United States General Accounting Office

GAO

Report to Congressional Requesters

June 1997

DRINKING WATER

Information on the Quality of Water Found at Community Water Systems and Private Wells

GAO/RCED-97-123

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-276974

June 12, 1997

The Honorable J. Dennis Hastert
The Honorable Bill Paxon
House of Representatives

As requested, this report provides information on (1) what is known about the quality of drinking water from community water systems and private wells in six states and (2) what factors influence the quality of drinking water from these sources. The report contains a recommendation designed to help ensure that owners of private wells are better informed of potential contamination problems whenever groundwater-based community systems detect contamination that may also be present at nearby private wells.

As arranged with your offices, unless you publicly announce its contents earlier, we will make no further distribution of this report until 30 days after the date of this letter. At that time, we will send copies to the appropriate congressional committees; the Administrator, Environmental Protection Agency; and the Director, Office of Management and Budget. We will also make copies available to other interested parties upon request. Major contributors to this report are listed in appendix III.

Stanley Czerwinski
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Executive Summary

Purpose

The vast majority of U.S. households get their drinking water from community water systems regulated under the federal Safe Drinking Water Act. These water systems must comply with a variety of federal and state requirements relating to their construction, the periodic monitoring of their water quality, inspections, and other matters. The remaining households do not have access to community water systems and rely primarily on private domestic wells that are not subject to the act but may be subject to state and local requirements.

To learn more about the quality of drinking water, Representatives J. Dennis Hastert and Bill Paxon and former Representative Blanche Lambert-Lincoln asked GAO to provide them with information on (1) what is known about the quality of drinking water from community water systems and private wells and (2) what factors influence the quality of drinking water from these sources. To meet these objectives, GAO gathered data from six states selected on the basis of such factors as the number or percentage of households that use private wells and the amount of information available on water quality from private wells. The states are California, Illinois, Nebraska, New Hampshire, North Carolina, and Wisconsin.

Background

The Safe Drinking Water Act, enacted in 1974, requires the Environmental Protection Agency (EPA) to establish drinking water standards for the nation's nearly 56,000 community water systems. The act also requires water systems to monitor the water delivered to consumers to determine whether it meets the standards. EPA generally grants to the states the responsibility for enforcing these standards and for overseeing community water systems. In both 1986 and 1996, the Congress amended the act to revise the standard-setting process; strengthen enforcement authority; and/or add other requirements for EPA, the states, and water systems.

An estimated 15 million households that are not served by community water systems get their drinking water from private, domestic wells. Although private wells are not covered by the Safe Drinking Water Act, state and local governments may establish their own requirements for constructing, testing, inspecting, and otherwise regulating these wells. Other federal and state laws' provisions are designed to protect groundwater and/or surface water from contamination. Both private wells, which are generally supplied by groundwater, and community water systems, which are supplied by either groundwater or surface water, may be affected by these laws.

Results in Brief

Much more is known about the quality of drinking water from community water systems than from private wells. To meet the Safe Drinking Water Act's requirements, community water systems must periodically monitor their water for contaminants, such as total coliform bacteria, pesticides, naturally occurring elements, and industrial solvents. In the six states that GAO reviewed, compliance data for fiscal years 1993 through 1996 show that violations of the standard for total coliform bacteria were the most common, being reported by 3 to 6 percent of the more than 17,000 community water systems. A sizable number of systems (although a small percentage of the total) violated standards for radiological contaminants, nitrate, and the herbicide atrazine. Violations of other standards were few.

For private wells, the available data on water quality are, for the most part, limited to data on total coliform bacteria and nitrate. These data have been collected for special studies, in response to state and local testing requirements for new wells, and through voluntary testing requested by well owners. While these data are not always representative or unbiased, those that are have shown rates of bacterial contamination as high as 42 percent and rates of excessive nitrate as high as 18 percent. Less extensive data on two commonly used herbicides show much lower levels of contamination in private wells.

Several factors influence the quality of drinking water obtained from community water systems and private wells. These factors include (1) the condition of the source from which the drinking water is extracted; (2) the use of construction standards and other controls designed to ensure that new water systems and private wells are properly constructed and protected from potential sources of contamination; and (3) ongoing oversight and maintenance activities, such as periodic testing and inspections, that help determine whether the water will continue to be safe.

Principal Findings

Data on Contamination Are Extensive for Community Water Systems and Limited for Private Wells

Under the Safe Drinking Water Act, community water systems are required to monitor their water for up to 72 specific contaminants, including bacteria, pesticides, industrial solvents, and other chemical and radiological compounds. The frequency of the required monitoring ranges from daily to once every 9 years, depending on the type of contaminant,

the population served by the water system, the source of the water, and the presence of contaminants in past samples. Community water systems may also have to employ treatment techniques to prevent unsafe levels of up to nine other contaminants.

Four of the six states reviewed by GAO do not require any testing at private wells; the other two states require testing for bacteria, and one of these states requires testing for nitrate before new wells are put into service. In some instances, local governments and lending institutions require limited testing at new wells. Other data on the quality of private well water are available because testing was initiated by well owners or special studies were conducted.

In total, community water systems in the six states reviewed by GAO exceeded the standard at least once for 25 of the regulated contaminants during fiscal years 1993 through 1996. By far the most common problem was contamination with total coliform bacteria, from a low of 577 systems (3.3 percent of 17,443) reporting at least one violation in 1996 to a high of 1,035 (5.7 percent of 17,976) doing the same in 1993. The next most common problem was exceeding the standard for naturally occurring combined radium; an average of 129 systems (no more than 0.8 percent per year) reported such violations over the 4 years. Other standards violated by a number of systems over the 4 years were for nitrate (58 systems per year, on average), naturally occurring alpha emitters (53 systems, on average), and the herbicide atrazine (22 systems, on average). Few community water systems reported violations for the other 20 contaminants.

Because water quality is not routinely monitored at private wells as it is at community water systems, the data available for private wells are limited. Through both representative and unrepresentative methods, such data have been gathered for special studies, tests required by state and local governments, and voluntary tests requested by well owners. In the six states reviewed by GAO, the available data were primarily for total coliform bacteria and nitrate, and only limited data existed for pesticides, heavy metals, and volatile organic compounds. Nearly all of the data show that contamination with total coliform bacteria is common for private wells, that excessive nitrate concentrations range from common to rare, and that contamination with herbicides is rare, as shown by the following. A 1994 survey led by the Centers for Disease Control and Prevention (CDC) collected data on total coliform bacteria and nitrate concentrations from a sample of geographically distributed private wells in three of the six states

included in GAO's study. Total coliform bacteria in excess of the standard were detected in 46, 37, and 23 percent of the wells tested in Illinois, Nebraska, and Wisconsin, respectively. Nitrate was detected in concentrations exceeding EPA's standard in 15, 15, and 7 percent of the wells tested in the three states, respectively. The study reported the herbicide atrazine at levels above EPA's standard at no more than 0.2 percent of the wells in these three states.

Community water systems and private wells located in the same general area may use the same source of groundwater. Thus, according to EPA and state drinking water officials, some of the contaminants detected in community systems are likely to be present in nearby private wells. This is most likely to be true for contaminants, such as nitrate and various pesticides, that have leached into the groundwater after long-term application on the land. However, community water systems are required to treat their water when necessary or to take other actions to avoid violating water quality standards.

In 1975, under authority of the Safe Drinking Water Act, EPA began requiring community water system owners to inform their customers whenever their systems exceed the standard for a regulated contaminant. The 1996 amendments require that after August 1998, community water system owners annually inform their customers of all detections of contaminants. Water quality data from testing community water systems that use groundwater may be useful to private well users if they derive groundwater from the same source, particularly because private well users rarely test their water for most contaminants regulated by the act. However, community water system owners are required to notify only their customers and not private well users whenever contamination is detected in groundwater. Hence, private well users may not be aware of nearby contamination that could affect their water supply.

Condition of Source, Standards for Well Construction, and Other Factors Influence Water Quality

The condition of the water source can significantly affect the quality of drinking water supplied by community water systems and private wells, particularly if the water is untreated. Community systems are much more likely than private well users to treat their water for contaminants that pose health risks. In addition, private wells are typically shallower than the wells in community systems and are more likely to tap into contamination that has leached into groundwater from the surface.

Another key factor influencing water quality is the nature of the controls in place to help ensure that new drinking water sources, including both community systems and private wells, are properly constructed and protected from potential contamination. All six of the states reviewed by GAO have established construction standards and siting requirements that specify minimum distances between the water source and potential sources of contamination for both community water systems and private wells. As regulated public water supplies, new or substantially modified community systems must undergo a rigorous approval process. However, states and local communities vary in the extent to which they impose controls over new private wells.

Ongoing oversight and maintenance activities, such as the periodic monitoring of water quality and routine inspections—and the extent to which such activities trigger corrective action—also influence water quality. As noted earlier, community water systems are subject to extensive testing, and states periodically conduct comprehensive inspections of water systems' design, operation, and maintenance. However, the primary responsibility for the ongoing oversight and maintenance of private wells rests with individual homeowners; none of the states GAO visited requires testing at existing wells or conducts routine inspections. For example, because of financial constraints, New Hampshire officials have inspected only four or five of the estimated 50,000 private wells constructed over the past 12 years. When contamination is detected at community systems, states can compel corrective action. But identifying and correcting contamination problems at private wells is generally left to the discretion of the well owners.

Recommendation

To help ensure that private well users are better informed of potential contamination problems and associated health risks, GAO recommends that the Administrator, Environmental Protection Agency, explore options that would provide such well users with information on how to learn more about the quality of their drinking water and the steps they can take to protect the source of their drinking water from contamination. For example, state and/or local health agencies could use the local media to alert private well users to consider testing their water whenever the testing of a groundwater-supplied community water system detects contamination that could potentially be present in the same geologic formation supplying nearby private wells.

