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Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

July 1989

DRINKING WATER

Safeguards Are Not Preventing Contamination From Injected Oil and Gas Wastes

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GAO United States
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Resources, Community, and
Economic Development Division

B-227690

July 5, 1989

The Honorable Mike Synar
Chairman, Environment, Energy,
and Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

As requested, we have reviewed how the Environmental Protection Agency (EPA) and states are regulating underground injection of wastes related to oil and gas production. Under the Safe Drinking Water Act, EPA established safeguards to protect underground sources of drinking water from improper injection of wastes.

As arranged with your office, unless you publicly announce its contents earlier, we will make this report available to other interested parties 30 days after the date of this letter. At that time, we will also send copies to other appropriate congressional committees; the Administrator, EPA; and the Director, Office of Management and Budget.

This work was performed under the direction of Richard L. Hembra, Director for Environmental Protection Issues. Other major contributors to this report are listed in appendix II.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

About half the population of the United States depends on groundwater for its drinking water. To help protect these supplies from contamination, the Safe Drinking Water Act of 1974 requires the Environmental Protection Agency (EPA) and states to whom EPA has delegated authority to regulate the injection of industrial waste products into the ground below drinking water supplies.

At the request of the Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, GAO has been examining EPA's underground injection control program. This report addresses the regulation of injection wells used in oil and gas production, focusing specifically on (1) whether evidence exists of drinking water contamination from these wells, and if so, the causes and actions taken to prevent similar occurrences and (2) the degree to which states have implemented program safeguards to protect against drinking water contamination.

Background

Through underground injection, wastes and other fluids are deposited in porous rock formations below drinking water sources. EPA's program, created in 1980, established five classes of injection wells. Those used during oil and gas operations are Class II wells; the other classes are used for various types of hazardous and nonhazardous waste disposal.

Class II injection wells are used to dispose of strongly saline water (brines) produced when oil and gas are extracted or for reinjecting these fluids into oil fields to enhance oil recovery. These brines contain high levels of chloride—up to four times more than seawater—and total dissolved solid levels up to 200 times greater than EPA's drinking water taste standard. Brines from Class II wells can enter drinking water supplies directly, through cracks and leaks in the well casing, or indirectly, through nearby wells, such as those once used for oil and gas production, that have ceased operating. If these abandoned wells are not properly plugged—that is, sealed off—and have cracked casings, they can serve as pathways for injected brines to enter drinking water. Because groundwater moves very slowly, any contaminants that enter it will remain concentrated for long periods of time, and cleanup, if it is technically feasible, can be prohibitively costly.

The United States has about 160,000 Class II injection wells located in 31 states. Under provisions of the Safe Drinking Water Act, EPA has delegated primacy, or primary authority to regulate underground injection, to 21 of these states, with 84 percent of the Class II wells, while the remaining states have EPA-administered programs.

EPA did not issue regulations for primacy states to follow in developing their programs but issued less binding guidance documents, which specified a number of basic safeguards to protect against drinking water contamination. The guidance includes: (1) operator-conducted pressure tests to check for cracks and leaks in the wells before they receive a permit to begin operations and (2) pressure tests and reviews of well files for wells that were already operating under state programs before the federal program went into effect to make sure the wells had been properly constructed and were being properly operated.

While GAO's evaluation of contamination cases was nationwide, its evaluation of how safeguards have been implemented focused only on state-administered programs, under which most Class II wells are regulated. GAO analyzed, in late 1987 and early 1988, a randomly selected sample of Class II wells in four of the primacy states—Kansas, New Mexico, Oklahoma, and Texas—to determine the extent to which states implemented program safeguards. About two-thirds of the state-regulated Class II wells are located in these four states.

Results in Brief

Although the full extent is unknown, EPA is aware of 23 cases nationwide in which drinking water was contaminated by Class II wells. In many of these cases, improperly plugged oil and gas wells in the vicinity of injection wells served as the pathway for brines to reach drinking water. Although operators of wells that began operating after the program went into effect are required to search for and plug any improperly plugged wells in the immediate vicinity of their injection wells, this requirement does not apply to those Class II wells that were operating before the program. Injection wells already operating before the program accounted for nearly all of the cases in which contamination has occurred through migration into improperly plugged wells. Moreover, GAO estimates that at least 70 percent of its universe of Class II wells were already operating before the program and therefore have not been subject to the requirement to search and plug nearby improperly plugged wells.

Although the four state programs we analyzed require the safeguards that are currently part of EPA's program, some of these states are issuing permits to operate new Class II wells without evidence that pressure tests were conducted, and some have not finished reviewing files and pressure testing some of the existing wells. EPA and the states have taken steps to address some of these problems, but the states still need better documentation before issuing permits.

Principal Findings

Drinking Water Contamination

The full extent to which Class II wells have caused drinking water contamination is unknown, largely because the method for detecting contamination—installing underground monitors—can itself create a conduit for contamination and is therefore not widely used. Among the 23 known contamination cases, most resulted from cracks in the injection wells or from injection directly into drinking water; these cases were discovered, for the most part, as a result of required pressure testing and file reviews. However, in more than a third of the known cases, drinking water became contaminated when injected brines traveled up into improperly plugged abandoned wells in the vicinity of the injection wells and entered drinking water through cracks in these old wells. Since all but one of these injection wells were already operating at the time the program took effect, searches for and plugging of improperly plugged wells in the vicinity of the injection wells were not required. Contamination was not discovered, for the most part, until water supplies became too salty to drink or crops were ruined.

In 1976, before beginning the program, EPA proposed requiring all operators to search for and plug any improperly plugged abandoned wells within a 1/4-mile radius of their injection wells. However, commenters objected to making all wells subject to this rule because of the high costs involved. EPA decided to exempt those wells already operating, reasoning that because of the proximity between new wells and existing wells, the searches undertaken in the 1/4-mile radius of new wells would eventually uncover and result in the plugging of all the old wells.

Since then, however, relatively few new injection wells have come into operation. As a result, less than a third of GAO's universe of wells has been subject to area-of-review requirements. On the basis of a survey of old oil and gas production records, EPA has estimated that there are approximately 1.2 million abandoned oil and gas wells in the United States, of which about 200,000 may not be properly plugged. Moreover, among the four states that GAO examined, state officials in all but New Mexico believe that the numbers of improperly plugged wells are increasing—the result of the current economic decline in the oil industry. Although these four states have programs to plug these wells, Texas and Oklahoma officials said they now have more wells to be plugged than they can afford to pay for, and Kansas officials fear that with the increased numbers of wells reported each year, their plugging program may not be sufficient in the future.

Implementation of Program Safeguards

At the time of GAO's review of well files in late 1987 and early 1988, implementation of program safeguards in the four states reviewed was mixed. GAO found that the files of 41 percent (with a sampling error of ±14 percent) of the wells with permits contained no evidence that pressure tests had ever been performed, even though these tests are required before start-up and every 5 years thereafter. In three of the four states GAO reviewed, internal controls were not in place to ensure that all necessary documentation was on file.

States have also had mixed results in their reviews and tests of wells that were operating before the program took effect. About 32(±18) percent of the file reviews and 69(±16) percent of the pressure tests had been performed. Having completed an equivalent review prior to achieving primacy, New Mexico was considered to have met its file review requirements. In the three other states, officials said their reviews had been hampered by the large number of wells to review, incomplete information in the files, and insufficient staff and resources. With additional funds provided by EPA, the states now expect to complete their reviews in 1989 or 1990.

Recommendations

In order to better safeguard drinking water supplies from contamination from Class II wells, GAO recommends that the Administrator, EPA, take steps to help ensure that (1) EPA- and state-administered programs are revised to make existing as well as new wells subject to area-of-review requirements and because of the large number of reviews that would have to be conducted, areas with a high potential for contamination from improperly plugged wells should be reviewed first, and (2) state program agencies institute internal controls to ensure that all necessary documentation is obtained before they issue Class II permits.

Agency Comments

GAO discussed its findings with EPA officials and has included their comments where appropriate. However, as agreed, GAO did not obtain official agency comments on a draft of this report.

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Figures

Abbreviations

DCI	data collection instrument
EPA	Environmental Protection Agency
FURS	Federal Underground Injection Control Reporting System
GAO	General Accounting Office
MIT	mechanical integrity test
UIC	underground injection control
USDW	underground source of drinking water

Introduction

About half the population of the United States depends on groundwater for its drinking water. To help protect these supplies from contamination, the Congress passed Part C of the Safe Drinking Water Act in 1974. This law requires the Environmental Protection Agency (EPA) to establish an underground injection control (UIC) program. Through this program, EPA, directly or through delegation to states, regulates the design, construction, and operation of underground injection wells, which inject wastes and other fluids below underground drinking water sources.

At the request of the Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, we have been examining how EPA is managing the UIC program. In this report, we look at EPA and state management of that part of the program that regulates two-thirds of the underground injection wells, or the Class II wells used in oil and gas production to inject salt water either for enhanced recovery or for disposal purposes.

