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Report to the Chairman, Subcommittee on Hazardous Wastes and Toxic Substances, Committee on Environment and Public Works, U.S. Senate

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GROUNDWATER QUALITY

State Activities to Guard Against Contaminants

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Program Evaluation and Methodology Division

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February 2, 1988

The Honorable Max Baucus
Chairman, Subcommittee on Hazardous Wastes
and Toxic Substances
Committee on Environment and
Public Works
United States Senate

Dear Mr. Chairman:

In response to your January 9, 1986, letter, this report focuses on state groundwater standards activities. As you know, groundwater contamination has been increasingly recognized as a problem in recent years. The federal role in dealing with this problem has been largely supportive and the Congress has been considering whether this role is sufficient.

This study examines what the states are doing in setting standards to protect groundwater in terms of the context within which the states establish standards, which states have set groundwater standards for what contaminants, how the standards differ across the states, how the states have developed their standards, and how they use the standards.

Copies of the report are being sent to the Environmental Protection Agency and will be made available to interested organizations, as appropriate, and to others upon request.

Sincerely yours,

Eleanor Chelimsky
Director

Executive Summary

Purpose

Groundwater, a source of drinking water for about 50 percent of the U.S. population, is threatened by contamination. In the past 10 to 15 years, groundwater contamination has been increasingly recognized as a problem while solutions to the problem have emerged very slowly. The states have been the primary guardians of groundwater resources; the federal role has been largely supportive. To decide whether this role is sufficient, the Congress needs current information on how the states are dealing with contamination.

Senator Baucus, Chairman of the Subcommittee on Hazardous Wastes and Toxic Substances of the Committee on Environment and Public Works, asked GAO to examine what the states are doing in setting standards to protect groundwater. To accomplish this objective, GAO examined the context within which standards were developed, determined which states have set groundwater standards for what contaminants, how the standards differ across the states, how the states have developed their standards, and how they use their standards.

Background

Groundwater is a major source of the fresh water that is used for purposes such as drinking water and irrigation. Groundwater use has been increasing at a faster rate than the use of surface water. In 1950, the United States used 34 billion gallons of groundwater per day. In 1980, this almost tripled to 89, a 160-percent increase in 30 years.

Groundwater contamination arises from a wide variety of agricultural, industrial, municipal, and domestic activities. Because cleanup or treatment may be very costly, prevention is generally recognized as the best solution. Frequently, this is accomplished through the application of standards that specify the maximum concentration of a contaminant allowed in groundwater. Anyone discharging the contaminant must ensure that the discharge does not exceed the standard.

The federal government has no comprehensive role in groundwater protection but does have many programs that affect groundwater. The state governments have developed widely varying programs to deal with the wide variety of sources of groundwater contamination. The question has been raised (in proposed federal legislation) whether a stronger federal role might be useful.

Relying heavily on federal drinking water standards, many states have developed their own standards in two forms: numeric, specifying contaminant levels that should not be exceeded, and narrative, establishing general prohibitions about discharges that might contaminate groundwater. To find out how the states develop standards, GAO surveyed 57 states and territories (collectively, "states").

Results in Brief

Forty-one states have either numeric or narrative standards. Except for the standards that follow the federal drinking water standards, there is little uniformity or consistency across the states. No two states have the same set of numeric standards (because of state-specific conditions), yet a large majority of the survey respondents called for interstate consistency. The effectiveness of these standards is unknown.

Knowing the states that have standards and the contaminants they cover is only part of the picture, however. GAO's survey found great disparity with regard to type, number, and speed of adoption. Only 11 states have adopted numeric standards since early 1983, 2 since late 1985; 16 states are still without standards of either type. The increase in standards is about 110 per year, mostly from states previously without standards. Only 4 states have added standards to others already adopted, although some other states are considering additional standards. With potentially thousands of unregulated contaminants, there is considerable uncertainty about the extent to which groundwater is being protected.

Because of resource constraints, the states do not usually conduct their own research to develop information on toxicology or on the risks of groundwater contaminants to health. They rely instead on information from the federal government. When it is not available, they must develop their own information, but this is duplicative when standards are developed for the same contaminant by more than one state. Most of the states with numeric standards have only rudimentary standard-setting processes; only 5 have more elaborate procedures. They report a need for federal leadership and a gap between the information they need and the information the federal government disseminates.

GAO's Analysis

Context of Standards

The states usually deal with the threat of groundwater contamination within the framework of an overall protection program. Many states have organizations directly responsible for groundwater protection, while others have placed these duties within existing organizations. Many states have developed or are in the process of developing groundwater protection plans and policies, supported in part by grants under the Clean Water Act. Although contamination problems are similar across the states, each state has unique problems. (See chapter 2.)