Agency Comments

GAO provided a draft of this report to EPA, CDC, and the six states that GAO reviewed. GAO obtained comments from EPA officials, including the Director of the Implementation and Assistance Division of the Office of Ground Water and Drinking Water, and CDC officials from the National Center for Environmental Health and the National Center for Infectious Diseases. GAO also obtained comments from representatives of the state agencies responsible for overseeing drinking water quality. The federal agencies and states generally agreed with the information presented in the report. They did offer updated information or technical comments, which GAO incorporated throughout the report, as appropriate. EPA, CDC, and the states agreed with the intent of GAO's recommendation and offered suggestions for clarifying and expanding it. GAO has revised the recommendation to give EPA and the states more flexibility in achieving the goal of increasing the amount of water quality information available to private well users.

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Abbreviations

CDC	Centers for Disease Control and Prevention
EPA	Environmental Protection Agency
GAO	General Accounting Office
MCL	maximum contaminant level
SDWA	Safe Drinking Water Act

Introduction

Because safe drinking water is essential to public health, the quality of the nation's drinking water supply is an issue of national importance. For the most part, consumers receive drinking water from either community water systems or private wells. The water, which may be tapped from groundwater aquifers or surface water bodies, is vulnerable to a wide range of pollutants from agricultural, industrial, urban, and residential land uses, as well as natural causes. In response to these threats, federal, state, and local governments have put regulatory programs in place to prevent consumers from drinking contaminated water. However, variations in the sources of drinking water, in its delivery to consumers, and in the extent to which its quality is regulated have raised questions about whether safe drinking water is being consistently delivered to all citizens.

Most Americans Get Their Drinking Water From Community Water Systems or Private Wells

The vast majority of Americans get their residential drinking water from one of two categories of delivery systems—community water systems or private wells. According to the 1990 census, about 84 percent of the nation's 102 million households obtained their drinking water from community water systems, most of which are regulated under the Safe Drinking Water Act (SDWA) of 1974.[1] Of the remaining 16 percent of households, about 15 million received their drinking water from private wells and about 1 million used small unregulated water systems.[2] Private wells are not regulated under SDWA but may be regulated by state and local governments. Other means of drinking water delivery include SDWA-regulated noncommunity systems.[3]

About 55,600 community water systems operated in the United States in fiscal year 1995, compared with over 59,000 in fiscal year 1991. This decline is attributed, at least in part, to the consolidation of small systems into larger ones. Despite this trend toward consolidation, about 85 percent of the community systems are small, serving fewer than 3,300 people.

[1]The U.S. Bureau of the Census defines a community water system as one that supplies water to five or more housing units. This definition contrasts with SDWA's, under which a community water system is one that serves at least 25 year-round residents or has at least 15 year-round service connections.

[2]A water system that has fewer than 15 service connections or serves fewer than 25 people is not regulated under SDWA. Such a system may be regulated by a state or local government. An estimated 1 percent of the population is served by this type of system.

[3]Under SDWA, noncommunity water systems are divided into two categories: transient and nontransient noncommunity systems. Transient noncommunity systems serve at least 25 people for more than 60 days a year but do not regularly serve any given 25 people for more than 6 months a year. Examples include gas stations and roadside rest areas. Nontransient noncommunity systems regularly serve at least 25 of the same people for more than 6 months a year. Examples of these systems are schools, factories, or office buildings.

The National Ground Water Association estimates that over 300,000 new private wells are drilled each year. There are several reasons why many Americans obtain their drinking water from private wells. Many live in sparsely populated rural areas where it is not economically feasible to install community water systems. Some consumers have put in private wells to avoid the increasing cost of the water supplied by community systems, and others simply prefer to control their own water source.

Most Americans also drink water outside the home, such as at work, school, and restaurants and while traveling. The source of this water may be a community water system, a private well, or what is known under SDWA as a noncommunity system. While noncommunity systems do not serve residential customers, they must still meet certain requirements for their operation, water quality monitoring, and water treatment. The focus of this report is on water consumed in the home from private wells and regulated community systems. In this report, the term private well includes the well, the pump, and the connections leading to the household tap.

Sources of Drinking Water Are Vulnerable to Contamination

Drinking water delivered by community systems and private wells comes from two sources: surface water and groundwater. Both sources are vulnerable to contamination. Surface water is drawn from rivers, lakes, streams, and reservoirs. Groundwater is pumped by wells from porous rock, sand, or gravel saturated with water that has percolated down from the surface. Community water systems may rely on groundwater, surface water, or both, while private wells generally rely on groundwater. Groundwater and surface water each supply about 50 percent of the country's drinking water.

The quality of the water source can be affected by a variety of factors, including local land uses, the local geology, and—for groundwater—the depth of the aquifer from which the water is extracted. Groundwater is vulnerable to contaminants that filter down into underground aquifers from the surface; when this occurs, the water level closest to the surface is affected first. Deeper levels of an aquifer or areas that are protected by a confining clay layer are often unaffected by surface contamination. Surface water is vulnerable to contaminants from runoff, precipitation, air pollution, and direct discharges from industrial and municipal facilities.

Local land uses can have a significant impact on groundwater and surface water. For example, in some agricultural areas, the long-term application of pesticides and fertilizers has contaminated underlying groundwater.

Near landfills and industrial facilities, improper waste disposal or chemical spills have also contaminated groundwater. And man-made contaminants may be introduced into groundwater by other means. For example, abandoned wells that have not been properly sealed can serve as conduits for contamination from the surface. Naturally occurring inorganic compounds—such as fluoride, arsenic, and various radiological compounds—may also be present in groundwater, depending on the type and location of geological formations. The extent and depth of the contamination that leaches down from the surface can vary with the volume and type of the contaminant, the permeability of the soil, the amount of rainfall in the area, and other environmental characteristics.

Surface water has also been affected by contaminated runoff from agricultural lands and urban areas. Regions that experience greater rainfall or are prone to flooding are more vulnerable to contamination from runoff than more arid regions. Other potential sources of surface water contamination include chemical discharges from industrial and municipal wastewater treatment facilities and the atmospheric deposition of heavy metals and other substances contained in emissions from manufacturing plants and other facilities.

Drinking water contamination can also occur within the distribution system. For both private wells and community water systems, this system includes the connections between the well or treatment facility and the household tap. For example, a breach in the distribution system could allow bacteria to contaminate drinking water.

EPA Regulates Community Water Systems and Sets Standards for the Quality of Drinking Water

With the enactment of SDWA in 1974, the Congress established a national program to ensure that all community water systems meet minimum standards to protect public health. SDWA directed the Environmental Protection Agency (EPA) to establish (1) national drinking water standards or treatment techniques for contaminants that could adversely affect public health and (2) requirements for monitoring the quality of drinking water and for ensuring the proper operation and maintenance of water systems. SDWA also authorizes EPA to grant primary enforcement authority for the drinking water program, commonly referred to as “primacy,” to states that meet certain requirements. With EPA’s oversight, the states with primacy enforce the drinking water program’s requirements and oversee the public water systems within their jurisdiction. The states maintain other oversight activities to ensure that public water systems meet design, construction, and water quality standards.

For each of the currently regulated contaminants,[4] EPA was required under SDWA to establish (1) a health-based goal at a level at which no known or anticipated adverse health effects occur and that allows an adequate margin of safety and (2) a national primary drinking water regulation, generally based on the highest allowable concentration of a contaminant in drinking water, called a maximum contaminant level (MCL). SDWA required EPA to set the MCL as close to the health-based goal as feasible, considering the available technology and costs.[5] EPA was allowed to specify a treatment technique in lieu of an MCL whenever it was not feasible to measure the level of a contaminant in drinking water.[6] EPA's responsibilities in setting standards for the quality of drinking water were recently modified under the 1996 amendments to SDWA. The agency now has more flexibility in deciding which contaminants should be regulated and may give greater consideration to relative costs and risk-reduction benefits.

EPA currently regulates 81 contaminants that could adversely affect public health[7] and has established MCLs for 72 of these contaminants. Community water systems are required to test their water for the 72 contaminants and take certain corrective actions if they find levels above an MCL. For the remaining nine contaminants, EPA requires that community systems use specific treatment techniques that will reduce contaminants to acceptable levels. Additional monitoring may be required in conjunction with the use of these treatment techniques. EPA also sets "secondary" standards for contaminants that affect the aesthetic quality of drinking water, such as its taste, odor, and appearance. While the presence of these contaminants may be unpleasant, EPA does not consider them to be unhealthy. Both community water systems and private wells may be affected by the presence of secondary contaminants, and both systems have treatment options that may improve their water.

[4]The contaminants currently regulated under EPA's safe drinking water program include various inorganic, volatile organic, and synthetic organic chemicals; radioactive chemicals; and microbiological contaminants.

[5]On the basis of the legislative history, EPA decides, when considering costs, whether the technology is reasonably affordable to regional and large metropolitan water systems.

[6]For some contaminants, the available analytical methods are not economically or technologically feasible; that is, the methods are too costly or are not sufficiently accurate or reliable. For these contaminants, EPA identifies treatments that are effective in reducing risks.

[7]EPA has set standards for three other contaminants (aldicarb, aldicarb sulfone, and aldicarb sulfoxide) but is reconsidering these standards in light of new evidence and has delayed their implementation.

State and Local Governments Set Requirements for Private Wells

Although private wells are not regulated under SDWA, they are subject to state and local regulations. For example, state and local governments may issue permits for, require testing of, or conduct inspections at private wells. The degree to which state and local governments have acted to regulate private wells varies from state to state.