Nature of Groundwater

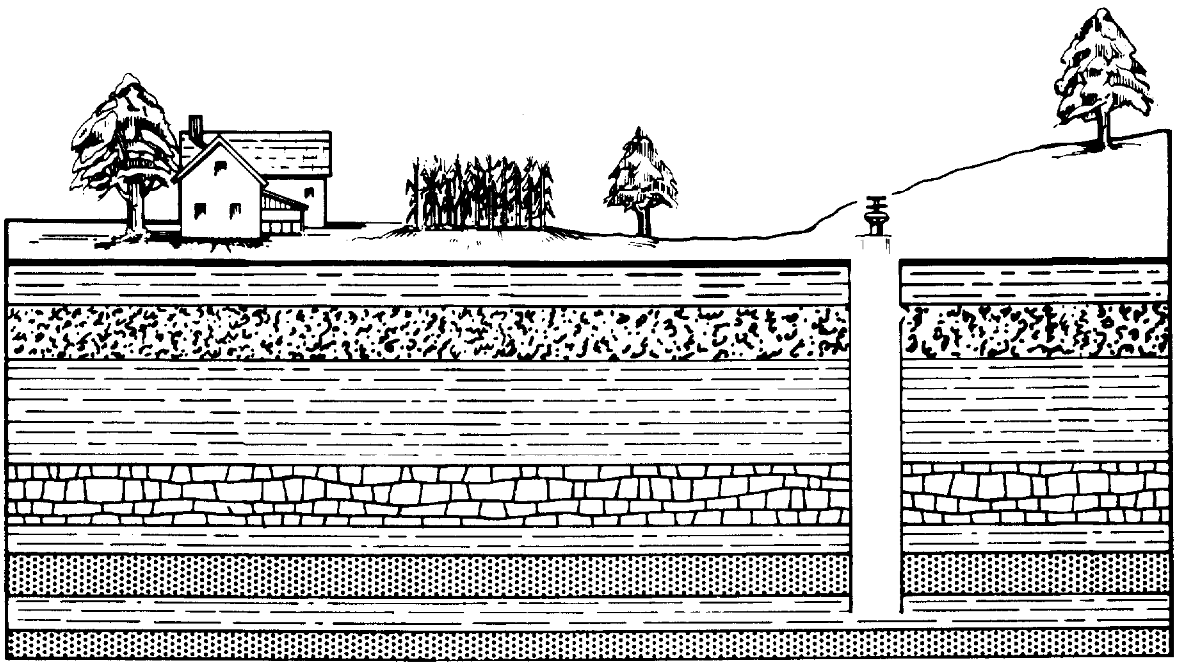
Groundwater is a vast resource that underlies the earth's surface. Within one-half mile of the surface of the United States, the volume of groundwater is estimated to be four times greater than that of the Great Lakes. Contained in layers of sand and rock called aquifers, groundwater can be located close to the surface or thousands of feet underneath.

For some parts of the country, groundwater is the sole or principal source of drinking water. Residents of 34 of the 100 largest cities in the United States rely on groundwater, as do about 95 percent of rural households. Because of this large dependency, groundwater contamination is a particular concern. Although it was once thought that natural filtration processes would change contaminants into harmless substances, groundwater contamination is being discovered with greater frequency and it is now recognized that the earth's cleansing capacity is limited.

Use of Injection Wells

Through underground injection, wastes and other fluids are deposited in porous rock formations, called injection zones, below drinking water sources. (See fig. 1.1.) Ideally, an injection zone is sealed above and below by unbroken, impermeable rock strata and is large enough to keep the injected fluids from reaching pressures great enough to fracture the confining rock layers.

Figure 1.1: Underground Injection



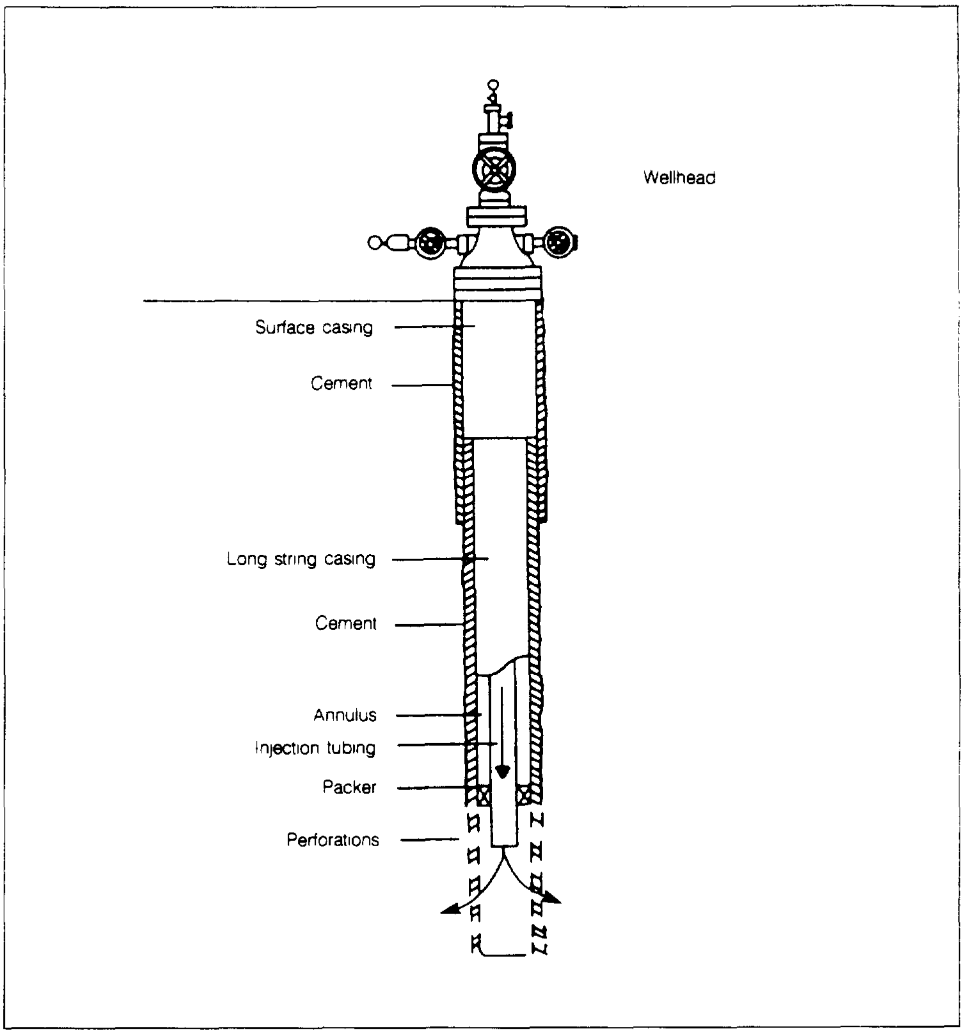
Source: GAO.

A modern injection well, shown in fig. 1.2, consists of three concentric pipes inserted into a well bore. The outermost casing is called the surface casing. This encloses the long string casing, which, in turn, contains the injection tubing. Fluids are injected through the injection tubing and enter the ground through perforations in the long string casing. To keep the injected fluids from entering the annulus, or the space between the tubing and the long string casing, the bottom is closed off by a packer.

Injection Wells in Oil and Gas Production

Although injection wells are used by other industries, particularly the chemical industry, they were first developed by the oil and gas industry and have been used for more than 50 years to dispose of salt water as well as to reinject it for production purposes. As oil and gas are extracted, strongly saline water, or brine, that occurs in underground rock formations flows up through production wells. In the early stages of production, very little brine is produced, but as oil and gas are removed, they are replaced by increasingly larger volumes of brine.

Figure 1.2: Modern Underground Injection Well



Source: Based on B. Klemt, et al., "Industrial Waste Disposal Wells: Mechanical Integrity, Proceedings of the International Symposium on Subsurface Injection of Liquid Wastes, New Orleans, Louisiana, 1986.

In the early part of this century, brines were disposed of in surface pits, but once the brines began to enter drinking water supplies, states banned this disposal practice. Oil producers then turned to underground injection for brine disposal. More recently, oil producers have used deep injection of brine for enhanced recovery of oil and gas, injecting it into oil-bearing formations to create the pressures necessary to force greater quantities of oil out of the ground. According to an American Petroleum Institute study, the domestic oil industry generated about 20.9 billion barrels of brine in 1985, more than 5 barrels for each barrel of oil produced.

Brines associated with oil and gas production contain very high levels of chlorides and other dissolved solids. Chloride levels in brine can range from a few thousand parts per million (ppm) to over 150,000 ppm, as compared with seawater, which typically contains about 35,000 ppm of chlorides. Brines may also contain some amounts of petroleum hydrocarbons and additives, such as corrosion inhibitors, as well as radium and other radioactive materials. Altogether, brines generally contain about 30,000 to 100,000 milligrams of total dissolved solids per liter (mgl). By comparison, EPA's secondary drinking water standard (related to drinking water taste) calls for no more than 500 mgl total dissolved solids and it defines an underground source of drinking water as a water bearing formation containing less than 10,000 mgl of total dissolved solids.

Regulation of Underground Injection

Once contaminated, groundwater can be difficult and expensive to clean. Unlike rivers and streams, groundwater moves very slowly; therefore, contaminants remain concentrated for long periods of time. Cleansing an aquifer contaminated by brines could entail either pumping fresh water into it, to accelerate its flow into the body of water into which the aquifer normally discharges, or pumping the water out of the aquifer. If contamination is extensive, however, and covers a large area, rehabilitation may be extremely costly. In these cases, if the aquifer is left to cleanse itself, the process can take as long as 250 years.

Recognizing that cleanup was not always possible, Part C of the Safe Drinking Water Act of 1974 stressed prevention of contamination in order to ensure safe drinking water supplies. The act established a system of state and federal regulation of underground injection wells. EPA was to set standards for the design, construction, and operation of underground injection wells and establish a regulatory program to enforce those standards. However, EPA could delegate to the states primary regulatory authority, or primacy, if the states adopted federal minimum standards, or, in the case of oil and gas injection wells, if they could demonstrate to EPA that their existing programs prevented contamination of drinking water. In those states that chose not to assume primacy, or did not meet federal requirements, EPA assumed regulatory authority.

The UIC program created by EPA in 1980 established five classes of injection wells. Class I wells are used to dispose of hazardous waste and non-hazardous industrial and municipal waste below the deepest underground sources of drinking water. Class II wells are those used during oil and gas operations. Class III wells are used for special processes, such as mineral production. Class IV wells, which inject hazardous waste into or above underground sources of drinking water, are illegal and were required to be plugged by May 1985. Class V wells are all injection wells that do not fit into the other four classifications.

Oil and Gas Injection Wells

Of the approximately 253,000 active and temporarily inactive injection wells in the United States in 1987, the largest number—160,265—were Class II, oil and gas injection wells. These wells are located in 31 states, 21 of which have approved state programs, and on Indian lands. (See table 1.1.) These 21 states also contain 84 percent of the Class II injection wells. The 10 remaining states and Indian lands have EPA-administered regulatory programs.

