakota and Oklahoma only request information on fluid characteristics during the class II well permitting process or when requested by state officials. Ohio regulations allow state officials to sample injection fluids at any time during a well's operation.

Table 1 presents detailed information requested from operators by select states and EPA regional offices on the characteristics of fluids injected into class II wells.

Table 1: Information Collected by EPA and Selected States on the Characteristics of Fluids Injected into Class II Wells

State, Agency	Fluid characteristics reported	Frequency of testing (or reporting)
California, Division of Oil, Gas, and Geothermal Resources	According to officials, the chemical analysis typically lists the major constituents of the injection fluid, total dissolved solids, and pH.	The source and analysis of the injection fluid is required in any injection project application.[a] After the project is approved, a chemical analysis of the liquid being injected should be provided by the operator whenever the source of injection fluid is changed, or when the division requests the data from the operator.[b]
Colorado, Oil and Gas Conservation Commission	According to officials, injected fluids must be analyzed for total dissolved solids, major cations and major anions.[c] Officials stated that they include these conditions in permit approval letters.	According to officials, water analyses of fluids injected into injection wells are required within 1 year of commencement of injection. Injected fluids are required to be monitored with sufficient frequency to yield data representative of their characteristics. Therefore, water analyses of fluids injected are required as a Condition of Approval, on Form 26 (Source of Produced Water For Disposal), when sources are added or deleted. Water analyses of fluids injected are also required at 5-year intervals.
Kentucky, EPA Region 4	According to officials, the fluid analysis must include the pH, total dissolved solids, and specific gravity; as well as a list of all chemicals and their composition used for any well stimulation and fracturing during that sampling year, and a list of any additives	According to officials, analyses shall be made beginning within 12 months from the effective date of the permit, or 12 months from the most recent analysis, whichever is later. For wells that resume injection

	used and their chemical composition, including any inhibitors used to prevent scaling, corrosion, or bacterial growth, and these lists should indicate the brand name of the product and the manufacturer. On EPA's written request, an injection fluid analysis can include the following additional constituents: barium, calcium, total iron, magnesium, sodium, bicarbonate, carbonate, chloride, sulfate, carbon dioxide, dissolved oxygen, hydrogen sulfide, and purgeable aromatic hydrocarbons.	after having been shut-in, the permittee will have 30 days from the date injection resumes for the submission of the injection fluid analysis.[d]
North Dakota, Industrial Commission, Oil and Gas Division	Only fluids brought to the surface in connection with natural gas storage, or conventional oil or natural gas production, and wastewater from gas plants that are integral to production operations may be injected into a class II well.[e] In the permit application, a quantitative analysis from a state-certified laboratory of a representative sample of the fluid to be injected is required.[f] This analysis reports the major anions and cations.	After the permit is approved, the operator must conduct sampling as the commission may require.[g]
Ohio, Department of Natural Resources, Division of Oil and Gas Resource Management	According to officials, class II injection well operators are not required to analyze the chemical composition of injected fluids. Only saline geological formation water resulting from, obtained from, or produced in connection with exploration, drilling, stimulation, production, or plugging of oil and gas wells (defined in Ohio law as "brine"[h]) is permitted to be injected into class II saltwater injection wells.[i] According to officials, the division has supported research to analyze produced water samples from oil and gas producing formations.[j] In addition, operators may monitor the specific gravity of fluids when applying to increase permitted injection pressure limits.	The division may sample injection fluids at any time during injection operations.[k] According to officials, division inspectors collect fluid samples from permitted injection facilities for analysis at an EPA certified laboratory.
Oklahoma, Corporation Commission	In the permit application, operators will provide an analysis of sodium, chloride, and total dissolved solids.[l]	According to state officials, fluids may be tested during pollution investigations or as a result of citizen complaints.
Pennsylvania, EPA Region 3	According to EPA officials, in the permit application, operators are required to do a fluid analysis including: specific gravity, total organic carbon, pH, specific conductance, sodium, chloride, iron, manganese, total dissolved solids, barium, hydrogen sulfide, alkalinity and dissolved oxygen, hardness, and magnesium to characterize the fluids to be injected.	According to EPA officials, operators are required to provide an analysis of injected fluids during permitting. Commercial wells are required to resample every year and whenever the operator anticipates a change in the source of the fluid to be injected. Privately owned wells should be resampled every 2 years and whenever the source changes.
Texas, Railroad Commission	According to officials, during permitting, an operator provides general categories of fluid types, such as exempt oil and gas waste, fresh water, salt water, fracture water flowback, natural gas, hydrogen sulfide, steam, air polymer, carbon dioxide, nitrogen, and naturally occurring radioactive material as defined by Texas law.	According to officials, a permit amendment is required if the operator wants authority to inject a fluid that is different from that approved in the permit.

Sources: GAO analysis of EPA and state regulations and guidance. | GAO-14-857R

[a]Cal. Code Regs. tit. 14 § 1724.7(c)(7) (2014).

[b]Cal. Code Regs. tit. 14, § 1724.10(d) (2014).

[c]A cation is a positively charged atom or molecule. An anion is a negatively charged atom or molecule.

[d]Shut-in wells are wells that are shut off for a period of time and do not accept injected fluids.

[e]*See* N.D. Admin. Code 43-02-05-01(2)(a) (2014).

[f]N.D. Admin. Code 43-02-05-04(1)(m) (2014).

[g]N.D. Admin. Code 43-02-05-12(4) (2014).

[h]Ohio Rev. Code Ann. § 1509.01(U) (2014).

iAccording to Ohio officials, samples were analyzed for total dissolved solids, specific conductance, pH, specific gravity, sodium, potassium, calcium, magnesium, manganese, iron, chloride, sulfate, alkalinity, strontium, lithium, aluminum, cadmium, chromium, cobalt, copper, lead, mercury, nickel, titanium, and zinc.

[j]*See* Ohio Admin. Code 1501:9-3-06 (2014).

[k]Ohio Admin. Code 1501:9-3-07(J) (2014).

[l]Okla. Admin. Code § 165:10-5-5(b)(5)(D) (2014).

Agency Comments

We provided EPA and the managers of the eight state class II programs we reviewed with a draft of this report for comment. EPA and Ohio provided technical comments that were incorporated, as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Administrator of EPA, and other interested parties. In addition, this report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff has any questions about this report, please contact me at (202) 512-3841 or gomezj@gao.gov. Key contributors to this report were Susan Iott, Assistant Director; Mark Braza, John Delicath, Micah McMillan, and Rich Johnson.

J. Alfredo Gómez
Director, Natural Resources and Environment

List of Requesters

The Honorable Barbara Boxer
Chairman
Committee on Environment and Public Works
United States Senate

The Honorable Henry Waxman
Ranking Member
Committee on Energy and Commerce
House of Representatives

The Honorable Peter DeFazio
Ranking Member
Committee on Natural Resources
House of Representatives

The Honorable Benjamin Cardin
Chairman
Subcommittee on Water and Wildlife
Committee on Environment and Public Works
United States Senate

The Honorable Diana DeGette
Ranking Member
Subcommittee on Oversight and Investigations
Committee on Energy and Commerce
House of Representatives

The Honorable Edward Markey
United States Senate

The Honorable Sheldon Whitehouse
United States Senate

(361594)