One area of state regulation concerns the construction of private wells. Over time, different types of wells have been developed to meet specific geological conditions and to reflect advances in technology. Not all construction methods are now considered acceptable, and state requirements can be very specific. (See app. I for a brief description of common construction methods for wells.)

State and local oversight of private wells not only provides some degree of consumer protection to well users but also helps protect the nation's groundwater resources. Inadequately constructed or improperly abandoned wells can serve as conduits for contamination from the surface to enter the groundwater.

Other Federal, State, and Local Programs May Protect Sources of Drinking Water

In addition to the federal, state, and local programs that specifically address community and private drinking water delivery systems, other programs are in place to protect source waters from contamination. Some of these programs are implemented by the states under the authority of federal statutes, while others exist at the states' discretion. Such programs include, for example, groundwater protection standards and monitoring; wellhead protection and underground injection control programs under SDWA; controls over facilities that treat, store, and dispose of hazardous waste under the Resource Conservation and Recovery Act; statewide septic system and pesticide management regulations; well abandonment standards; and controls over chemical discharges from industrial and municipal wastewater treatment plants under the Clean Water Act. Other programs are targeted at more diffuse, or "nonpoint," sources of pollution, such as agricultural and urban runoff.

Objectives, Scope, and Methodology

At the request of Representatives J. Dennis Hastert and Bill Paxon and former Representative Blanche Lambert-Lincoln, we reviewed the quality of drinking water in community water systems and private wells. In discussions with the requesters' offices, we agreed to provide information in response to the following questions:

- What is known about the quality of drinking water from community water systems and private wells in six states?
- What factors influence the quality of drinking water from community water systems and private wells?

In conducting this review, we collected information from a wide variety of sources, including EPA, the U.S. Geological Survey, the U.S. Public Health Service's Centers for Disease Control and Prevention (CDC), the U.S. Department of Agriculture, the Bureau of the Census, selected states, and other relevant organizations. We judgmentally selected six states for our review—California, Illinois, Nebraska, New Hampshire, North Carolina, and Wisconsin. These states were selected on the basis of several factors, including (1) the amount of information available on private wells located in the states as identified in interviews with knowledgeable officials, (2) the number or percentage of households that obtain their drinking water from private wells, and (3) the states' geographical location.

To answer the first question, we obtained data from EPA on contaminants found in community water systems in the six states for fiscal years 1993 through 1996. We identified and obtained data on contaminants found in private wells through interviews with drinking water officials responsible for overseeing private wells in each state. We also identified and obtained water quality studies done by researchers in academia, industry, or government who analyzed private wells in any of the six states as well as other states. We interviewed federal, state, and local agency officials to discuss the testing data available on community water systems and private wells. We used EPA's primary drinking water standards—the MCLs that EPA has established to protect public health—as our criteria for assessing water quality at private wells.

To answer the second question, we interviewed federal, state, and local government officials; representatives from the National Ground Water Association; representatives of the state well drillers' association within each of the six states; and water quality experts from academia. We reviewed the federal and state regulations for community water systems. For private wells, we obtained state and local regulations on the construction and location of wells, as well as operating and licensing requirements for well drillers. We also collected and reviewed public educational literature designed for private well users.

We provided a draft of this report to EPA, CDC, and the six states for their review. Specifically, we obtained comments from EPA officials, including

the Director of the Implementation and Assistance Division of the Office of Ground Water and Drinking Water, and CDC officials from the National Center for Environmental Health and the National Center for Infectious Diseases. We also obtained comments from representatives of the state agencies responsible for overseeing drinking water quality. We responded to their comments throughout the report and summarized their views in the executive summary and chapter 2.

Our work was conducted from July 1996 through April 1997 in accordance with generally accepted government auditing standards.

Data on Total Coliform Bacteria, Nitrate, and Other Contaminants at Community Systems and Private Wells

Much more is known about the quality of drinking water from community water systems than from private wells because community water systems are tested much more extensively. Under SDWA, community water systems must routinely test their water for the presence of up to 72 contaminants.[8] Private wells are not subject to SDWA, and none of the six states we reviewed requires any routine testing of operating wells. Two of the six states and some local governments require minimal testing at new private wells before they are put into operation.

Extensive data from community water systems in the six states that we reviewed showed that total coliform bacteria[9] were the most common contamination problem. Between 3 and 6 percent of the community systems operating in the six states between fiscal years 1993 and 1996 exceeded the MCL for total coliform bacteria.[10] Relatively few community systems exceeded other MCLs. The next most frequently exceeded standard was for combined radium, with fewer than 1 percent of the systems exceeding that standard in any one year.[11]

Most of the data that we found on the quality of private well water are for total coliform bacteria and nitrate.[12] The data—which come from a variety of states, including the six we reviewed in detail—indicate that a high percentage of private wells were contaminated with total coliform bacteria

[8]EPA requires that community water systems have treatment techniques in place to reduce the presence of nine additional contaminants that are not economically or technologically feasible to detect through testing. Additional monitoring may be required together with the use of the treatment techniques.

[9]Total coliform bacteria are microscopic, generally harmless, organisms that live in the intestinal tracts of warm-blooded animals. According to EPA, the presence of total coliform bacteria indicates the possible presence of fecal and disease-causing bacteria.

[10]The MCL for total coliform bacteria that community systems must meet is based on the presence or absence of coliform bacteria in a percentage of all samples taken each month. The number of samples taken depends on the size of the population served. The MCL is exceeded when systems that take fewer than 40 samples per month detect total coliform bacteria in more than 1 sample or when systems that take 40 or more samples detect the bacteria in more than 5 percent of the samples. The MCL is also exceeded if any fecal coliform bacteria or E. coli are detected.

[11]Note that the community water systems' data in this report are limited to violations of MCLs and do not include violations of monitoring requirements. It is possible that monitoring violations could obscure violations of water quality standards.

[12]The sources of nitrate in drinking water include fertilizers, animal waste, the contents of septic tanks, and decaying plant material. Nitrate levels below 3 parts per million are considered background levels, and higher levels are considered to be caused by human activity. EPA's MCL for nitrate in drinking water is 10 parts per million. Infants are particularly susceptible to high nitrate levels and may develop methemoglobinemia (also known as "blue baby syndrome"), a potentially fatal condition that restricts the movement of oxygen through the bloodstream.

and a lower percentage contained excessive nitrate concentrations.[13] For example, studies have reported contamination with total coliform bacteria in 15 to 42 percent of the private wells tested and excessive nitrate concentrations in 2 to 18 percent of the private wells. In contrast, fewer than 1 percent of the private wells contained a particular pesticide above acceptable levels, according to the studies we identified. Data from CDC, EPA, and others suggest to us that contamination rates at private wells are related to a number of characteristics of the wells, including their age and type.

EPA and state officials indicated that contaminants such as pesticides found in community water system wells may also be present in nearby private wells that draw on the same groundwater, but private well water is seldom tested for contaminants other than bacteria and nitrate. The 1996 amendments to SDWA require EPA to develop, by August 1998, regulations that will require that community water system operators notify their customers of the amount of contamination found in their drinking water. However, this information will not be provided routinely to private well users who may use the same source of groundwater as the community system.

Compared With Private Wells, Community Systems Must Comply With Extensive Testing Requirements

All community water systems must test their water for contaminants regulated by SDWA. The frequency of testing varies from one contaminant to another and ranges from more than once a day to once every 9 years. Other factors that affect the frequency of testing include the size of the population served by the system, the source of the water (groundwater versus surface water), and past test results. In addition, states with primacy and approved waiver programs may grant waivers that reduce the sampling frequency for a specific contaminant on the basis of previous sampling results and/or an assessment of the system's vulnerability to each specific contaminant.[14] Community systems report their test results to the states and must also notify their customers when MCLs are violated. The notification may be through the local media, by mail, or by hand, depending upon the nature and duration of the violation.

[13]In this report, private wells are considered contaminated if total coliform bacteria are present in any amount. Nitrate concentrations of more than 10 parts per million are considered excessive.

[14]We reported on the states' participation in the waiver program in November 1995 (Flexibility in the Safe Drinking Water Act, GAO/RCED-96-12R). At that time, we reported that 42 states had begun issuing monitoring waivers by 1995. Of the remaining eight states, three had approved programs but had not issued any waivers at the time of our survey and five were still developing their waiver programs.

While community water systems must test for dozens of contaminants as part of their normal operations, testing at private wells is much more limited, and the data are not always available for review. None of the six states we reviewed requires any routine testing of operating wells.[15] Of these six states, two (Wisconsin and Illinois) require only that newly constructed wells be tested for total coliform bacteria before they are put into operation. Illinois also requires, and Wisconsin recommends, that new wells be tested for nitrate. According to state officials, while North Carolina does not require any testing, 22 of its 87 local health boards have private well inspection and oversight programs and may require testing for total coliform bacteria at new wells.[16] Similarly, all 58 counties in California have private well oversight and inspection programs and some may require testing for bacteria at new wells. State officials were not able to identify how many counties require testing.

According to state officials, some commercial mortgage lenders require that private wells be tested as a condition of the loan approval. They said that testing is typically limited to total coliform bacteria and nitrate. Well owners may choose to have the testing done by either a private or a public (state or county) laboratory. Officials told us that test data generated by private laboratories are not submitted to any public agency, and therefore the information is not captured in any state database. Several of the state laboratories in the six states conduct testing for these real estate transfers and do maintain the results in a public database. Federal agencies that provide mortgage insurance, including the departments of Veterans Affairs and Housing and Urban Development, also require testing as a condition of providing their insurance. For example, the Department of Housing and Urban Development, in consultation with EPA, developed a testing requirement for total coliform bacteria, nitrate, lead, and other contaminants of local concern.