Table 1.1: Class II Regulatory Programs

	Number of wells
State programs	
Alabama	206
Alaska	266
Arkansas	1,128
California	11,201
Colorado	932
Illinois	14,147
Kansas	14,009
Louisiana	4,212
Missouri	275
Nebraska	624
Nevada	8
New Mexico	3,913
North Dakota	595
Ohio	3,952
Oklahoma	22,579
Oregon	1
South Dakota	40
Texas	49,476
Utah	664
West Virginia	760
Wyoming	5,749
Total	**134,737**
EPA programs	
Arizona (including Indian lands)	413
Florida	77
Indiana	3,274
Kentucky	5,399
Michigan	1,631
Mississippi	936
Montana	1,449
New York	3,254
Osage Mineral Reserve (Oklahoma)	4,298
Pennsylvania	4,788
Tennessee	9
Total	**25,528**
Total	**160,265**

Under federal and state UIC programs, owners and operators of wells that began operating after the programs were established must obtain permits in order to operate. The permits specify construction, operating, and reporting requirements, as well as procedures for monitoring the well and plugging it—that is, sealing it off—when it is no longer being used. Permit applications generally include information on the characteristics of both the well and the area in which it is to be located, including the location of nearby underground sources of drinking water and the composition of the injected fluid.

Although EPA initially expected that all Class II wells would have to obtain permits under the UIC program, states argued against this plan as impractical because of the large numbers of wells already operating under state programs that predated the federal program. They also pointed out that they already had on file much of the information that would be required in a permit application, such as injection pressure, design and construction specifications, and so on. EPA agreed, noting that a file review would be sufficient and would spare both the well operator and the states much of the costs involved in completing and reviewing permit applications.

EPA consequently allowed states that had regulatory programs to establish a combination of rule and permit procedures. Under this arrangement, those wells that were already operating when the states obtained primacy and already had permits issued by the state did not have to submit new permit applications but were authorized to continue to operate by rule. However, to verify that the well is not endangering underground sources of drinking water, the state had to review the files of these existing wells within 5 years after the state received primacy.

Under section 1425 of the Safe Drinking Water Act, EPA was authorized to delegate to states primary authority to regulate Class II injection wells as long as the states could demonstrate that they had programs that protected drinking water sources; states also had to have some form of inspection, monitoring, recordkeeping, and reporting requirements in their programs. Unlike the other UIC programs, EPA was not required by the act to establish specific regulatory standards that state Class II programs had to meet in order to obtain EPA's approval. Instead, EPA believed it was appropriate to issue more broadly worded guidance that would leave considerable discretion to the states on how to apply for primacy and to EPA regions on the criteria to be used in reviewing state programs.

Regarding state implementation of the program, the guidance outlines a number of basic safeguards that are not required but that EPA regards as demonstration of a state program's ability to prevent drinking water contamination. In states with EPA-administered programs, these same safeguards are required by regulation with EPA regional offices acting as regulatory agencies.

- State programs are expected to require operators to conduct a mechanical integrity test before a well can begin operating, in the case of new wells, and at least every 5 years for all wells. These tests include pressure tests to check for cracks and leaks in the casing and reviews of construction records to establish the quality of the cement lining between the outer casing and the injection formation.
- The programs should also require well operators to submit reports at least annually that describe monthly average injection pressures and flow rates and volume. The reports are also to include the results of all mechanical integrity tests and an analysis of injected fluids if there have been major changes since the initial test.
- The authority issuing the permit must make periodic inspections of the wells to determine compliance and to verify the accuracy of information submitted.
- States are expected to require operators to properly plug their wells when they cease operating and maintain some form of financial responsibility for plugging.
- States must complete file reviews for wells that were permitted under a state program that predated the federal UIC program within 5 years after approval of their programs to make sure that these existing wells are properly constructed and operated.

Once it approves a state program, EPA remains responsible for making sure that the states are effectively regulating underground injection and withdrawing primacy if they are not. EPA's oversight activities consist of visiting the state agencies and evaluating their performance at least once a year and reviewing operator noncompliance reports prepared by the states quarterly. To assist the states in carrying out their Class II and other UIC programs, EPA provides grant funds according to a formula based on population, geographic area, and injection practices.

Objectives, Scope, and Methodology

Following the issuance of our earlier report on the Class I UIC program,[1] in August 1987, the Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations,

[1] Hazardous Waste: Controls Over Injection Well Disposal Operations, GAO/RCED-87-170 (Aug. 28, 1987).

asked us to evaluate how EPA and the states are regulating underground injection related to oil and gas production. In subsequent discussions with his office, we agreed to examine

- whether evidence existed of contaminated drinking water as a result of underground injection of brines associated with oil and gas production, and if so, the causes of contamination and any actions taken to prevent similar cases from occurring in the future;
- how the states were regulating oil and gas underground injection wells; and
- the extent of states' efforts to properly plug all types of abandoned wells such as oil and gas wells that might serve as a pathway for injection fluids to reach drinking water.

To determine the extent of contamination across the country, we compiled EPA reports and other information obtained from state and EPA regional and headquarters officials in charge of UIC programs. From these sources, we identified known and suspected cases of contamination caused by Class II wells. We obtained additional information on each case and its disposition from officials of the responsible companies. For the contamination cases identified, we also obtained information on EPA and state officials' determinations of the causes of contamination. We traced the causes identified to state and EPA UIC program controls to determine whether controls existed to prevent similar cases of contamination from occurring in the future.

In contrast to our review of contamination, which was nationwide in scope, our review of state regulation of oil and gas injection wells focused only on state-administered programs and on their control mechanisms, including internal controls, for protecting drinking water. As agreed with the Chairman's office, we did not examine EPA-administered programs, since only 16 percent of Class II wells are in states with such programs. Among the 21 primacy states, we excluded Illinois because EPA conducted an extensive review of Illinois' program in 1986. Also, at the time of our review, Nevada had not yet been granted primacy.

From the 19 remaining states, we randomly selected four—Kansas, New Mexico, Oklahoma, and Texas—whose selection had a probability proportional to the total number of active and temporarily inactive wells in each state. Within these four states, we randomly selected a sample of active and temporarily inactive wells from EPA's inventory, known as the Federal Underground Injection Control Reporting System (FURS). For our sample of active and temporarily inactive wells, we collected information on the extent to which UIC program safeguards were implemented by the states for both permitted and rule authorized wells.

Because of differences between the FURS inventory and state records, we were unable to fill out data collection instruments for about 27 percent of our sample. Our sample estimates, therefore, represent approximately 88,000 (± 10,400) active and temporarily inactive Class II wells for which we expect we could have obtained the required information. In this report, we refer to this as the number of Class II wells in our universe.

Sampling errors for specific estimates discussed in this report are stated at the 95-percent confidence level and are included in parentheses following the estimate. They may be presented in either of two ways, depending on the type of sampling error calculation used. With one type of calculation, for example, the sampling errors are presented as "23(±7) percent," which means that the chances are 19 out of 20 that the true value could be as low as 16 percent—23 minus 7—or as high as 30 percent—23 plus 7. For the other type of calculation, the range of values above and below the estimated values are different and the sampling errors are presented as "23 (15 to 32) percent." (See app. I for a more detailed description of our methodology.)

The information we collected on wells in our sample reflects the status of those wells at the end of 1987 and early 1988. In Oklahoma, we conducted our review of well records during October, November, and December 1987; in Kansas, our review took place during January and February 1988; and in New Mexico and Texas, we looked at well records during February and March 1988. The information came from records kept at state offices, including well authorization documents, well completion records, operators' quarterly reports, mechanical integrity test results, inspection reports, financial surety records, and reports on file reviews conducted by state regulatory authorities. Information on state activities, as well as information on EPA oversight of state activities, came from state UIC program staff and EPA officials in regions VI and VII, which oversee the four states we reviewed.

For our last objective, these same state officials, as well as field officials of state agencies, also gave us information on plugging programs and abandoned wells in their states.

We sought the views of EPA and state officials on the facts and findings discussed in this report and incorporated their comments where appropriate. In general, they agreed with the facts presented. However, as requested, we did not obtain official agency comments on a draft of this report from EPA or the states included in our review. We conducted our review in accordance with generally accepted government auditing standards between September 1987 and August 1988 and updated certain information through December 1988.

Injected Brines Can Continue to Contaminate Drinking Water

Because of possible underreporting by individuals whose drinking water was contaminated and difficulties in detection, the full extent to which injected brines have contaminated underground sources of drinking water is unknown. However, 23 cases of contamination have been confirmed and 4 are suspected.

In many of these cases, abandoned improperly plugged oil and gas wells—that is, wells that had ceased operating without having been properly sealed off—near an active injection well provided the path through which brines reached the aquifer. Although injection well operators seeking permits have to search for improperly plugged wells in the immediate vicinity of injection wells, this requirement does not apply to those injection wells already operating when states were delegated authority for the federal UIC program. Injection wells already operating comprise at least 70 percent of the estimated 88,000 Class II wells in our universe.

According to EPA, improperly plugged wells near operating injection wells present significant environmental problems. The agency has estimated that there may be about 1.2 million abandoned wells across the country, many of which may be improperly plugged, and, with one exception, the states we reviewed foresee the numbers growing as the oil industry remains in an economic slump. Each of the four states we visited use either special funds or general revenues to plug improperly plugged wells, but funding has not always been adequate, and many wells remain unplugged.

Drinking Water Contamination Caused by Class II Wells

On the basis of EPA's studies and information furnished by EPA and state agency officials, we identified 23 cases in which injected brines contaminated underground sources of drinking water (USDWs). These cases, listed in table 2.1, occurred in seven states: Kansas, Kentucky, Michigan, Mississippi, New Mexico, Oklahoma, and Texas. In all 23 cases, a USDW was contaminated, although the contamination may not have spread to sections of an aquifer that are actually used.