Types of Standards

A total of 41 states have numeric or narrative groundwater standards or both; 15 states have only narrative standards. Almost half the states, or 26 of 57, have 1,019 numeric standards covering 260 physical characteristics of groundwater, inorganic compounds, radiological activity, and a large group of organic compounds, including volatile organic compounds and pesticides. These numeric standards require great technical expertise to produce; the states have relied on the federal drinking water standards for 62 percent of their standards. (See chapter 3.)

Differences in Standards

The states' drinking water standards diverge from the federal standards in several ways. In some states, the natural background level of a contaminant is higher than the level set in a federal standard; the state standard is correspondingly higher. Other differences arise because some state standards that were adopted years ago have not been updated. Several survey respondents questioned the appropriateness of the drinking water standards for groundwater. On the average, each state with additional numeric standards covers 20 contaminants beyond the 34 contaminants on the federal list. Many of these additional standards are based on the potential for contamination, not on the detection of contaminants. (See pages 47-52.)

The diversity of narrative standards is even greater, since there is no guiding principle for them. The diversity makes it impossible to count their number or to compare them except in general terms. Some survey respondents believed narrative standards are a more reasonable approach to protecting groundwater than numeric standards, perhaps because of the great number of potential contaminants. Narrative standards do seem to require less effort to produce and may be being increasingly used in lieu of numeric standards, but no empirical data are available with which to compare their effectiveness. (See pages 52-55.)

Standards Development

The states with the more advanced standard-setting procedures rely on the detection of contaminants before deciding to set a standard. They rely to the extent possible on federal information when it is available, and they resort to their own consideration of health-effects data when it is not. A large majority of the respondents reported that their states are constrained by inadequate technical expertise and limited financial resources. They believe that basic research findings are needed from the federal government if they are to develop more numeric groundwater standards. (See chapter 5.)

Use of Standards

State protection efforts seem to lie less in the development of standards than in their application through permits. More than 80 percent of the states, including those without standards, have discharge control programs of moderate or greater extent. Standards are used in the evaluation of permit applications and the establishment of conditions under which permits are issued. Frequently, they require a discharger of contaminants to monitor groundwater quality. The usefulness of standards and the effectiveness of groundwater protection based on these discharge control programs are not known. (See pages 87-92.)

Groundwater standards are used in the classification of groundwater, frequently with different standards for different classes, and in monitoring levels of contamination. Groundwater standards clearly aid in understanding their contamination problems. (See pages 92-95.)

Recommendation

This report contains no recommendations. GAO plans to issue a second report that will address the extent to which the data the states need to develop standards are currently available through the federal government. GAO intends in that report to consider the role, if any, that the federal government might play in developing information on groundwater contaminants and disseminating it to the states.

Agency Comments

EPA thought that the report is a comprehensive and useful reference. The agency also had a number of comments pertaining to one general point—that groundwater standards are only tools in protecting groundwater—and to specific passages in the draft. EPA's comments are reproduced in appendix V, followed by GAO's responses.

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Figures

Abbreviations

API	American Petroleum Institute
EPA	Environmental Protection Agency
GAO	General Accounting Office
OTA	Office of Technology Assessment

Introduction

Groundwater is an increasingly important and vital resource threatened to an unknown extent by pollution. The existence of the threat has only recently been recognized. During the last 10 to 15 years, the federal and state governments have devoted increasing efforts toward understanding the nature of the problem of contaminated groundwater supplies. This report provides information that can help the Subcommittee on Hazardous Wastes and Toxic Substances of the Senate Committee on Environment and Public Works both understand what state governments are doing in the way of setting standards for the protection of groundwater and judge whether, in the subcommittee's view, these activities provide sufficient impetus to the national effort or whether a more active federal role is needed.

The Importance of Groundwater

Groundwater is subsurface water that completely saturates interconnected spaces between soil particles and rocks. Layers of sand, gravel, or rocks bearing groundwater in useful quantities are called "aquifers." Aquifers may be located near the surface or hundreds to thousands of feet underground; the water table is the depth at which an aquifer lies closest to the surface. Aquifers may be tapped for their water at any point by sinking a well below the water table. Similarly, they may be replenished at any place as part of the hydrologic cycle at rates that depend on many factors.

Groundwater is a major source of fresh water, used for any of a wide variety of purposes. The use of groundwater has been increasing at a faster rate than the use of surface water. In 1950, 34 billion gallons per day were used in the United States. This doubled to 68 billion gallons per day in 1970 and further increased to 89 billion gallons per day by 1980, an overall increase of 160 percent in 30 years.