For the most part, private wells are tested at the well owner's discretion. As with the testing done as part of a real estate transfer, this self-initiated testing may be done by a private or a public laboratory. Consequently, the data may or may not be entered into a public database. According to officials we spoke with, private laboratories treat their data as confidential

[15]In this section, we make an important distinction between newly constructed wells, which have not yet been placed in operation, and existing wells, which are in operation and may have been so for many years.

[16]North Carolina has 87 local health boards that serve the state's 100 counties. Some health boards serve more than one county.

and do not make them available for review. This policy limits the amount of available data on the quality of private well water.

Although EPA, state drinking water officials, and industry groups recommend annual testing for bacteria, few well owners follow this advice. For example, EPA's 1984 National Statistical Assessment of Rural Water Conditions reported that "bacteriological tests and chemical (or physical) water tests by rural residents were not common. Slightly more than one-third of all rural households with individual systems had tested the water at least once, with bacteriological tests being more frequent than chemical tests." Data from a 1994 CDC survey of 5,520 private well users across a nine-state region show that 44 percent of the respondents said that their well had never been tested for contamination, 44 percent said that it had, and 11 percent did not know.[17] Of those that knew that their well had been tested and could say when the test had occurred, 39 percent said that it was prior to 1990.

In the course of testing water quality at the request of more than 32,000 well owners since 1985, the University of Wisconsin asked them how recently they had tested their water. Only 9 percent of the owners reported having had a test done within the last year. The overall responses are summarized in table 2.1.

Table 2.1: Years Elapsed Since Last Water Test Was Conducted for Private Well Owners Participating in University of Wisconsin's 1985-96 Testing Program

Time frame for most recent water quality test	Less than 1 year	1-2 years	2-5 years	5-10 years	More than 10 years	Never	Not known
Percent of respondents	9	6	10	6	6	3	61

Source: University of Wisconsin Cooperative Extension Service.

[17]We obtained data from CDC that it had gathered in its survey. CDC's report entitled A Survey of the Presence of Contaminants in Water From Private Wells in Nine Midwestern States, U.S. Public Health Service, Centers for Disease Control and Prevention, is currently under review at CDC. The states surveyed were Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin.

Bacterial Contamination Is the Most Common Problem at Community Water Systems in the Six States

Data for the six states we reviewed show that the standard for total coliform bacteria was the most frequently exceeded standard at community water systems. The number of systems exceeding the standard for total coliform bacteria from fiscal year 1993 through fiscal year 1996 ranged from 577 to 1,035. This represented about 3 to 6 percent of the approximately 17,000 to 18,000 community water systems operating in the six states at some point during these years.

The community water systems in the six states we reviewed exceeded the MCLs for contaminants other than total coliform bacteria much less often. The most commonly exceeded standards, other than the standard for total coliform bacteria, were those for radiological elements, nitrate, and the herbicide atrazine.[18] Fewer than 1 percent of the systems exceeded the standard for any one of these contaminants in any particular year. While the systems that reported violations varied in size and used both surface water and groundwater, most served fewer than 3,301 people and most relied on groundwater as their source.[19] Violations of the most commonly exceeded standards in the six states are analyzed in table 2.2.

[18]Atrazine is an herbicide used to control grasses and broadleaf weeds, primarily on corn and sorghum fields. It is known to cause mammary gland cancer in laboratory animals, and EPA classifies it as a possible human carcinogen.

[19]EPA categorizes community water systems as very small, small, medium, large, and very large. Very small systems serve from 25 to 500 people, while small systems serve from 501 to 3,300 people. From fiscal year 1993 through fiscal year 1996, 80 percent of the systems with at least one water quality violation were very small or small. During that same period, 87 percent of the systems with at least one water quality violation used groundwater, while 13 percent used surface water.

Table 2.2: Number and Percentage of Community Water Systems in Six States With at Least One Water Quality Violation in Fiscal Years 1993-96 for the Most Frequently Exceeded Standards[a]

SDWA contaminant	Systems with at least one violation of standard in FY 1993 (No. = 17,976)		Systems with at least one violation of standard in FY 1994 (No. = 17,727)		Systems with at least one violation of standard in FY 1995 (No. = 17,580)		Systems with at least one violation of standard in FY 1996 (No. = 17,443)	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Total coliform bacteria	1,035	5.76	785	4.43	659	3.75	577	3.31
Fecal coliform bacteria and/or E. coli[b]	229	1.27	101	0.57	63	0.36	51	0.29
Nitrate	72	0.40	58	0.33	52	0.30	51	0.29
Combined radium (radium 226 and/or radium 228)	147	0.82	130	0.73	121	0.69	116	0.67
Atrazine	10	0.06	28	0.16	34	0.19	15	0.09
Alpha emitters, excluding radon and uranium	55	0.31	56	0.32	53	0.30	47	0.27
Total for all contaminants[c]	**1,303**	**7.25**	**1,047**	**5.91**	**906**	**5.15**	**774**	**4.44**

Legend

No. = number
Pct. = percent

[a]Both surface water and groundwater systems are combined.

[b]Violations for fecal coliform bacteria and E. coli are a subset of the violations for total coliform bacteria and represent more acute health risks to consumers.

[c]Will not equal the total number of systems included above for two reasons: (1) a system may have a violation in several SDWA contaminant categories and (2) the total includes violations of standards for other contaminants not listed above.

Source: GAO's analysis of data from EPA.

Limited Test Data on Private Wells Indicate Frequent Contamination From Bacteria and Nitrate

Available data on the quality of water from private wells are, for the most part, limited to information on total coliform bacteria and nitrate. Whereas data on community water systems are collected using EPA's standardized methodology, the data on private wells come from a variety of sources using various methodologies. Given that potential limitation, the data generally indicate that a high percentage of private wells were contaminated with total coliform bacteria at the time they were tested. A smaller percentage of private wells were contaminated with excessive

concentrations of nitrate. For example, CDC's 1994 survey of the geographic distribution of contamination in private wells across a nine-state region found that over 41 percent of the wells were contaminated with total coliform bacteria and over 13 percent contained excessive concentrations of nitrate. In addition, the survey showed that 11 percent of the wells were contaminated with E. coli bacteria, which present a more acute health risk than total coliform bacteria. Data from one national and one statewide study that both used statistically random sampling techniques found total coliform bacteria contamination in 42 and 15 percent of the private wells tested, respectively. Other data from studies that used random sampling techniques showed excessive nitrate concentrations at 2 to 19 percent of the private wells tested. Data gathered by CDC, EPA, and others also suggested that contamination rates can be affected by characteristics of a well, such as its type, depth, and age.

Specific Studies Show a High Percentage of Private Wells With Contamination

Several studies have shown a high percentage of private wells contaminated with total coliform bacteria and nitrate above acceptable levels. One of the more recent and extensive efforts was by CDC. In 1994, CDC and state agencies sampled wells in nine states, including three of the six that we reviewed. The purpose of the survey was to measure total coliform bacteria, E. coli, nitrate, and the herbicide atrazine. The study was motivated, in part, by the discovery that a high proportion of water samples from rural wells were contaminated with total coliform bacteria and E. coli shortly after the disastrous 1993 flooding of the Missouri and Mississippi rivers. The survey was intended to show the geographic distribution of microbiological and chemical contamination in water from these wells.[20] In total, over 5,500 wells were sampled, including more than 500 each in Illinois, Nebraska, and Wisconsin. The samples included wells ranging in age from 1 to 200 years and wells of many different construction types, including wells that would not meet the states' current construction standards. The total coliform bacteria, E. coli, and nitrate results for all nine states are shown in table 2.3. (The atrazine data are presented later in this chapter.)

[20]While CDC's sampling strategy was designed to show the geographic distribution of water conditions, it was not designed so that estimates could be made about contaminated wells as a percentage of the total universe of private wells in a particular state or in the nine-state area. The testing was done at wells near the intersections of a 10-mile grid overlaid on a map of each of the nine states.

Table 2.3: Results of CDC's Survey of the Presence of Contaminants in Water From Private Wells in Nine Midwestern States

State and number of wells sampled	Percentage of wells with total coliform detections[a]	Percentage of wells with E. coli[b]	Percentage of wells with nitrate levels above EPA's standard
Illinois (540)	45.9	15.4	15.3
Nebraska (598)	37.3	2.5	14.7
Wisconsin (534)	22.8	2.6	6.6
Iowa (526)	58.6	20.5	20.6
Kansas (716)	48.7	16.3	24.3
Minnesota (718)	27.3	4.5	5.8
Missouri (632)	57.4	22.6	9.7
North Dakota (673)	35.5	8.2	13.5
South Dakota (583)	40.1	8.4	10.4
Total (5,520)	**41.3**	**11.2**	**13.4**

[a]CDC's survey procedure was to test one water sample per private well and note the presence or absence of any total coliform bacteria.

[b]Wells in CDC's survey were also tested for E. coli. EPA requires community water systems that detect total coliform bacteria in any water sample to test that sample for fecal coliform bacteria or E. coli.

Source: CDC.

Other studies have also reported the incidence of contamination with total coliform bacteria and nitrate. The scope and methodology of these studies are described below, and their results are summarized in table 2.4. (Note that these studies were also not limited to the six states we reviewed.)