Table 2.1 also lists three cases in Mississippi and Montana in which brines were suspected of migrating from the injection zone, but no tests were performed to determine whether drinking water had become contaminated. In addition, table 2.1 lists one case in Oklahoma in which drinking water has been contaminated and Class II wells are suspected of causing the contamination.

Table 2.1: Known and Suspected Cases of Contamination From Class II Wells

Operator	Number of injection wells	Aquifers contaminated	Path for contamination
Martha Oil Field, Ashland Exploration Inc., Lawrence & Johnson Counties, Ky	601	Alluvium, Breathitt, & Lee	Improperly plugged and constructed wells.
Taffy Oil Field, CNB Corporation, Ohio County, Ky	102	Chapman Stray Sand	Improperly plugged wells.
Big Sinking Field, Charmane Oil Corp., Lee County, Ky	124	Big Lime	Improperly plugged wells.
Big Sinking Field, Hydrocarbon Inc., Lee County, Ky	46	Breathitt	Improperly plugged wells.
Big Sinking Field, L.P. Bretagne, Lee, Powell, Estill, and Wolfe Counties, Ky	29	Newman	Improperly plugged wells.
Irvine-Furness Field, Western Crude Reserves Inc., Powell & Estill Counties, Ky	115	Newman, Alluvium, Breathitt, & Lee	Improperly plugged wells.
Burrton Oil, Hollow-Nikkel Oil Field, Harvey and Reno Counties, Kans.	50–100	Equus Beds	Improperly plugged wells.
East Gladys Unit, Gulf Oil Company, Sedgwick County, Kans.	57	An alluvial deposit	Improperly plugged wells.
Yankee-Canyon Field, Cactus Operating Company, Tom Green County, Tex.	12–15	Leona and Bull Wagon	Improperly plugged wells.
Moore-Devonian Oil Field, Texaco U.S.A., Lea County, N. Mex.	1	Ogallala	Leaks in casing.
J. J. Hobgood Lease, Sun Exploration and Production Company, Hockley County, Tex.	1	Trinity Sands	Leaks in casing.
Madden-Davis Lease, Petro-Lewis Company, Graham County, Kans.	1	Alluvium near the South Soloman River	Leaks in casing.
Laketon Oil Field, Harris Oil Co., Muskegon County, Mich.	1	Surficial water table	Leaks in casing.
Albright Field, Kahn Operating Company, Noble County, Okla.	1	Warren	Leaks in casing.
North LaGrange Field, R&H Oil Corp., Adams County, Miss.	1	Wilcox	Injection into USDW.
T. K. Stanley, Inc., Wayne County, Miss.	2	Wilcox	Injection into USDW.

How and when detected	Effects	Remedial action
Discovered by U.S. Army Corps of Engineers in 1985.	Contaminated drinking water for 83 to 88 households.	No cleanup; judged technically infeasible. Ashland to plug 1,450 surrounding wells, monitor aquifer, and provide alternative water supplies. Ashland also fined $125,000 for violating the Safe Drinking Water Act.
Citizen compliant in 1985 of undrinkable water.	Damaged household water supplies.	No cleanup; judged too costly. Original owner filed for bankruptcy; EPA deciding whether or not to sue. EPA working with two new owners to identify wells needing to be plugged. EPA may have new owners install monitoring wells to measure progress of aquifer self-cleaning.
Citizen complaint in 1986 of undrinkable water.	Contamination of drinking water and stained clothes and porcelain.	No cleanup; judged too costly. EPA plans to fine company $125,000 and order it to provide alternative water supplies to citizens and plug or rework the wells in the field.
Citizen complaint in 1986.	Contamination of drinking water source.	No cleanup; judged too costly. EPA will not assess fine but will order wells to be plugged or reworked.
Discovered by EPA inspectors and monitoring wells in 1987.	Contamination of drinking water source.	No cleanup; judged too costly. EPA will not assess fine but will order wells to be plugged or reworked.
Citizen complaint in 1985 of undrinkable water.	Contaminated residential drinking water source.	Decision on cleanup pending. EPA will probably order company to provide alternative water supplies and plug or rework wells so as to prevent future contamination.
Citizen complaints began in 1943; a state task force confirmed in 1982.	Damaged major supply of drinking and irrigation water. People have to use bottled water and city has to relocate well.	State authorized $300 million to begin cleanup. All operating wells have passed mechanical integrity tests. All abandoned wells have been plugged.
Citizen discovered in 1970.	Farmer's wells and peach orchard were damaged.	No cleanup; judged too costly. Gulf Oil plugged wells judged to be the source of pollution. Farmer successfully sued Gulf for damages to crops.
Citizen complaint in early 1970s.	Contaminated water well.	No cleanup; judged too costly. Cactus Operating Company drilled a new water well for the citizen and plugged 30 wells in the field.
Citizen complaint in 1977.	Crops damaged. Farmer's property foreclosed.	No cleanup; judged too costly. The well has been reworked and is in compliance with UIC regulation. Farmer successfully sued Texaco for damages.
Sun pressure test in 1984.	Contaminated public drinking water and irrigation supplies.	Once Sun detected decline in pressure, it shut in well. Sun is voluntarily pumping aquifer and has installed monitoring wells to track cleanup.
Citizen complaint in 1981.	Irrigation well contaminated.	A majority of the contamination was cleaned up after Petro-Lewis pumped water into the aquifer. The well has been plugged.
Citizen complaint in 1980 of undrinkable water.	Contaminated drinking water.	Decision on cleanup pending. Michigan ordered Harris to submit cleanup proposal, but Harris has not yet done so. Harris reworked wells.
Citizen complaint in 1984.	Damaged soil and vegetation and polluted freshwater stream used by residents for domestic uses.	No cleanup; judged impractical. State ordered Kahn to plug well. Field has since shut down.
EPA reviews beginning in 1985.	None reported.	No cleanup; judged too costly. R&H fined $5,000 and ordered to rework its well to extend into a deeper injection zone.
EPA reviews beginning in 1985.	None reported.	No cleanup; judged too costly. T. K. Stanley told to rework well to extend into a deeper injection zone.

(continued)

Operator	Number of injection wells	Aquifers contaminated	Path for contamination
Flora Field, Belden & Blake Co., Madison County, Miss.	10	Wilcox	Injection into USDW.
Heidelberg Field, Fina Oil and Chemical Co., Jasper County, Miss.	1	Wilcox	Injection into USDW.
Overton Field, Oilwell Acquisition Co., Adams County, Miss.	1	Moody Branch	Injection into USDW.
Raleigh Field, Chevron Oil Co., Smith County, Miss.	2	Wilcox	Injection into USDW.
Board of Supervision Field, XMCO-Triad, Smith County, Miss.	1	Wilcox	Injection into USDW.
Summerland and South Central Fields, Triad Oil & Gas Company, Covington, Jones, and Smith Counties, Miss.	4	Wilcox	Injection into USDW.
Mize Field, Chevron USA, Inc., Ranking County, Miss.	1	Eutaw	Injection into USDW.
Suspected Cases			
Flat Coulee Field, Breck Operating Corporation Liberty County, Mont.	10	Eagle (Virgelle) Sandstone	Improperly plugged wells.
South Central Cut Bank Sand Unit, Unocal Company, Glacier County, Mont.	54	Two Medicine and Eagle	Improperly plugged wells.
Langsdale Field, Charles H. Moore Co., Clarke County, Miss.	6	Wilcox	Leaks in casing.
Prue Sand Unit, Sac and Fox Tribal Land, Lincoln County, Okla.	Unknown	Vamoosa	Improperly plugged wells.

How and when detected	Effects	Remedial action
EPA reviews beginning in 1985.	None reported.	No cleanup; judged too costly. Belden and Blake ordered to rework well to extend into a deeper injection zone.
EPA reviews beginning in 1985.	None reported.	No cleanup; judged too costly. Fina fined $75,000 for violating Safe Drinking Water Act and ordered to rework well to extend into a deeper injection zone.
EPA reviews beginning in 1985.	None reported.	No cleanup; judged too costly. Oilwell fined $4,000 for violating Safe Drinking Water Act and ordered to rework well to extend into a deeper injection zone.
EPA reviews beginning in 1985.	None reported.	No cleanup; judged too costly. Chevron ordered to rework well to extend into a deeper injection zone.
EPA reviews beginning in 1985.	None reported.	No cleanup; judged too costly. XMCO-Triad ordered to rework well to extend into a deeper injection zone.
EPA reviews beginning in 1985.	None reported.	No cleanup; judged too costly. Triad ordered to rework well to extend into a deeper injection zone.
EPA reviews beginning in 1985.	None reported.	No cleanup; judged too costly. Chevron ordered to rework well to extend into a deeper injection zone.
Citizen complaint in 1985 of purging wells.	None reported.	Owner plugged the abandoned well.
Citizen complaint in 1986 of purging wells.	Residence's backup water supply may be contaminated.	A production well that was flowing at the surface was plugged by the state.
Routine inspection and pressure test in 1988.	None reported.	State arranged for wells to be plugged.
Citizen complaint in 1977.	Contaminated drinking water.	The Department of the Interior is attempting to determine the party responsible for contamination.

There may be more instances of contamination because not all occurrences are detected nor are all known cases necessarily reported. According to EPA officials and a state official, individuals whose drinking water is affected may choose to deal directly with the well operator and never inform the regulatory authority.

Contamination is difficult to detect. As shown in table 2.1, about half the known and suspected cases were discovered only after contamination had become obvious to the people affected, for example, when their well water became too salty to drink, their crops were ruined, or when they could see water flowing at the surface of old wells. Neither EPA nor the states routinely require groundwater monitoring for Class II wells. Although monitoring wells can be used to measure the extent of contamination, they are of limited value for detecting contamination away from the well since they can only be used in a small area and are therefore not useful for assessing large aquifers. In addition, deep monitoring wells themselves create potential routes by which contaminants can reach drinking water.