Almost two thirds of withdrawn groundwater is used for irrigation; the remainder is predominantly used for public water supplies and industry. Approximately 11.5 billion gallons of groundwater are used every day for public water supplies, one third of the total water consumed for this purpose. About 50 percent of the population in the United States relies to some extent on groundwater for drinking water. This is the part of the population that could be most affected by groundwater contamination.

The Nature of Groundwater Pollution

Unlike rivers and streams, groundwater moves very slowly, and its rate of flow and its direction are affected by many factors, including the composition of the subsurface and surface water that percolates down to the water table. When the surface water is contaminated—as it is in wastewater—the groundwater also becomes contaminated. The slow movement of groundwater causes the contaminants to remain in concentrated areas for long periods of time rather than dissipating, as happens in more rapidly moving surface water.

Groundwater can become contaminated from a wide variety of agricultural, industrial, municipal, and domestic activities. Many types of waste disposal (including septic systems and hazardous-waste disposal), leaking storage tanks, fuel transportation and spills, well operations, agricultural practices, road salting, and urban runoff can lead to groundwater contamination. The nature and extent of groundwater contamination nationally is unknown. Various studies have documented contamination from these sources, but none of the studies provides an estimate of the extent of the problem from any particular source.

Similarly, many states have conducted studies of groundwater contamination, but none of the state studies provides an estimate of the extent of groundwater contamination from all conceivable sources within a state. Although many states have knowledge of groundwater contamination for a few types of well-recognized problems, other potential sources may not have been fully assessed. This issue is explored in detail in later sections of the report.

The Role of Groundwater Standards

Groundwater contamination poses difficult problems. Contamination may persist for long periods of time when the movement of water through the subsurface is slow. Contamination in one area of an aquifer may eventually spread to other areas of the aquifer, although this may take several decades. Because some contamination may exist at great depths, it may be virtually impossible to remove it all, although some cleanup or treatment may be possible in specific circumstances. It seems that the best method for dealing with groundwater contamination is to prevent it.

Several prevention techniques have been used. The one we focus on is the use of groundwater standards. Other measures of prevention (which are essentially controls over the sources of contamination) include reducing the disposal of wastes on or in the land, enforcing strict standards for sources of contamination, and prohibiting the placement of potential contamination sources above aquifers that are particularly vulnerable to contamination. Groundwater standards, which do not prevent contaminants from entering groundwater, become preventive primarily by playing a role in each of the techniques above.

A groundwater standard can specify a maximum concentration of a contaminant, describe an acceptable level of quality, or define a permissible level of degradation. And a standard can be used in many ways: to establish limits on contaminants in effluents (that is, discharges), evaluate ambient groundwater quality, define the level of protection to be achieved, establish a goal for remedial cleanup, trigger enforcement, and help establish preventive programs to protect groundwater.

The two types of groundwater standards are numeric and narrative. A numeric standard specifies a maximum concentration of a particular contaminant. A narrative standard specifies a general prohibition against particular types of contaminant discharges or identifies a general level of quality to be achieved.

Numeric standards are based on specific information about the effects of contaminants and the level of protection that is attempted. A numeric standard is usually based on an estimate of the effect on health and public welfare of exposure to specific levels of a contaminant. Once the standard has been established, conditions of applicability are developed; for example, the standard might be applied to specific classes of groundwater or might be used in setting discharge limits. In this report, we are especially interested in ambient standards—that is, standards applied to groundwater in the ground. Ambient standards constitute the reference points by which groundwater quality is measured.

Establishing narrative standards does not require specific knowledge about contaminants. Narrative standards, because of their general wording, are applied case by case. In addition, if a narrative standard is applied in such a way as to make potential polluters responsible for showing that the standard will not be violated, regulators need not anticipate every possible situation in which contamination may occur.

The number of chemicals that may enter the environment makes the development of numeric standards for any substantial proportion of the chemicals almost completely infeasible, yet many states attempt to set such standards. Similarly, the flexibility of narrative standards places a heavy administrative burden on regulators to evaluate each permit application. Neither approach has emerged as the first choice of state regulators; indeed, both types of standard may be necessary. We explore this issue in later chapters, examining also the relationship between state standard-setting activities and some federal activities pertaining to groundwater standards.