- In 1991, the University of Nebraska published a study statistically designed to estimate the population at risk of ingesting contaminated water from rural private wells.[21] The study gathered test results from 2,195 rural wells from all of the state's 93 counties. The selection criteria for the wells required that they be on property actively engaged in farming and/or at least 6 acres in size. In 1996, the Nebraska Department of Health and the University of Nebraska-Lincoln published a follow-up study that reported on tests done at 1,808 of the original 2,195 private wells. The studies reported total coliform bacteria in about 18 percent of the wells and excessive nitrate concentrations in 17 to 19 percent of the wells.
- In 1990, EPA issued the National Survey of Pesticides in Drinking Water Wells (Phase I). One of the two objectives of the study was to determine

[21]Assessment of Statewide Groundwater Quality Data From Domestic Wells in Rural Nebraska (Lincoln, Neb.: University of Nebraska Press, 1991).

the frequency and concentration of pesticides and nitrate in drinking water wells nationwide. (This study included both community and private wells.) The survey was designed to yield results that were statistically representative of the nation's community and rural private wells. The study estimated that excessive levels of nitrate were in 2.4 percent of the rural private wells. (The pesticide results are discussed later.)

- In 1990, an herbicide-manufacturing company presented to EPA the results of its National Alachlor Well Water Survey, which included testing for nitrate. The study sampled 1,430 rural domestic wells in counties that used alachlor in 1986.[22] As such, it is representative of the universe of private, rural domestic wells in counties where the herbicide was sold. The study reported excessive nitrate levels in 4.9 percent of the wells. (The data on alachlor are presented later.)
- In 1984, EPA issued the National Statistical Assessment of Rural Water Conditions. The sampling, done in 1978 and 1979, covered 400 counties. Testing for water quality was done at 2,654 households that used either private wells, "intermediate systems" (systems with 2 to 14 service connections), or community water systems. This study reported total coliform bacteria in 42 percent of the private wells and excessive nitrate in 4.1 percent.

Table 2.4: Summary of Total Coliform and Nitrate Results From Other Studies Using Statistically Representative Methodologies

Study's name and date	Percentage of samples testing positive for total coliform bacteria	Percentage of samples exceeding MCL for nitrate
Nebraska Department of Health/University of Nebraska, 1991/1996	18 in 1991 study 15.1 in 1996 study[a]	17.4 in 1991 study 18.4 in 1996 study[b]
EPA National Survey of Pesticides in Drinking Water Wells, 1990	Not tested	2.4
National Alachlor Well Water Survey, 1990	Not tested	4.9
EPA National Statistical Assessment of Rural Water Conditions, 1984	42.1 percent	4.1

[a]The 1996 results are for 1,805 of the 2,195 wells tested in 1991.

[b]The 1996 results are for 1,633 of the 2,195 wells tested in 1991.

In addition to the data described above, data that are not statistically representative of conditions in a particular state also exist. These data are

[22]Alachlor is an herbicide used on corn, soybeans, and peanuts. EPA classifies it as a probable human carcinogen.

generally consistent with the results just described and are presented in appendix II. The two primary reasons why these data may not be representative are that (1) the tests were done at the request of well owners, who may have had the test done because they suspected problems, or (2) the tests were done at new wells that might have become contaminated with total coliform bacteria during construction and would have had to be disinfected before being put into operation. Some of the results are also from specific studies that did not use statistically valid sampling techniques.

Data Suggest That Contamination Rates Are Affected by Characteristics of Wells

EPA, CDC, and others have also gathered data on private wells by type, age, and depth. These data suggest that higher contamination rates are associated with certain well construction characteristics. The most common well types, which are described in more detail in appendix I, are known as drilled, driven, bored, and dug. In its 1984 assessment of rural water conditions, EPA concluded that

> "households served by dug and bored wells, wells in which the water leaves the casing above ground level, wells with inadequate covers, inadequately maintained wells, and shallow wells all tended to have high coliform levels more commonly than those served by wells without those characteristics."

According to data gathered by CDC, bored and dug wells had the highest proportion of contamination. The material used to construct the well casing is related to the well type and appears to affect contamination rates. CDC's data showed that the brick and concrete tile casings characteristic of dug and bored wells had higher contamination rates than the steel casings characteristic of drilled and driven wells. Other water quality researchers who have analyzed data in Nebraska, Iowa, Kansas, and Ohio have also concluded that the incidence of nitrate contamination is higher in wells with open-jointed casing (i.e., brick or concrete tile) than continuous casing (i.e., plastic or steel).

Researchers investigating the incidence of contamination do not all emphasize the significance of the same well construction characteristics, however. For example, a study of private wells in Iowa concluded that "by far the most significant factor explaining water-quality variations is well depth,"[23] while a study of nitrate contamination in wells in Kansas

[23]The Iowa State-Wide Rural Well-Water Survey, Iowa Department of Natural Resources (Nov. 1990).

emphasized the age of the well.[24] In a statement that applies to both the age and the type of well, water quality scientists from the University of Nebraska concluded that evidence supports

> "the widely held belief that modern well construction practices provide an effective barrier to surface contamination and can reduce the incidence of nitrate contamination in domestic rural wells."[25]

Other factors that can influence water quality are discussed in chapter 3.

Data on Private Wells for Other Contaminants Are Very Limited and Show Low Rates of Excessive Contamination

Limited data have been collected in the six states and elsewhere on contaminants such as pesticides, heavy metals, and volatile organic compounds in drinking water from private wells. State and local governments do not require testing for these contaminants, and states' databases show that well owners rarely request such testing. The bulk of the data for these contaminants is collected through specialized studies by government, industry, or academia. In general, the incidence of these contaminants at concentrations above their MCLs is on the order of 0 to 2 percent. The following studies, not all of which used statistically random sampling techniques, provide examples.

- The University of Nebraska and the Nebraska Department of Health issued a report in 1996 that described pesticide data collected for two studies from 1985 through 1989 and during 1994 and 1995. The first study tested water at 2,195 private wells, and the second tested water at a subset of 1,808 of the original wells. The wells were all on property that was actively being farmed and/or at least 6 acres in size, and the studies were representative of drinking water conditions under those circumstances. Atrazine has been the most frequently detected pesticide in Nebraska. Atrazine was detected at concentrations above EPA's MCL in 1.0 percent of the private wells tested in the first study and 2.6 percent in the second study. (All of these later cases were accounted for by 2 of the state's 13 groundwater regions.)
- In the 1994 effort described above, CDC also gathered data on atrazine contamination in 4,847 wells across eight of the nine midwestern states surveyed. Of the wells sampled, the percentage with atrazine above the MCL ranged from 0.0 percent to 0.6 percent for the eight states, with an aggregate percentage of 0.2.

[24]J. Steichen et al., "Contamination of Farmstead Wells by Pesticides, Volatile Organics, and Inorganic Chemicals in Kansas," Ground Water Monitoring Review (Summer 1988).

[25]R.F. Spalding and M.E. Exner, "Occurrence of Nitrate in Groundwater—A Review," Journal of Environmental Quality, Vol. 22 (July-Sept. 1993).

- The 1990 National Alachlor Well Water Survey, sponsored by the herbicide manufacturer and representative of rural private wells in counties that used alachlor, estimated that 0.02 percent of the rural private wells in those states had concentrations above the MCL. The study also estimated that 0.1 percent had atrazine concentrations above the MCL. EPA's representative 1990 National Survey of Pesticides in Drinking Water Wells estimated that 0.6 percent of all rural private wells were contaminated with a pesticide at a level over its MCL or Lifetime Health Advisory Level. The same study estimated that 0.8 percent of community water systems were contaminated with a pesticide at concentrations above these levels.
- Wisconsin's Department of Agriculture, Trade, and Consumer Protection tested for atrazine in a sample representative of private wells at dairy farms in 1988. Fewer than 1 percent of the wells had concentrations above the state's enforcement standard (which is the same as EPA's MCL). In another Wisconsin Department of Agriculture project, the state distributed atrazine testing kits to 2,187 people statewide. This unrepresentative study showed that samples from 1 percent of the wells tested exceeded the state's enforcement standard.
- The Heidelberg College Water Quality Laboratory has also tested for pesticides in thousands of midwestern private wells whose owners have volunteered for testing since 1987. Although this is not a representative sample, the results show that samples from 1.1 percent of the wells exceeded the MCL for alachlor and that samples from 0.1 percent exceeded the MCL for atrazine.

Contaminated Groundwater May Affect Both Community Water Systems and Private Wells

According to EPA and state drinking water officials, testing at community water systems that detects contaminated groundwater may indicate that water in nearby private wells is also contaminated. If a private well and a community system both obtain their water from groundwater that is contaminated, both may be affected. This is more likely for contaminants that persist in the environment and migrate through the soil to the groundwater. These include nitrate, some pesticides, and volatile organic compounds. EPA also noted that naturally occurring contaminants in groundwater, such as radiological compounds, may affect both community and private drinking water wells. In contrast, the presence of total coliform bacteria is likely to be localized to a particular well because they are not especially long-lived or able to travel far through the groundwater.

While it is difficult to generalize about the contamination levels that community water system users and private well users face when both obtain water from a contaminated aquifer, there is reason to believe that

the users of private wells may face higher exposure levels. First, many community systems treat their water to remove pollutants. The treatment is intended to remove some percentage of the contamination from the source water. In contrast, most private well users do not treat their water, particularly not using a method capable of removing pesticides or organic compounds. Second, community water wells are typically deeper than private wells. Because contamination from human activity usually originates near the surface and then disperses vertically and horizontally, concentrations of contamination are likely to diminish with the distance from the source and depth. Therefore, a shallow private well is likely to tap into contaminated water before a deeper community well does.[26]

SDWA's Requirement for Expanded Public Notification Could Benefit Private Well Users

SDWA requires that owners and operators of community water systems notify their customers when treated water exceeds the MCL for a particular contaminant. The 1996 amendments to SDWA require EPA to strengthen the regulations for this requirement. In addition, EPA must develop, by August 1998, regulations that will require more comprehensive public notification about contaminated drinking water. The owners and operators of community water systems will be required to prepare annual reports that provide their customers with data on all detections of regulated contaminants, regardless of whether the detections exceed the MCLs.