For the most part, the remaining cases were discovered by the operator or EPA staff during UIC program monitoring operations required to ensure that wells are being properly operated. Three were discovered during pressure tests, which revealed leaks in the casing or some other structural failure. The other nine cases, all in Mississippi, were discovered by EPA while reviewing injection records. From these records, EPA staff could determine that the wells, which were constructed before the UIC program went into effect, were injecting directly into a USDW. In all 12 of these cases, EPA or the state directed operators to cease injection until the wells were repaired or reworked.

In addition to the 23 cases of contamination that have been confirmed, 4 cases are also suspected. Two were reported to the state of Montana by residents who saw water flowing out of abandoned oil and gas production wells located near enhanced recovery wells. The state suspected that the pressure from these enhanced recovery operations was forcing fluids up through the unplugged production wells. Because of the possibility that these fluids could be entering drinking water supplies through leaks in the casing of the old wells, both wells were plugged. In Mississippi, the state arranged for wells that failed mechanical integrity tests because of numerous cracks in the casing to be plugged. In addition, on Indian lands in Oklahoma, the Department of the Interior is determining whether enhanced recovery wells or production wells are responsible for contaminated drinking water.

Causes and Consequences of Contamination

The 23 cases in which contamination was confirmed can be traced to three principal causes: five cases resulted from leaks in the casing of the injection wells, nine cases resulted from injection into the USDW, and nine resulted from migration of brines from operating injection wells into nearby oil and gas wells that had been left unplugged or improperly plugged.

Once contamination was discovered, regulatory authorities in either EPA regions or the states directed responsible companies to prevent further contamination by plugging their injection wells or the abandoned wells, reworking injection wells to repair cracked casings, or extending the wells below the USDW. Some companies were also directed to provide alternative drinking water supplies. In a few instances, property owners sought and received court-awarded compensation for damages. According to an EPA official, although the Safe Drinking Water Act and EPA regulations do not require cleanups in every contamination case, EPA and the states can require cleanups. In three cases, cleanup efforts were undertaken and in two other cases, cleanup efforts are currently under consideration. In the other 18 cases, EPA or the state decided that cleanup was either technically not feasible, too expensive, or not practical because the aquifer was already high in brine content and not usable for drinking water without treatment.

The following case examples depict the circumstances under which contamination has occurred and the efforts to remedy it.

Contamination Through Leaks in Casing

Lea County, New Mexico

During the 1970s, 20 million gallons of salt water leaked from a Texaco disposal well in Lea County, New Mexico, into portions of a drinking water source, the Ogallala aquifer. Some of the brine made its way into a rancher's irrigation well, damaging his crop and, according to the rancher, ultimately causing the foreclosure of his farm property. On the basis of the results of a pressure test, the rancher successfully sued Texaco in 1977 for damages. Texaco subsequently made repairs to the well, and it is now operating in compliance with UIC regulations. Texaco was not required to clean the aquifer, however, because, according to the Chief of New Mexico's Environment Bureau, the cost could not be economically justified.

Hockley County, Texas

In 1984, the Sun Exploration and Production Company discovered that its disposal well in Hockley, Texas, was contaminating the Trinity Sands aquifer, which provides drinking water to parts of northern Texas and irrigation water to much of northern and central Texas. After Sun detected a decline in the pressure of its disposal well, it conducted a mechanical integrity test and found that the casing had ruptured. The company then notified state authorities and plugged the well. Sun also began taking water samples to determine the extent of the contamination, flushing the salt water from the aquifer, and installing monitoring wells to determine whether chloride levels were returning to acceptable levels. As of November 1988, monitoring showed that the chloride level has been reduced but has not yet returned to the original level. State officials said that there have been no complaints about drinking water quality as a result of this episode.

Contamination Through Direct Injection Into the Aquifer

While reviewing the injection records of existing disposal wells in Mississippi beginning in 1985, EPA discovered that 23 wells in 9 different fields were injecting directly into a drinking water source. Since direct injection is prohibited by UIC regulations, EPA ordered the operators to cease injecting into the aquifer and to rework their wells so that they extend into a deeper injection zone. EPA also assessed penalties against the operators ranging from $4,000 to $75,000 for violating the Safe Drinking Water Act and from $100 to $1,000 a day for continued non-compliance, depending on the operator's history of compliance and other factors. EPA officials told us that the operators would not be required to perform any cleanup since there had been no complaints about the drinking water and the costs of cleanup could not be economically justified.

Contamination Through Abandoned Wells

Lawrence and Johnson Counties, Kentucky

In 1985, while constructing lakes in the area, the U.S. Army Corps of Engineers discovered that brine was contaminating Blaire Creek in Lawrence and Johnson Counties, Kentucky. After the Corps reported it, EPA traced the contamination to an Ashland Exploration Company field of 601 enhanced recovery wells. After sampling 20 water wells, EPA found that the drinking water for 83 to 88 households had become contaminated.

The Ashland field contained 1,450 abandoned oil and gas wells that had not been plugged, and brines had entered drinking water supplies through cracks in the casing of these wells. EPA therefore required Ashland to properly plug the abandoned wells, provide alternative water supplies to homeowners whose wells were contaminated, and install long-term monitoring devices to track the natural cleanup process. EPA also fined the company $125,000 for violating the Safe Drinking Water Act. Because of the extent of contamination, EPA officials decided it would not be technically feasible to clean up the aquifer. Drinking water supplies will consequently remain contaminated for perhaps another 20 years, according to the head of the UIC program in EPA region IV, until the affected aquifers can cleanse themselves.

Ohio County, Kentucky

Also in 1985, residents of Ohio County, Kentucky, complained to EPA that their drinking water had become contaminated. EPA traced the contamination to a CNB Corporation field of 102 enhanced recovery wells, known as the Taffy Oil Field. According to EPA's staff geologist in region IV, there were over 100 unplugged abandoned wells in the field. EPA reported that 62 injection wells failed mechanical integrity tests and lacked adequate casing and cementing. As a result, brines had entered the Chapman Stray Sand aquifer, which is a source of drinking water.

EPA's analysis of a sample of four water wells in the vicinity of the Taffy field revealed that one well had a total dissolved solid concentration above the maximum contaminant level—4.5 times the drinking water standard. EPA could not determine the concentration for one of the other wells because the resident's well contained oil so thick it coated EPA's measuring instrument. No contamination was found in the two remaining wells. Residents with contaminated drinking water wells had to obtain water from other sources, in some cases using pond water or installing cistern systems to collect rainwater.

An EPA official said CNB subsequently went bankrupt and lost its leases in the Taffy field. EPA and the new owners are now identifying wells that need to be plugged. Although EPA will not require cleanup because of its high costs, the agency is considering having the new owner install monitoring wells to track the natural cleanup process. EPA is also considering suing the original owner.

Safeguards Do Not Prevent Contamination by Abandoned Wells

Of the three causes of contamination, two—cracked casings and improper injection—were detected during the course of required pressure tests and record reviews for the most part. However, in only one case did these activities detect contamination through unplugged wells. While some states have special programs to plug abandoned wells, the number of improperly plugged abandoned wells, already estimated to be large, is growing, and some states are even now unable to pay for all the wells that need to be plugged.

Area-Of-Review Requirements

According to EPA guidance and state regulations (in the four states we reviewed), applicants for Class II permits must undertake a search for abandoned wells within at least a 1/4-mile radius of the injection well. The search is limited to wells of public record. Once these wells are identified, permit applicants must ensure that the abandoned wells are plugged in a manner that prevents the movement of brines into USDWS.

When EPA first proposed this so-called "area-of-review" requirement in 1976, it applied to both new injection wells and those that were operating when the UIC program went into effect. However, commenters objected to imposing this requirement because of the large costs involved. While noting that dangers to underground sources of drinking water would also be great if there were large numbers of wells that had to be plugged, EPA nevertheless decided to limit the area-of-review requirement to new wells only. The agency believed that since new wells would be constructed in or near old fields, the area reviews for these new wells would eventually identify most abandoned wells, albeit over a longer period of time than if existing wells also had to conduct area reviews. EPA stated, however, that its decision would be open to review and that after the first year of state program operation, EPA would examine information submitted by the states on the costs and benefits of conducting area reviews and consider whether to change its requirements.

After publishing these proposed regulations, an EPA consultant reported to the agency on the costs of complying with its proposal.[1] On the basis of estimates of the number of abandoned and producing wells in the United States, the consultant calculated the rate at which these wells would be reviewed. Assuming that 5,000 new injection wells would be added each year, the consultant estimated that it would take roughly 10 years before at least half the wells to be reviewed had been covered and over 20 years before nearly all the wells were reviewed. The consultant also estimated that most wells reviewed would not require any work but that 7.5 percent of all abandoned wells would have to be replugged, at an average cost of $20,000 per well.

Since EPA delegated regulatory authority to the states, they have issued permits to relatively few new wells. According to our projections, only 23(±7) percent, or about 20,300 out of the estimated 88,000 wells in our universe at the end of 1987, began operating after the UIC programs

[1] Cost of Compliance, Proposed Underground Injection Control Program, Oil and Gas Wells, prepared for Office of Drinking Water, EPA (June 1979).

were implemented. Consequently, the majority of Class II wells in our universe have not been subject to area-of-review requirements.

Although EPA did not conduct the anticipated first-year review, it began a Mid-Course Correction review in 1988 to examine area-of-review requirements, along with four other UIC program safeguards. As part of this effort, a panel of headquarters and regional staff, as well as state UIC program officials, plans to determine how effective the area-of-review requirement has been in identifying improperly plugged abandoned wells and whether the requirements should apply to all wells rather than only new wells. As of October 1988, EPA had begun to survey the states as to how they have been implementing area-of-review requirements. EPA staff expect to complete their work and develop recommendations for the Director of EPA's Office of Drinking Water in 1989.

State Efforts to Plug Improperly Plugged Abandoned Wells

According to EPA, there are approximately 1.2 million abandoned oil and gas wells, including formerly producing wells, in the United States. Of these, about 193,000, or roughly 17 percent of the total, may not be properly plugged. However, because of differences in construction practices and well depth, among other factors, the degree of risk from contamination from improperly plugged wells differs.