The Issue of State and Federal Responsibilities

The protection of groundwater is presently viewed as primarily a state and local responsibility. Notwithstanding this, many federal laws and programs affect the monitoring, protection, or conservation of groundwater through regulations, technical assistance, research, funding, or land management requirements. In 1983, the Department of the Interior compiled a directory of groundwater programs that listed 44 federal programs related to groundwater; some of these provided for the establishment of state enforcement programs.[1] These activities do not reflect a unified federal role in connection with groundwater but, rather, provide resources and requirements that are frequently interwoven into state groundwater programs.

The Environmental Protection Agency (EPA) has the primary federal responsibility for many of the programs that affect groundwater quality. Although there is no specific federal legislation establishing a single regulatory program dealing with groundwater quality, EPA has recognized the wide range of its groundwater activities and established an Office of Ground-Water Protection to coordinate its role in this area. In 1984, EPA developed a groundwater protection strategy for four major areas of concern: strengthening state groundwater programs, creating a policy framework for guiding EPA programs, strengthening its own groundwater organization, and coping with currently unaddressed groundwater problems.

Notwithstanding the absence of a single regulatory program specifically for groundwater protection, several EPA programs are related to—and affect—state efforts to protect groundwater quality. The most notable of these are the programs implemented under the Safe Drinking Water Act (42 U.S.C. 300g et seq.) that are intended to ensure the safety of drinking water for human consumption. Under this act, EPA has established primary, or health-based, and secondary, or welfare-based, quality standards that set maximum contaminant levels for drinking water at the tap. The states have frequently used these standards in their

[1]Full bibliographic details for this and other citations are in the bibliography.

groundwater programs, sometimes adopting them as ambient groundwater quality standards. The extent to which they have done so is addressed later in the report.

The act also establishes a program for underground injection control, which regulates the injection of wastes into underground wells and helps protect groundwater quality by ensuring that specific contaminants do not migrate into groundwater sources. The act establishes a sole-source aquifer program that provides special protection for aquifers that serve as the primary source of drinking water for an area by limiting federal financial assistance for projects that may threaten the aquifers. Finally, the most recent amendments to the Safe Drinking Water Act (Public Law 99-339) require states to develop a wellhead protection program that must protect health against contaminants within a specified area around each well supplying a public water system; the extent to which this program will protect groundwater is not yet clear.

Under the Resource Conservation and Recovery Act (42 U.S.C. 6901-6987), EPA regulates hazardous-waste and solid-waste disposal, particularly focusing on potential contaminant seepage into groundwater. Under the Comprehensive Environmental Response, Compensation, and Liability Act (sometimes called Superfund, 42 U.S.C. 9601-9657), EPA provides assistance to clean up or contain contamination from hazardous substances released from dangerous disposal sites. The Clean Water Act (33 U.S.C. 1251 et seq.) is intended to protect surface water quality, but some activities under EPA's administration can be used in protecting groundwater—most notably the preparation of criteria documents for surface water quality (which establish the technical basis for justifying permissible levels of surface water contaminants) and the provision of planning funds (which are being specifically used in the development and implementation of state groundwater protection strategies). Finally, under the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136 et seq.), EPA has the authority to restrict the use of pesticides that may affect groundwater adversely.

These and other federal programs afford some degree of protection to groundwater, but the extent of federal involvement is still open and under debate. States use the federal programs in developing overall programs to deal with their own unique circumstances. The federal role is primarily one of encouraging the states to develop their own comprehensive groundwater protection programs. The current issue is whether this role is sufficient or appropriate or whether something additional is necessary. The resolution of this issue depends ultimately on whether adequate protection of groundwater quality by the states is consistent with the restricted federal role.

Objectives, Scope, and Methodology

Objectives

On January 9, 1986, Senator Max Baucus asked us to examine several questions concerning groundwater standards. Among other things, he asked us to examine what the states are doing in setting standards to protect groundwater. The results of our work were to assist the Senate Committee on Environment and Public Works in its deliberations concerning S. 1836 in the 99th Congress, now S. 20, designed to "provide for the protection of ground water through State standards, planning, and protection programs."

From discussions with the Senator's office and other members of the committee, we concentrated on the types of information that would be necessary to respond to questions about the context within which standards were developed, which states have set groundwater standards for what contaminants, how the standards differ across the states, how the states have developed their standards, and how they use their standards. More specifically, we determined that the questions listed below would provide the appropriate focus to our work:

1. What is the context within which state groundwater standards have been developed?

2. Which states have set groundwater standards?

3. For which contaminants have state groundwater standards been set?

4. What numeric and narrative state groundwater standards have been set?

5. How do the states' numeric groundwater standards compare with EPA's drinking water standards?

6. How do groundwater standards differ across the states?

7. What factors account for variation in state groundwater activities?

8. How do the states set groundwater standards?

9. How do groundwater standard-setting processes differ across the states?

10. What types of information are used in setting groundwater standards?

11. How are state groundwater standards used?

Scope and Methodology

We began our work by examining the literature on state groundwater standards and the context within which these standards were developed. Much of this literature was oriented toward describing recent, innovative regulatory approaches being developed and implemented by particular states. We used several compilations of state groundwater activities and standards as the nucleus of our information about each state. Then, from officials in each state, we requested documentation concerning the state's groundwater protection program: legislation, regulations, state groundwater plans, budget documents, and other studies relating to groundwater. As we received documents, we extracted information pertinent to our needs.