While only a very small percentage of community water systems violate the MCL for any contaminant other than total coliform bacteria, a substantially larger percentage of systems do find and, if necessary, remove some amounts of other contaminants. The Congress, in reauthorizing SDWA, indicated that it was important for the customers of community water systems to know about the levels of contaminants in the water they consume. Because private well users who are consuming untreated water from the same source may be exposed to even higher levels of contamination, this information is likely to be of interest to them as well, but there is now no requirement to notify them.

Conclusions

Drinking water is vulnerable to contamination, and users that do not have access to complete information about their water cannot be certain that it is safe. Because private wells are not as extensively regulated as

[26]There are possible exceptions to this. One is that the flow of contaminated groundwater from the pollution source may be away from a private well and toward a community well. The reverse, of course, could also be true. Another possible exception concerns contaminants known as light, nonaqueous-phase liquids, such as benzene and petroleum products, that "float" on groundwater—in contrast to dense, nonaqueous-phase liquids that sink and collect toward the bottom of an aquifer.

community water systems and because private well owners do not generally conduct frequent or comprehensive tests of their water, they do not have complete information about its safety.

This does not imply that private well users are all at risk or that they should begin to test their water for all of the contaminants regulated by community water systems. That would be unnecessarily expensive. What it does suggest is that when there is information already available from community systems that could alert private well users to possible local contamination problems, these users could benefit from that information. For example, community water systems could provide a copy of their annual water quality report to state and/or local public health agencies, which could then alert private well users to localized contamination problems and advise them to consider having their well tested for specific pollutants, if appropriate. The agencies could publicize the availability of the annual report through the local media, making sure that the notice alerts private well users to the report's potential relevance to their water supply. With the information from the annual report, private well users can make informed choices about testing or maintenance. Without the information, they may not be aware of potentially harmful contamination.

Recommendation

To help ensure that private well users are better informed of potential contamination problems and associated health risks, we recommend that the Administrator, Environmental Protection Agency, explore options that would provide such well users with information on how to learn more about the quality of their drinking water and the steps they can take to protect their drinking water source from contamination. For example, state and/or local health agencies could use the local media to alert private well users to consider testing their water whenever the testing of a groundwater-supplied community water system detects contamination that could potentially be present in the same geologic formation supplying nearby private wells.

Agency Comments

EPA officials commented that this report will prove useful in educating the public on the threats to private drinking water wells. EPA also noted that it sees its role in protecting the public health as including private well users and providing them with helpful information about drinking water. The agency, therefore, supported the intent of our recommendation but suggested that it give EPA and the states more flexibility and discretion in deciding how to ensure that private well users are better informed about

their water quality. EPA also suggested that there is a need for general public outreach to educate consumers on the need for periodic testing of private drinking water wells. We have made revisions to reflect EPA's comments.

CDC also agreed with the intent of the recommendation. The agency commented that the data presented in this report could support additional recommendations. Specifically, CDC pointed to gaps in knowledge that could be filled by the routine testing of wells and centralized collection of the test results. CDC also suggested that reductions in the factors that influence contamination could be achieved through the use of construction standards, maintenance, inspections, and controls on land use and siting. We agree that routine testing and centralized data collection would help fill the gaps in knowledge about the quality of water from private wells and that steps could be taken to reduce the factors that contribute to water contamination. However, we do not include such recommendations because the authority to require them rests with the states rather than with EPA.

CDC also commented that this report does not emphasize the water quality problems of small community water systems and that it compares the quality of private well water only to that of large community systems. Our report discusses data on the compliance of community water systems of all sizes. It also points out that about 85 percent of the community systems are small and that 80 percent of the systems with at least one MCL violation between fiscal years 1993 and 1996 were small or very small. Furthermore, in chapter 3, we refer to a 1994 GAO report that discusses the technical and financial difficulties of small systems in meeting the requirements of the drinking water program.

The state representatives generally agreed with the intent of our recommendation. However, several of the states expressed concern that implementing the recommendation might place a large burden on community water systems. In light of these comments and those from EPA, we have revised the recommendation to provide flexibility in how water quality information is made available to private well users. The state representatives also provided other technical clarifications and suggestions, which we incorporated as appropriate.

Several Factors Influence the Quality of Drinking Water From Community Water Systems and Private Wells

The quality of drinking water supplied by community water systems and private wells can be influenced by a variety of factors. First, the quality of the source from which drinking water is extracted can have a major influence in the quality of water at the tap, particularly if the water is not treated in any way. Construction standards and other controls are designed to ensure that new water systems and private wells are properly constructed and protected from potential sources of contamination. The extent of such controls and how well they are implemented can also influence water quality. Finally, once a new drinking water source—whether a community system or a private well—is constructed, the extent of ongoing oversight and maintenance activities can help determine whether the water will continue to be safe. Activities such as periodic testing and inspections can prevent minor problems from becoming major ones and thus minimize problems that could adversely affect the quality of drinking water.

The Condition of the Source Influences Drinking Water Quality

Depending on the extent of treatment, the quality of the water sources used to supply community water systems and private wells can be a key factor in the quality of drinking water delivered at the tap. Both groundwater and surface water are vulnerable to contamination from human activities and naturally occurring substances. When a water source is contaminated, some form of treatment may be needed to ensure that the water is safe to drink. However, community water systems are much more likely to treat their water than private well owners.

According to EPA's recent survey of community water systems,[27] 81 percent of the systems reported providing some type of treatment for some or all of the water delivered to consumers. Some of the reported treatment, such as water softening and iron and manganese removal, is intended to improve the aesthetic quality of drinking water while other types of reported treatment, such as disinfection and the removal of organic chemicals, may be necessary for compliance with EPA's health-based quality standards, or MCLs. More significantly, community water systems are required to take corrective action—by treating water or taking other measures—whenever water quality testing detects contamination in excess of the MCLs. Detecting and treating contamination at private wells is generally done at the discretion of individual well owners.

[27]During 1995 and 1996, EPA surveyed a statistically representative sample of community water systems to collect information on their operational and financial characteristics. See Community Water System Survey (EPA-815-R-97-001a and EPA-815-R-97-001b, Jan. 1997).

Limited data are available on the extent to which private well owners treat their drinking water. The Water Quality Association, an industry group representing manufacturers and vendors of home water treatment devices, does not collect data on sales to private well owners. According to the association's executive director, however, most of the treatment devices sold to the public are water softeners that improve the aesthetic quality of water by removing hardness, iron, and manganese. In addition, the state officials we interviewed believe that well owners rarely treat their water except to improve its aesthetic quality. However, in the shallower levels of the aquifers tapped by private wells, untreated groundwater may contain contaminants such as nitrate and pesticides that can pose health risks.

Construction Standards, Siting Requirements, and Other Controls Help Reduce Potential for Contamination

State construction standards and siting requirements play a key role in determining the quality of drinking water at the tap and, for private wells and community systems that rely on groundwater sources, protecting the aquifer from contamination. All six of the states we visited have established construction standards and siting requirements for community water systems and private wells. However, we found that while these states have a fairly rigorous approval and inspection process for community systems, there is less oversight of new private wells and less assurance that these wells comply with state requirements.

New Community Systems Are Subject to Approval and Construction Requirements

In keeping with their status as regulated public water suppliers, community systems must go through a rigorous approval process. As a condition of obtaining primacy under EPA's safe drinking water program, a state must have a process for ensuring that all new or substantially modified public water system facilities will be capable of complying with applicable drinking water regulations. The six states we visited require that detailed plans and specifications for a new or substantially modified community system be prepared and/or approved by a professional engineer. To ensure that such a system is constructed according to the approved plans, the states conduct inspections during construction or, when construction is complete, require a certification from an engineer hired by the system that it was constructed as approved. For new groundwater wells at community systems, some states, such as Nebraska and New Hampshire, require that test wells be drilled to ensure that the water will meet SDWA's standards. Once the final well has been constructed, the states generally require additional water quality testing before the new system can be brought on line.

According to a recent EPA survey of drinking water infrastructure needs,[28] community water systems must make significant investments in improvements to their water sources and their treatment, storage, and water distribution facilities if they are to continue providing water that is safe to drink. EPA estimates that these systems' infrastructure needs will total $138.4 billion over the next 20 years, including $76.8 billion needed now to meet SDWA's requirements and protect public health. Many of the identified needs are related to meeting current or future drinking water quality standards or replacing facilities that have met the end of their useful lives and are deteriorating. Furthermore, according to EPA, many small water systems were improperly designed and constructed in the first place. EPA's report states that "many small systems were built without review of plans and specifications and were not required to adhere to minimum design and construction standards." Officials in five of the six states we visited generally agreed with EPA's conclusions, particularly for older systems that were constructed before state approval and construction requirements were in place. A Wisconsin official told us that although some systems in the state may fit EPA's description, they are exceptions.

State construction standards for community systems include criteria for siting new facilities so that they are not located close to potential sources of contamination. All of the states we visited have established minimum distances, called setback requirements, between a well and specific sources of contamination, such as landfills and sewage lagoons. Community water systems may also take steps to protect a larger area around their water source. In general, this means identifying potential sources of contamination within a designated area and adopting various controls, such as zoning or land-use ordinances, to manage existing sources of contamination and prevent new sources from locating within the protected area. Depending on the source of their water, community systems may protect the area around their groundwater well (wellhead protection) or their surface water intake.

We did not obtain comprehensive information on the extent to which community systems in the six states are participating in source water protection programs. However, we learned that California does not have an approved wellhead protection program[29] and that in several other

[28]EPA Drinking Water Infrastructure Needs Survey: First Report to Congress, EPA Office of Water (EPA 812-R-97-001, Jan. 1997).