According to officials in Texas, Oklahoma, and Kansas, the number of improperly plugged wells may be growing. While New Mexico officials believe that they do not have a problem with abandoned wells, officials in the three other states told us that the number of improperly plugged wells in their states has been steadily rising in the last few years, as the decline in oil and gas activity has forced many operators into bankruptcy. Although these three states, as well as New Mexico, have plugging programs for abandoned wells, Texas and Oklahoma officials reported that they currently have more wells to be plugged than they can afford to pay for.

Texas, for example, has had a plugging program since 1965. Until 1983, the number of wells that were plugged with state funds ranged from 20 to 50 a year. By 1984, however, the total number of wells that were plugged rose to 177, and the state began to charge a $100 drilling permit fee that went into a plugging fund; the first year, $4.5 million was collected. However, because of the downturn in the oil industry, by 1987, drilling fee collections had dropped to $2 million, while the number of wells to be plugged went up to a total of 703. As of January 1988, the plugging fund contained $1.2 million, but the cost to plug the 489 wells awaiting plugging was estimated to be $2.6 million, leaving a shortfall of $1.4 million. In addition, the state is now attempting to compel the owners of 6,350 abandoned and improperly plugged wells to properly plug them. Depending on the extent to which owners have the resources to pay for plugging, the state could have several thousand more wells to plug.

Oklahoma, which also has a plugging program, plugged 53 wells during fiscal year 1987 using about $122,000 in funds appropriated from general revenues, according to a state official. However, these were only purging wells—wells from which brine could be seen flowing at the surface. Although there were even more wells to be plugged the following year, fewer funds were available, according to the official, and only 19 wells were plugged—those that posed an immediate threat to water supplies and residents. In one field office in Oklahoma, the district manager told us that 149 unplugged abandoned wells had been reported to his office, but he did not have funds for plugging them. Noting that the number of unplugged abandoned wells has increased significantly in recent years, the district manager estimated that there were thousands of such wells in his district alone.

Kansas also maintains a plugging fund made up of permit fees and general revenues. A state law also allows abandoned wells to be plugged using proceeds from the sale of pipe and equipment left on-site. While these two means of paying for plugging have thus far been adequate, Kansas officials fear that with increases in the number of improperly abandoned wells being reported, their plugging programs may not be sufficient in the future. Although they did not know the precise number of unplugged abandoned wells, officials are aware that they have increased enormously in the last few years. In 1983, Kansas had to plug one well at a cost of $1,400, but by 1987, the state had 56 wells to plug, which cost $213,000.

Conclusions

Given the difficulties in detecting contamination and obtaining reports on contamination from affected individuals, the full extent to which Class II wells have contaminated drinking water is unknown. Nevertheless, for those cases that we know of, two points are striking. One is that UIC program safeguards have in some instances detected and prevented further contamination. Of the 27 known and suspected cases, close to half were discovered during routine pressure tests and record reviews. As a result, injection was halted until the wells could be reworked to correct the problem, or the wells were plugged.

The other point that stands out is that although the UIC program protects against continued contamination from structural deficiencies and improper injection, it does not always protect against contamination from a leading source: improperly plugged abandoned wells. Close to half of the known and suspected cases of contamination were the result of fluids flowing up through improperly plugged wells and entering USDWs. In these cases, contamination was allowed to spread until it had become extensive enough to incur noticeable damage, by making water undrinkable or ruining crops. EPA and the states have recognized that these types of wells are potential threats, and the four states in our review have programs to plug improperly plugged abandoned wells. However, these programs are not always adequate to plug all the wells that three of these states believe need or will need to be plugged.

While not all improperly plugged abandoned wells are immediate threats to drinking water supplies, those that are near operating injection wells can serve as conduits. For this reason, EPA and the states adopted the area-of-review concept, but they adopted it only for new wells, reasoning that all improperly plugged abandoned wells would eventually be discovered, although at a slower rate than if existing wells were also subject to the requirements.

Events occurring since EPA adopted the area-of-review concept have demonstrated—as EPA has recognized in its Mid-Course Correction review—that it is time to reconsider the decision to exempt existing wells from area-of-review requirements. Since 1980, several cases of contamination have been detected as a result of migration of fluids from existing injection wells into surrounding unplugged wells. While no one can say whether contamination would have been entirely prevented if area-of-review requirements had been imposed, the spread of injected fluids would more likely have been discovered and halted sooner.

Also, in the past 2 years, states have faced increasing demands on their plugging funds as oil and gas activity has declined and the number of improperly plugged abandoned wells has grown. By relieving well operators of the responsibility to identify and plug any improperly plugged abandoned wells in the vicinity of their injection operations, EPA has, in effect, transferred the costs to the states or, in those cases where states do not have sufficient funds, to the public whose drinking water supplies are in danger of becoming contaminated.

The importance of having sufficient safeguards is underscored by the fact that there are usually no practical remedies once contamination occurs. For most of the 23 confirmed cases, the drinking water sources that were contaminated will remain so for years until natural processes restore water quality.

Extending the area-of-review requirement to existing as well as new Class II wells would affect a large number of wells—at least 70 percent of the estimated 88,000 wells in our universe—and thus could require states to devote additional resources to reviewing the information submitted by operators and ensuring that abandoned wells are properly plugged. However, to the extent that these existing wells are in the same area-of-review as new wells already permitted, the reviews for existing wells should have already been completed. In addition, because the degree of risk from contamination differs among existing wells, depending on well depth and construction practices, for example, not all area reviews conducted by operators would have to be reviewed at once by the state or EPA regulatory agency, but rather they could be reviewed over a period of time.

Recommendations

In order to better safeguard drinking water supplies from contamination from Class II wells, we recommend that the Administrator, EPA, require that UIC program regulations and/or guidance be established for state- and EPA-administered programs to make existing wells subject to area-of-review requirements as are new wells. Because of the large number of such reviews that would have to be conducted, EPA should establish a priority system to ensure that the regulatory agencies review those area reviews containing improperly plugged wells that pose the greatest environmental risks first.

Existing Safeguards Against Contamination Have Not Been Fully Implemented

On the basis of our review in late 1987 and early 1988, states' performance in implementing existing UIC program safeguards was mixed. Although the four state programs we examined are meeting most requirements for issuing permits, a considerable portion of their well files did not contain sufficient documentation to support issuance of injection well permits. In addition, Kansas, Oklahoma, and Texas have not finished reviewing the files of rule-authorized, or existing wells, with Oklahoma and Texas taking longer than the 5-year period that EPA's guidance allowed. Similarly, Oklahoma and Kansas have not finished pressure testing about 44 percent of their existing wells. Kansas and Oklahoma are also not monitoring the activities of many of their wells. Finally, while all four states require proper plugging and abandonment procedures, only two provide for financial responsibility on the part of the operator. The others rely instead on state plugging funds, which, as noted in chapter 2, have not always been sufficient to pay for all the wells that have to be plugged.

EPA regions are aware of delays in program implementation and problems with financial surety, and EPA has increased state program funding and created a financial surety task force to address these problems. However, although EPA has been assessing the states' programs, the agency has not been aware of the extent of gaps in documentation.

Class II Program Safeguards

As noted in chapter 1, the Safe Drinking Water Act gave states considerable discretion in their programs to regulate Class II wells, requiring only that they demonstrate that they were protecting drinking water sources and included inspection, monitoring, recordkeeping, and reporting practices. EPA guidance specified a number of basic safeguards to be included in state programs, including

- area-of-review, mechanical integrity tests, and construction requirements for wells that have permits;
- file reviews and mechanical integrity tests for rule-authorized wells; and
- inspections and operator reports (as monitoring devices) and proper plugging and abandonment procedures, including some form of financial responsibility for plugging both types of wells.

We found that all four states—Kansas, Oklahoma, New Mexico, and Texas—had adopted these safeguards in some form. As discussed in the following sections, however, the procedures followed and the extent to which they have been implemented differ.

Requirements for Permits Are Not Fully Documented

In order to obtain a permit to operate a Class II well, states require operators to, among other things (1) meet certain construction standards including those for surface casing, (2) search for and plug any abandoned unplugged wells in the area-of-review (as discussed in chapter 2), and (3) conduct a mechanical integrity test. While surface casing requirements vary among and even within states, state programs generally require that new wells be constructed with surface casing that protects the lowest USDW. Files on the new wells we examined showed that this standard was met.[1] However, we found that many wells with permits contain no evidence in their files that area-of-review information was checked or that the pressure test portion of mechanical integrity tests was conducted.

To make sure that government programs are operating efficiently and accomplishing their objectives, program managers should have in place a system of internal controls. According to standards for internal controls developed by GAO in 1983,[2] significant agency transactions and events are supposed to be properly recorded.

We found, however, that the four states did not have internal controls in place to ensure that all necessary documentation was on file. For example, for all types of wells with permits we found that, in general, files had information on the status of wells, both active and abandoned, within the area-of-review: in Kansas, 100 (65 to 100) percent; in Oklahoma, 88 (68 to 97) percent; and in Texas, 100 (89 to 100) percent of the files met this requirement. (In New Mexico, 100 (37 to 100) percent of the files also had met this requirement, but this estimate is based on a very small number of wells; hence, the broad confidence interval.) In none of the states, however, did UIC program staff document their reviews of the information submitted to meet area-of-review requirements.[3] Although staff in New Mexico, Kansas, and Oklahoma told us

[1]Because all 14 of the new wells in our sample met this standard, we cannot compute a meaningful estimate for our universe. At the individual state level, the estimates are Oklahoma, 100 (47 to 100) percent; Texas, 100 (55 to 100) percent; Kansas, 100 (47 to 100) percent; and New Mexico, 100 (4 to 100) percent. These calculations are based on very small numbers of wells; hence, the broad confidence intervals.