[29]A few local communities in the state have received grants directly from EPA to implement wellhead protection, but, according to California officials, the state is not involved.

states, the approved programs are voluntary for most water systems. In New Hampshire, for example, all new community water systems are required to have wellhead protection programs, but for existing systems, participation is voluntary. Some states allow their water systems to qualify for reduced monitoring for some contaminants as an incentive to participate in the protection program. According to EPA's January 1997 survey of community water systems, over one-third of all community water systems participate in some type of effort to protect source water, such as adopting land use or zoning controls and educating the public on the impact of land use.

States' Construction Standards for New Private Wells and Efforts to Ensure Compliance Vary

All six of the states we visited have construction standards for private wells. These standards generally specify appropriate materials and construction techniques for various types of wells and establish criteria for siting wells and for ensuring that they are protected from contamination. In most instances, the states' construction codes are the minimum statewide standards; state and local regulators may establish more stringent requirements if warranted by site-specific geologic or hydrologic conditions. Officials in all six states generally agree that as long as an aquifer is not contaminated, private wells that are (1) constructed in accordance with current standards and (2) located an adequate distance from potential contamination sources will provide good-quality drinking water. However, we found that the states vary in their efforts to ensure that construction and siting requirements are met.

According to the National Ground Water Association, CDC, and state drinking water officials, two of the most important elements of well construction for ensuring good-quality drinking water are (1) requirements for sealing or grouting the well to prevent contamination from entering the groundwater[30] and (2) criteria for siting the well, including requirements for minimum setback distances between the well and potential contamination sources. We found that these elements vary widely from state to state. For example, Nebraska requires that the annular space (see ftn. 30) be sealed to a minimum depth of 10 feet while in Wisconsin, the minimum ranges from 0 (no grouting required) to 40 feet, depending on the drilling method and the geological conditions. In New Hampshire, well drillers are responsible for ensuring that each well is sealed adequately for

[30]Many wells are constructed in a manner that creates a space between the larger borehole and the well casing. Unless this area, called the annular space, is properly sealed with cement or other grouting material, contaminants may enter the groundwater through runoff from the ground's surface. In addition, properly sealing the annular space may prevent contamination from a shallow aquifer infiltrating a deeper one.

its particular location; the state does not specify any minimum requirement for the depth of the seal. According to an official of the California Department of Water Resources, which is responsible for promulgating well construction standards, the state is proposing to increase its requirements for sealing the annular space in private wells from a depth of 20 feet to the 50-foot depth required for community water systems. Both Illinois and Nebraska are considering an increase in their requirements because state officials believe that the current requirements may not be sufficiently protective.

Similarly, the minimum setback distances between a private well and various contamination sources also vary among the states we visited. For example, the required setback distance from animal enclosures ranges from 20 feet in New Hampshire to 100 feet in California and North Carolina. The distance required between a well and a septic tank ranges from 25 feet in Wisconsin to 100 feet in California and North Carolina.[31] Officials from both California and Wisconsin told us that the setback requirements for a private well are not necessarily based on an assessment of what distance would be safe. According to an official from the Wisconsin Department of Natural Resources, the minimum distance required between a private well and a septic tank or other potential source of contamination is simply a matter of "what will fit on an average lot."

During our visits to the six states, we also obtained information on various controls that are intended to ensure that newly constructed private wells provide safe drinking water, meet state standards, and are constructed by qualified individuals. We found differences in several areas:

- Permit requirements for new wells. Of the six states we visited, only California and Illinois require water well contractors to obtain permits for new wells prior to construction. For the most part, the permits are issued by county health departments. In Illinois, the permit application must contain a plan and drawing of the proposed construction, including the lot's size; the location of property lines and the distances from the proposed well to septic tanks, abandoned wells, and other sources of contamination; the type of well to be constructed; and the driller's license number. Permit applications may be denied if the available information indicates that groundwater at the proposed site is contaminated. Nebraska is implementing a permitting program; most of the state's 23 natural

[31]North Carolina will approve a setback of 50 feet between a well and a cesspool or septic tank if a lot is not large enough for a 100-foot setback.

resource districts[32] have established groundwater management districts that will be responsible for issuing permits for new wells. In North Carolina, the permitting requirement is limited to the 22 (out of 87) local health boards that have programs for overseeing private wells. Four of the 72 counties in Wisconsin are authorized to issue permits, and New Hampshire does not require permits for new wells.

- Registration of new wells. All six states require well drillers to prepare a drillers' log or "well completion report" on each new well. These reports contain information on the type and depth of the well, the site, the materials used in construction, and other information. The reports could be useful in helping the state to develop an inventory of private wells, but we found that some states question the accuracy of the reporting. For example, North Carolina officials estimate that they are notified of about 60 percent of all new wells through the well completion reports, and in Nebraska, where well owners are responsible for filing the drillers' reports with the state, an estimated 40 to 60 percent of new wells are reported. California officials raised questions about the reliability of these reports; they said that reports from some drillers are "suspiciously similar."

- Water quality testing at new wells. Only two of the six states we visited require water quality testing at newly constructed wells, and the testing is limited to one or two contaminants. Both Illinois and Wisconsin require testing for total coliform bacteria, and Illinois also requires that new wells be tested for nitrate. Some counties in California and North Carolina require testing at new wells, generally for bacteria.

- Inspection of new wells. Of the six states we visited, only California and Illinois require the inspection of new private wells to ensure that they are built in accordance with state standards. In California, under the state's model well ordinance, counties must inspect all new wells to ensure that the annular space is properly sealed and that potentially contaminated surface water or shallow subsurface water is thus prevented from flowing into the well along the outside of the well casing. The counties may also make an initial inspection of the proposed drilling site, inspect the completed well, and conduct other inspections as appropriate. State officials told us that enforcement of the state's well construction standards varies from county to county. Illinois also requires the inspection of all new wells—either by the state or an approved local agency—to determine whether construction and siting requirements have been met. In North

[32]Nebraska has established 23 natural resource districts to protect and manage natural resources at the local level.

Carolina, 22 of the state's 87 local health boards are authorized to inspect new wells, but state officials were not sure about the extent to which inspections were actually conducted. New Hampshire officials told us that they do not have the resources to inspect new wells, and neither Nebraska nor Wisconsin has an inspection program for new wells.[33]

Licensing of water well contractors. According to the chief of Nebraska's water well standards program, the first line of defense in avoiding well construction problems is the water well contractor. With the exception of North Carolina, the states we visited all have programs to license well drillers and pump installers. North Carolina officials told us that anyone who can pay the $50 fee can register as a well driller regardless of his/her experience or technical proficiency. However, a proposal for licensing water well contractors is before the state legislature; under this proposal, well drillers and pump installers would have to pass a written exam and a skills test. The state well drillers' association supports the licensing proposal.[34]

- Public education programs. A variety of state and local organizations—including public health, environmental protection, and agriculture agencies and the well-drilling industry—are involved in efforts to educate consumers about drinking water and groundwater protection. For example, both EPA and the states have published information pamphlets that advise well owners of the importance of locating wells away from septic tanks and other sources of contamination and avoiding the use or storage of dangerous chemicals near the wellhead. In addition, several of the states we visited participate in a program known as Farm*A*Syst, which is designed to provide farmers and rural homeowners with the tools they need to identify pollution risks on their property, including risks to their private wells. The Farm*A*Syst program has been jointly sponsored by the U.S. Department of Agriculture and EPA since 1991. Some state and local agencies, such as county extension services, offer free water quality testing to private well owners.

[33]In Wisconsin, 4 of the state's 72 counties have programs to inspect new well construction.

[34]According to data filed in support of North Carolina's proposal to establish a licensing program for well drillers, 15 states, including North Carolina, do not have a licensing and certification program for well drillers and pump installers.

Ongoing Oversight and Maintenance Help Ensure That Existing Sources of Drinking Water Continue to Provide Good-Quality Water

While the proper construction and siting of community water systems and private wells may be the most important safeguards against contaminated drinking water, ongoing oversight is also necessary to ensure that water continues to be safe. Community water systems are subject to periodic testing, maintenance, and inspection requirements. States are responsible for overseeing community water systems to ensure that they meet the requirements and to take corrective action when problems are identified. For private wells, however, the primary responsibility for routine monitoring and maintenance rests with individual homeowners. For the most part, states play a minimal role in the oversight of existing private wells.

Community Systems Are Subject to Periodic Testing and Inspection Requirements

Community water systems are subject to extensive requirements for testing water quality. In addition to periodic testing, community systems must undergo comprehensive inspections, called sanitary surveys, performed by state or county inspectors. According to EPA's guidance, sanitary surveys should entail a detailed review of all aspects of a water system's design, operation, and maintenance, including an inspection of the water source, treatment and storage facilities, and distribution system. In addition, a sanitary survey can provide regulators with an opportunity to establish a "field presence" with the owners and operators of water systems and to educate them about proper monitoring and sampling procedures, as well as any changes in regulations. States see sanitary surveys as one of the most important tools they can use to help ensure the capability of water systems to deliver safe drinking water. The six states we visited had a policy of inspecting their community water systems at least once every 2 to 5 years.

When problems are identified through water quality testing or sanitary surveys, federal and state regulations require community water systems to correct these problems. For example, if periodic testing discloses contamination in excess of allowable levels, water systems must treat the water or take other steps, such as finding a new water source or consolidating with a neighboring system, to comply with water quality standards. If the systems fail to come into compliance, they are subject to enforcement action by the states or EPA. Sanitary surveys also detect some serious problems with a direct impact on water quality, but more often, they identify less significant operational or maintenance deficiencies that, if left unaddressed, could become major problems. Timely corrective action helps ensure that drinking water will continue to be safe.

Despite these safeguards, we have previously reported concerns about several aspects of EPA's safe drinking water program and how it is being implemented by states and community water systems. On the basis of a nationwide questionnaire and a review of 200 sanitary surveys in four states (Illinois, Montana, New Hampshire, and Tennessee), we reported in 1993 that sanitary surveys were often deficient in how they are conducted, documented, and/or interpreted and that deficiencies disclosed in the surveys frequently went uncorrected.[35] In 1994, we reported that small community water systems, which comprise about 85 percent of all community systems, often lack the technical or financial capability to meet the requirements of the drinking water program.[36] We found that the lack of reliable cost and performance data on affordable alternative technologies, inadequate authority to address nonviable water systems, state resource constraints, and other barriers have impeded efforts to help bring the systems into compliance. We also reported that as the requirements for the drinking water program expanded after the 1986 amendments to SDWA, states lacked the resources to fully implement key oversight and quality assurance activities, such as conducting sanitary surveys and providing technical assistance to small water systems.[37]

With the passage of the 1996 amendments to SDWA, the Congress has slowed the pace of regulation and provided significant new funding for state oversight programs and loans for capital improvements to community water systems. In addition, the 1996 amendments require EPA to identify technologies for small water systems that are affordable and feasible for achieving compliance with MCLs and establish other programs and requirements designed to improve the capacity of small water systems to meet SDWA's requirements.

[35]Drinking Water: Key Quality Assurance Program Is Flawed and Underfunded (GAO/RCED-93-97, Apr. 9, 1993).

[36]Drinking Water: Stronger Efforts Essential for Small Communities to Comply With Standards (GAO/RCED-94-40, Mar. 9, 1994).

[37]See Drinking Water: Widening Gap Between Needs and Available Resources (GAO/RCED-92-184, July 6, 1992) and Drinking Water Program: States Face Increased Difficulties in Meeting Basic Requirements (GAO/RCED-93-144, June 25, 1993).

Well Owners Are Responsible for Ongoing Oversight and Maintenance of Existing Private Wells but Often Are Unaware of Their Importance

Private well owners are responsible for ensuring that their wells continue to provide good-quality drinking water. None of the six states we visited requires periodic water quality testing or conducts routine inspections at existing private wells. Most testing at existing private wells is done at the discretion of the well owners or when required by lending institutions at real estate transfers. Although Wisconsin does not have a formal program for inspecting or monitoring existing wells, the state will test the quality of water from wells located in areas "at risk" for pesticides or volatile organic compounds. Similarly, North Carolina is conducting free nitrate testing in private wells located near intensive livestock operations. (See app. II for the results of tests in 1995-96.)

Although none of the states we visited conducts routine inspections of private wells, some state or county agencies will inspect wells at the request of individual well owners. For example, Nebraska offers a technical assistance program to private well owners and will inspect the condition of the well and look for potential sources of contamination. North Carolina also conducts inspections in response to consumers' complaints; the state receives more than 700 complaints each year from home or business owners because of problems with their wells or pumps. State officials told us that inspectors invariably find that the problems are due to improper well construction or pump installation.[38] New Hampshire does not have the resources to inspect new or existing wells; state officials told us that they have conducted only four or five inspections over the past 12 years, generally in response to consumers' complaints. According to a New Hampshire official, the state licensing board for water and well pump contractors hears several consumer complaints each year. Improperly constructed wells must be repaired or replaced by the licensed contractor.

Despite various efforts to educate consumers about these issues, officials in several states believe that many homeowners are not aware of the need to regularly inspect their wells to check for signs of deterioration, identify needed maintenance, and ensure that the wells are protected from contamination. The importance of routine oversight and maintenance of existing wells is evident from the results of CDC's survey of private wells in nine midwestern states. The survey identified a strong correlation between high rates of contamination and older, shallower wells. Many of the wells in which bacterial or nitrate contamination was detected showed evidence of deterioration or faulty construction, such as cracked well casings, which would have been revealed by routine inspections.

[38]Prior to about 15 years ago, North Carolina conducted random inspections of new and existing private wells, focusing on well drillers suspected of performing inadequate work. However, the state no longer has the resources to conduct random inspections.

Data obtained in CDC's survey indicate that many of the 5,520 wells would not meet current construction standards. For example, 2,051 (or 37 percent) of the wells had one or more openings—including holes or cracks in the well casing, openings between the lid and the casing, and faulty seals around the electric line inlet in the well cap—through which contamination could easily enter the well.[39] CDC's survey also found that of the 1,873 wells with a vent to allow air into the well, 655 (35 percent) did not have the vent properly screened to keep out animals and insects. While improper well construction does not guarantee poor-quality drinking water, it does increase the risk of contamination and the importance of periodic testing and inspection.

States vary in the extent of their authority to enforce well construction standards and regulate the well drillers responsible for implementing them. For example, several states have the authority to suspend or revoke the license of a water well contractor who violates well construction standards. In contrast to other states, North Carolina does not license well drillers, and state officials told us that the state has very little enforcement authority over well drillers. If the state or a county finds a well that was not properly constructed, the well driller is given 30 days to correct the problem or is subject to monetary penalties. Corrective action can include abandonment of the well.

Even where adequate enforcement authority exists, its use depends on whether states or local agencies become aware of problems and are willing to deal with them.[40] Neither Nebraska nor New Hampshire inspects new wells, and inspections are limited to certain counties in North Carolina and Wisconsin. An official from California's Department of Water Resources, citing the potential conflict between enforcing well construction standards and promoting development, said that enforcement of the standards varies from county to county.

[39]For another 1,216 wells included in the survey (22 percent), the applicable questions were left blank or the surveyors were unsure about the existence of improper openings.

[40]We did not collect information on the extent to which the states used their enforcement authority to force well drillers to correct identified problems or to suspend or revoke well drillers' licenses.

Description of Common Well Construction Methods

Many types of wells are currently in use, including some that are technologically obsolete. The following is a brief description of the most common well construction methods:

- Drilled well. This is the most common type of private well. It is constructed by either a cable tool or a rotary method, usually to depths of 50 feet or more, with a diameter of 4 to 6 inches. It may have the capacity to provide water for households, industry, irrigation, and community systems.
- Driven well. These wells are generally shallow and typically have a small diameter of 1.5 to 3 inches. They are constructed without the aid of any drilling or boring device. Instead, a series of threaded pipes are driven into the ground with a heavy weight. Driven wells are feasible where the water table is shallow and the ground is a permeable sandy soil.
- Bored well. These wells are typically 10 to 100 feet deep, 8 to 36 inches in diameter, and built with hand-operated or power-driven augers.
- Dug well. These are shallow, large-diameter wells constructed by excavating with power machinery or hand tools instead of drilling or driving. The sides of the well may be supported by brick, fieldstone, or wood, rather than steel piping. Dug wells are the most “old fashioned” of the well types, as well as the most vulnerable to contamination, because contaminated surface water can easily enter the top of the well or contaminated shallow groundwater can seep through the sides.

Data on Contamination by Total Coliform Bacteria and Nitrate at Private Wells

Table II.1: Data on Contamination by Total Coliform Bacteria at Private Wells

			Data collection process		
Source of data	**Location, approximate number of samples, and date**	**Percentage of wells with total coliform contamination and date**	**Nonrandom selection process[a]**	**New wells[b]**	**Owner's request[c]**
Illinois Department of Public Health	Illinois, 9,500 in 1994, 9,200 in 1995	32.2 in 1994 33.3 in 1995		X	X
North Carolina State Laboratory of Public Health	North Carolina, 23,000 in 1995, 22,000 in 1996[d]	24.9 in 1995 24.0 in 1996		X	X
University of Wisconsin Cooperative Extension	Wisconsin, 27,700 during 1985-96	14 during 1985-96			X
Iowa State-Wide Rural Well-Water Survey	Iowa, 686 sites during 1988-89	44.6 during 1988-89	X		

[a]The wells tested for this survey were not selected using a statistically randomized design.

[b]The state data contain an unknown proportion of results from tests at newly constructed wells. These states require that new wells be disinfected before being put into service. Therefore, contamination at these wells may have been eliminated before they were put into service.

[c]Data generated from tests requested by well owners may not be representative if well owners test because they suspect a problem.

[d]Based on 11 months of sampling.

Table II.2: Data on Contamination by Nitrate at Private Wells

Source of data	Location, approximate number of samples, and date	Percentage of wells with nitrate above EPA's standard of 10 ppm[a]	Data collection process	
			Nonrandom selection process[b]	Owner's request[c]
Illinois Department of Public Health	Illinois, 6,000 in 1994, 6,200 in 1995	10.3 in 1994 10.0 in 1995		X
Wisconsin Cooperative Extension Service	Wisconsin, 27,000 during 1985-96	10.2 during 1985-96		X
Wisconsin Department of Natural Resources	Wisconsin, 4,300, since 1988	17.9		X
North Carolina Department of Environment, Health, and Natural Resources	North Carolina, 948 wells adjacent to intensive livestock operations, 1995-96	9.4 in 1995-96[d]	X	X
North Carolina Statewide Nitrate Survey	North Carolina, 9,000 in 1989-90	3.2 in 1989-90	X	
Water Quality Laboratory, Heidelberg College, Ohio	Ohio, Illinois, Indiana, Kentucky, and West Virginia, 35,000 during 1987-94	3.4 during 1987-95		X
Iowa State-Wide Rural Well-Water Survey	Iowa, 686 sites during 1988-89	18.3 during 1988-89	X	
Kansas Farmstead Well Contamination Survey	Kansas, 103 during 1985-86	28.2 during 1985-86	X	

[a]Parts per million.

[b]The wells tested for this survey were not selected using a statistically randomized design.

[c]Data generated from tests requested by well owners may not be representative if well owners test because they suspect a problem.

[d]In this study, North Carolina reported the percentage of private wells with nitrate concentrations above 9.5 parts per million.

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