[2]Internal controls that federal agencies are required to follow are set forth in GAO's Standards For Internal Controls in the Federal Government, published in 1983 pursuant to the Federal Managers Financial Integrity Act of 1982.

[3]Because none of the 59 permitted wells in our sample showed any evidence of such a check, we cannot compute a meaningful estimate for our universe. At the individual state level, the estimated percentages of wells without documentation are Oklahoma, 100 (88 to 100) percent; Texas, 100 (89 to 100) percent; Kansas, 100 (65 to 100) percent; and New Mexico 100 (37 to 100) percent. These calculations are based on small numbers of wells and therefore have broad confidence intervals.

that they checked the information that permit applicants submitted against state maps and plugging records, we found no evidence of such a check. Moreover, while examining the files, we could find no evidence that state program staff had ever found improperly plugged wells. In Texas, officials acknowledged that they rarely reviewed the accuracy of information submitted to satisfy area-of-review requirements because of the time and staff required. The state now has a pilot project underway, funded by EPA, to determine the costs of checking area-of-review information.

Documentation was also missing from program files on mechanical integrity tests (MITS). MITS are performed in two parts: the first part is a check of cementing and other records in order to verify that enough cement was used to ensure that fluids are not migrating from the injection zone; the second part is a check for leaks in the well casing and tubing, either by annulus pressure tests, monitoring, or other means. For new wells, MITS are supposed to be conducted before injection can begin and every 5 years thereafter.

Overall, 41(±14) percent of the files in our universe had no documentation indicating that pressure tests had been conducted before the wells were allowed to begin operating. In Texas, the UIC program director explained that before 1986, the state did not require operators to submit this information. We found that those wells in Texas that had no record of pressure tests had all been issued permits before 1986 and were therefore not required to submit evidence. In Oklahoma and Kansas, program officials believed that the necessary tests had been conducted but that the reports documenting them had not been correctly filed or received from the states' district offices. EPA regional officials told us they had known of problems with missing documentation but were not aware they were as extensive as our review found. In New Mexico, the files in our universe had documentation indicating that pressure tests had been conducted before the wells were allowed to begin operating.

Existing Wells Have Not Been Fully Reviewed and Tested

According to EPA guidance, states were to review the files and test the mechanical integrity of all existing, or rule-authorized, wells within 5 years of achieving primacy to make sure that the wells are not endangering USDWS. As of the end of 1987 and early 1988, these reviews and tests were not complete, however.

File Reviews

File reviews are supposed to verify the following:

1. Each well extends below the lowermost USDW and has an adequate confining zone separating the injection zone from that USDW.

2. Each well is designed for the expected use and local geological conditions.

3. Each well is cased and cemented to prevent movement of fluids in or between USDWs.

4. Each well is operated at an appropriate pressure and with adequate controls to prevent fracturing of the confining zone.

5. Each well operator is monitoring and reporting as required.

6. Each well owner/operator is maintaining appropriate financial surety and plugging and abandonment plans.

In order to check on the first three items, state officials rely on operators' well completion reports, which contain information on the depth of the well, the length of the casing, and the extent of cementing. To check on well pressures, officials examine the operator's permit and the pressure authorized at issuance. Those states that require financial surety on the part of the well operator check the currency of financial information, and to monitor well activities, officials check to see whether operator reports, describing the current status of the well and monthly pressure readings, are on file.

Three of the four states in our review achieved primacy more than 5 years ago: New Mexico and Texas in 1982, and Oklahoma at the end of 1981. Since Kansas obtained program primacy in February 1984, its 5-year period just concluded. However, overall, at the time of our review only 32(±18) percent of the necessary file reviews had been completed. New Mexico conducted an equivalent review before it received primacy and was therefore given credit for having met this requirement by EPA. Oklahoma had completed 36(±16) percent of its file reviews and Texas, 29(±10) percent. Kansas had completed reviews on 7(±7) percent of its files.[4]

[4]Although Kansas officials claimed that 23, or 41 percent of our sample files, had been reviewed, 19 of these files were reviewed at the field level and state files did not contain documentation on these reviews. We were therefore able to verify only those 4 files reviewed by the state, which comprised 7 percent of our sample files.

In these three states, file reviews have been hampered by the large number of wells to review, incomplete information in the files, and insufficient staff and resources. With over 43,000 existing wells, Texas was skeptical from the start that it could complete its file reviews within 5 years, and its original memorandum of agreement with EPA, under which the state was delegated primacy, contained no deadline for completing its file reviews. The state did relatively few file reviews until January 1987, when it received a 3-year, $750,000 grant from EPA, which it has used to hire 12 staff members. Texas officials said that as of December 1987, they had completed file reviews of 9,768 wells, finding numerous instances of missing well completion reports, along with wells that were being regulated but had never been authorized to inject by the state. In these cases, operators are required to apply for a permit according to procedures. The state expects to complete all its file reviews by January 1990.

With almost 13,000 Class II wells to review, Oklahoma also faced a major undertaking, which similarly was slow to start. According to the state's UIC program director, although Oklahoma achieved primacy in 1981, it did not begin its review of rule-authorized wells until 1985 because until that time Oklahoma focused on permitting. At that point, after EPA expressed its concern about the state's lack of progress, the state hired a program director and instituted file reviews and other procedures. However, once file reviews began, reviewers found that much of the information they needed—mostly well completion reports—was missing and had to be obtained from well operators. In 1986, EPA region VI granted Oklahoma another 2 years to complete its file reviews, until December 1988, and also gave the state additional funding for its program. Since then, EPA has granted Oklahoma an additional extension to September 30, 1989.

Kansas' file reviews were also slowed by missing well completion information and a late program start. When Kansas was granted primacy, its program was jointly administered by two state agencies that disagreed over how the program should be run. Implementation was consequently delayed until 1986, when a single state agency assumed responsibility for the program. Once the file reviews got underway, program officials discovered that many files lacked well completion reports. As a result, the state began to require operators of existing wells to submit well completion information along with the results of pressure tests. Kansas officials expect to complete their file reviews sometime in 1989.

Mechanical Integrity Tests

Along with file reviews, MITS are the principal means by which authorities can ensure that existing Class II wells are not contaminating drinking water. According to EPA guidance, operators were to conduct the pressure test portion of the MITS within the same 5-year period as the file reviews. At the time of our review, however, 69(±16) percent of the required pressure tests overall had been conducted within the last 5 years.

In Texas, 93(±6) percent of the wells either had pressure tests completed or had been equipped with continuous monitoring devices. In New Mexico, 81(±18) percent of the wells had annulus pressure tests.

However, in Oklahoma, only 44(±16) percent of the wells and in Kansas, only 44(±13) percent of the wells had been tested within the last 5 years, in both cases, because incomplete and incorrect inventories of wells delayed the states' scheduling of pressure tests. As discussed further in the next section, it is the policy of both states to have inspectors witness as many pressure tests as possible. According to program officials, inspectors were often unable to locate wells that were listed in their inventories. In other instances, inspectors were sent out to a well only to discover that the test had already been conducted.

As with the MITS for wells with permits, Kansas program officials believed that tests had been conducted on many more existing wells and were surprised to learn that our sample results were much lower. Oklahoma officials and EPA officials in region VI recognized that progress had been slow, but they are hopeful that with the addition of funds and staff, the tests will be completed by September 30, 1989.

Operators Are Not Consistently Monitored

To help ensure that operators are meeting the terms of their permits, UIC programs contain provisions for inspection and monitoring. According to EPA guidance, state programs are supposed to provide for qualified state inspectors to witness at least 25 percent of the MITS conducted each year. To monitor activities on an ongoing basis, program officials rely on operator reports, submitted at least once a year and containing information on the injection pressures and volume of fluids injected each month.

We found that each of the four states has inspectors to witness MITS. Kansas, New Mexico, and Oklahoma require inspectors to witness as many MITS as possible, and we estimate that 72 percent or more of the MITS conducted in each of these three states had been witnessed. Texas' policy is for inspectors to witness at least 25 percent of the MITS, and we found that state inspectors had witnessed 29(±12) percent of the MITS.

Monitoring of operator activities was less consistent. While New Mexico had operators' annual reports on file for all or most of its wells (100 [88 to 100] percent) and Texas for nearly all its wells (96[±4] percent), Kansas had only 48(±13) percent of the required reports, and Oklahoma had only 25(±11) percent. Both Kansas and Oklahoma attribute this situation to incomplete inventories of Class II wells. Unlike New Mexico and Texas, which have computerized inventories, Kansas and Oklahoma are still in the process of compiling their inventories, with district offices gathering information as inspectors witness MITS. Once the inventories are complete, Kansas and Oklahoma officials said they will be able to check their files to ascertain whether they contain current operator reports and to send out notices when reports are found to be missing, as is done in Texas and New Mexico.

Kansas officials expect to have their inventory completed in 1989, while Oklahoma program officials expect their inventory will be completed once all the MITS have been conducted, in 1989.

Financial Surety Requirements Are Not Working

EPA guidance for state programs calls for Class II wells to be properly plugged upon abandonment, in a manner that will not allow the movement of fluids into or between USDWS. The guidance also calls for operators to maintain financial responsibility for plugging their wells but does not specify the forms it must take.

While all four states in our review have adopted requirements for plugging and abandonment, only New Mexico and Oklahoma require operators to provide some form of financial assurance, while Kansas and Texas use their state-administered plugging funds in lieu of requiring operators to maintain financial responsibility. New Mexico requires operators to provide a performance bond, either for a single well or an entire field, and we found that all or most wells (100 [88 to 100] percent) had evidence of surety on file that was current.

Oklahoma requires either a bond, a letter of credit, or a financial statement showing a net worth of at least $50,000. However, state officials have encountered problems with financial statements, claiming that many operators who were allowed to furnish financial statements went bankrupt and left no assets for plugging. According to our data, 41(±12) percent of the wells in Oklahoma with evidence of financial surety on file are covered by this form of assurance. In 1986, the state legislature tightened the requirements for financial statements by requiring operators of new wells to have bonds for at least 3 years before they can use financial statements as financial surety.

Even with this change, however, the state may still encounter problems. Twenty-four(± 18) percent of the wells in Oklahoma with financial statements on file as evidence of financial ability showed a net worth of less than $50,000. We also found that 18(± 10) percent of all forms of financial surety on file in Oklahoma, including financial statements, had expired or were not current.

Although EPA allowed Texas and Kansas to use their plugging funds instead of requiring operator financial responsibility, as discussed in chapter 2, Texas' fund is inadequate to pay for plugging all the known abandoned wells and Kansas' fund may not be sufficient in the future to plug increasing numbers of abandoned wells. The director of Texas' UIC program told us that the state has been looking into the possibility of requiring operator financial surety, although there is some concern about operators' ability to pay for bonds or other forms of surety. While Kansas has no plans to require operator surety, the UIC program official in charge of compliance is concerned that if the number of abandoned wells that are improperly plugged continues to grow at current rates, the plugging fund may become inadequate.

According to an EPA official, along with its Mid-Course Correction review, EPA is looking at the need for changes in financial surety requirements. While continuing to examine long-range issues, such as the viability of financial statements, an EPA work group has developed recommendations for immediate implementation that included requirements for annual updates of financial statements as well as updates of plugging and abandonment costs.

EPA Oversight of State Programs

In addition to the Mid-Course Correction review of the Class II program, which is looking at program requirements, EPA regulations also call for the agency to evaluate how well states are implementing their programs. According to EPA regulations, states are supposed to report to EPA annually on the implementation of their programs and quarterly on cases of noncompliance with permit requirements. On the basis of the states' reports and visits to the states, the EPA regions prepare annual assessments of each state's progress in implementing its program.

While we found that regional officials were reasonably familiar with the status of the four state programs we examined, their knowledge of the programs was based on general observations rather than on an in-depth review of well records, such as ours. EPA's annual evaluations have focused on more fundamental program implementation issues, such as staffing, funding, and adoption of regulations. As noted earlier, EPA officials in regions VI and VII, which have oversight over the four states in our review, believe that while Texas, Kansas, and Oklahoma were slow to put their programs into place (particularly the latter two states), the states have made progress in the last few years.

However, EPA is concerned about the adequacy of the states' data management systems and the accuracy of their reporting. Our findings reinforce the agency's concerns. In particular, we found that the information reported to EPA by Kansas and Oklahoma on completed file reviews and MITs differs from what we found in well records. For example, as shown in table 3.1, Oklahoma reported to EPA that by the end of 1987, about the same time we looked at well records in the state, it had completed 66 percent of its file reviews. Our review of records, however, found that a smaller portion of the file reviews had been completed—36(± 16) percent. Similarly, Oklahoma reported a higher completion rate for pressure tests than our record checks revealed. In Kansas, the difference between what we found and what the state reported is quite wide, the result, according to state officials of having some records kept in field offices, while others are kept in the central state office, where our review was conducted.

Table 3.1: Comparison of Selected State-Reported and GAO Data for Existing Wells (Percent)

	File reviews completed[a]		Pressure tests (MITs) completed[a]	
	State data[b]	GAO data	State data[b]	GAO data
Kansas	72	7(±7)[c]	60	44(±13)
New Mexico	[d]	[d]	[e]	81(±18)
Oklahoma	66	36(±16)	73	44(±16)
Texas	38	29(±10)	84	93(±6)

[a]Our estimates are for active and temporarily inactive wells in EPA's FURs inventory as of October 1987. EPA's data relate to similar wells listed in FURs as of December 1987.

[b]EPA officials said they consider these numbers to be estimates because the number of existing wells in the states' inventories is difficult to determine.

[c]State officials believe the actual percentage of completed file reviews within our sample was 41 percent. (See footnote 4 on p. 36.)

[d]New Mexico conducted an equivalent review before receiving primacy and was therefore considered to have already met this requirement.

[e]Since New Mexico requires a pressure test annually, the number of tests it reported is greater than the number of existing wells.

To address its concerns, EPA has begun a complete review of UIC program data needs and management systems. After identifying EPA headquarters' information needs, the agency plans this year to identify a minimum set of data elements to be collected and kept by the states and regions on a well-by-well basis. EPA expects that it will take about 5 years to have a satisfactory system in place for every program.

Conclusions

Under the wide latitude allowed by federal law, states have adopted those safeguards that EPA has determined to be fundamental to protecting USDWs from contamination. Most of the states we visited, however, have taken a long time to review existing wells and after 4 to 5 years, many of these wells had still not been reviewed and tested. The states and EPA are aware of this situation, however, and believe that the problems that caused these delays—lack of sufficient staff and resources to deal with the large number of wells—are being addressed. According to state officials, remaining file reviews and pressure tests should be completed within the next year or two.

EPA also realizes that financial surety requirements have to be strengthened. Although intended to ensure that operators would not abandon their wells without properly plugging them, financial surety has not always been effective in guaranteeing that funds will be available for plugging. In view of the large number of improperly plugged abandoned wells in the United States and the potential for contamination they represent, preventing any increase in their numbers should be a high priority. EPA's task force is an important effort toward this end.

On the basis of our findings, we also support EPA's efforts to improve its internal controls over the UIC program by developing better data management systems. Specifying precisely what information should be kept in the records of each well is an important step in helping ensure that the data that are reported by the states are accurate and reliable.

By contrast, EPA was not aware of the extent of problems with new permits. Although operators are supposed to pass a pressure test and search for and plug any improperly abandoned wells in their area-of-review before they can receive their permits, states issued a considerable number of permits, without any evidence on file that these requirements had been met or checked. EPA needs to make sure that states are issuing permits only if sufficient evidence exists that pressure testing is performed and area-of-review information is checked.

Recommendation

To help ensure that Class II wells are structurally sound and not injecting into areas of unplugged wells, we recommend that the Administrator, EPA, require state program regulatory agencies to institute the internal controls necessary to ensure that Class II permits are issued only if documentation exists that area-of-review information was checked and the pressure test portion of mechanical integrity tests was conducted.

Methodology

Our review focused on active and temporarily inactive (we are using the term temporarily inactive to refer to EPA's category of temporarily abandoned wells) Class II wells in the 20 states that had primary regulatory authority at the time of our analysis. As table I.1 shows these states contain a total of 134,729 active and temporarily inactive wells, which represent about 87 percent of all such wells in the United States.

Table I.1: Active and Temporarily Inactive Class II Wells in Primacy States (As of October 1987)

State	Number of wells
Texas	49,476
Oklahoma	22,579
Illinois	14,147
Kansas	14,009
California	11,201
Wyoming	5,749
Louisiana	4,212
Ohio	3,952
New Mexico	3,913
Arkansas	1,128
Colorado	932
West Virginia	760
Utah	664
Nebraska	624
North Dakota	595
Missouri	275
Alaska	266
Alabama	206
South Dakota	40
Oregon	1
Total	**134,729**

Source: EPA, FURS.

In choosing our sample from among these states, we excluded Illinois because EPA had conducted an extensive study of Illinois' program in 1986. This exclusion left 120,582 active and temporarily inactive Class II wells in our universe of interest.

Our sampling then proceeded in two stages. In the first stage, we randomly selected four distinct states, with the probability of their selection proportional to the total number of active and temporarily inactive

Class II wells in each state.[1] The information on Class II active and temporarily inactive wells in the four states came from EPA's FURS. Each time a state was selected meant that in the second stage of sampling, we would take a sample of 25 wells from that state. Thus, since Texas was selected five times, the total number of Texas wells that would be included in the sample was 125. In the second stage of sampling, we randomly selected a total of 350 wells from these four states. (See table I.2.)

Table I.2: Sample of State-Regulated Active and Temporarily Inactive Class II Wells

State	Number of times selected	Number of wells	Proporation of wells of interest	Number of wells sampled	Number of wells reviewed
Texas	5	49,476	.410310	125	108
Oklahoma	4	22,579	.187250	100	63
Kansas	4	14,009	.116178	100	61
New Mexico	1	3,913	.032451	25	24
Total		**89,977**	**.746189**	**350**	**256**

Of our 350 sample wells, we filled out data collection instruments (DCIS) for 256 wells, or 73.1 percent of the wells sampled. We did not fill out DCIs for the remaining 94 wells because of discrepancies between EPA and state records. The specific reasons for not filling out DCIs are listed in table I.3.

Table I.3: Reasons for Not Filling Out DCIs on Sample Wells

Reason	Number of wells: Texas	Oklahoma	Kansas	New Mexico	Total
FURS inventory contained more wells for a single permit than state files	•	29	17	•	46
Not an active or temporarily inactive well[a]	11	6	14	1	32
Permit application withdrawn	6	•	3	•	9
No file found for well in state records	•	2	5	•	7
Total	**17**	**37**	**39**	**1**	**94**

[a]Files showed that the wells had been plugged, converted to a production well, had never been activated, or were not injection wells.

Because we reviewed a statistical sample of wells, each estimate developed from the sample has a measurable precision, or sampling error.

[1]We randomly selected the four distinct states with replacement. This means that each time we selected a state from our 19-state universe of interest, its selection was noted and then it was returned to the universe prior to the next selection. Thus, a particular state could be selected more than once before we selected our four distinct states.

The sampling error is the maximum amount by which the estimate obtained from a statistical sample can be expected to differ from the true universe characteristic (value) we are estimating. Sampling errors are stated at a certain confidence level—in this case, 95 percent. This means that the chances are 19 out of 20 that, if we reviewed all of the Class II wells in our universe, the results of such a review would differ from the estimate obtained from our sample by less than the sampling errors of such estimates.

Our sample estimates represent approximately 88,000 (± 10,400) active and temporarily inactive Class II wells in the universe of interest—19 primacy states. These estimates represent Class II active and temporarily inactive wells that we would expect (1) to have been listed in the FURS inventory as of October 1987 and (2) to have files at the state level that would enable us to fill out a DCI on each well.

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