We also used the information to develop a questionnaire (printed in appendix I), tested it, and sent it to the officials responsible for groundwater programs in each state (listed in appendix II). Then we called them on the telephone to obtain their responses, simultaneously entering these data into our computer files. We analyzed the results of the survey and, in some cases, contacted the state officials again to obtain further details that permitted us to elaborate on specific aspects of a state's groundwater standards activities.

We obtained responses from all 50 states, the District of Columbia, and six territories: the Virgin Islands, Puerto Rico, Guam, American Samoa, the Northern Marianas, and the Trust Territory of the Pacific Islands.[2] We have answers to each question (as appropriate) from almost every state. In rare instances, some state officials did not believe that a particular question should be answered for their states. After examining state

[2] In the remainder of the report, we use the word "states" to refer to the 50 states, the District of Columbia, and the six territories.

documents, and sometimes after further discussions with the state officials, we made some changes in the initial responses on particular items in order to ensure consistency in the interpretation of questions and their answers across the states.

Our review was conducted during the period April 1986 to November 1986. The survey was administered to the state officials during August, September, and October 1986, with specific follow-up information gathered up to February 1987.

Report Organization

The report focuses primarily on the results of our survey, with explanatory and descriptive information extracted from various state documents we examined. In chapter 2, we answer the first question listed above, providing a context for the discussion of state groundwater standards in chapters 3-6, which are structured around the 10 other evaluation questions. In chapter 3, we answer questions 2, 3, and 4, detailing the states that have set groundwater standards, the contaminants these standards cover, and the specific numeric and narrative standards that have been set. In chapter 4, we provide information on how state groundwater standards differ from EPA's drinking water standards, how groundwater standards differ across the states, and the factors that may account for these differences, answering questions 5, 6, and 7. In chapter 5, we focus on how standard setting differs, questions 8 and 9, and on the information that is used in setting standards, question 10. In chapter 6, we describe some ways in which the states use groundwater standards, answering question 11. Finally, in chapter 7, we report our conclusions about how the states set groundwater standards.

The Context of State Groundwater Standards

A state's groundwater standards are generally part of a larger state groundwater protection program. Standards may be established because the state relies heavily on groundwater for drinking water or because the state has experienced groundwater contamination problems. They may be included in specific groundwater legislation or in other water legislation, and they may be administered by a specific state agency or many agencies. A state may or may not have developed specific groundwater plans, programs, or protection policies. In this chapter, we describe the context within which states have dealt with groundwater standards by presenting information on the states' reliance on groundwater, contamination problems, authorizing legislation, organization, plans, programs, and protection policy.

Reliance on Groundwater for Drinking Water

To examine the extent of the states' reliance on groundwater for drinking water, we asked the survey respondents to indicate the percentage of their states' drinking water that came from groundwater. Their responses are summarized by broad percentage ranges in table 2.1. The data show considerable variation. More than half the states (32 of 56 responding) obtained more than 50 percent of their drinking water from groundwater. Our results are generally consistent with similar data for 1980 available through the U.S. Geological Survey, with some upward movement noticeable in our data, corresponding to the overall increasing trend in the use of groundwater.

Table 2.1: State Reliance on Groundwater for Drinking Water

% drinking water from groundwater	Number of states
0- 10%	1
11- 20	1
21- 30	4
31- 40	8
41- 50	10
51- 60	11
61- 70	9
71- 80	4
81- 90	6
91-100	2
Total	**56[a]**

[a]One respondent did not answer this question

The reliance on groundwater for drinking is understated by the percentage of a state's drinking water obtained from groundwater. Since public water supply systems frequently mix groundwater and surface water, the percentage of a state's population relying at least in part on groundwater is usually greater than its percentage of drinking water from groundwater. We did not gather information on this percentage, but its distribution, which would show the population exposed to potentially contaminated groundwater, would have fewer states in the low percentages and more in the higher, compared to the distribution in table 2.1.

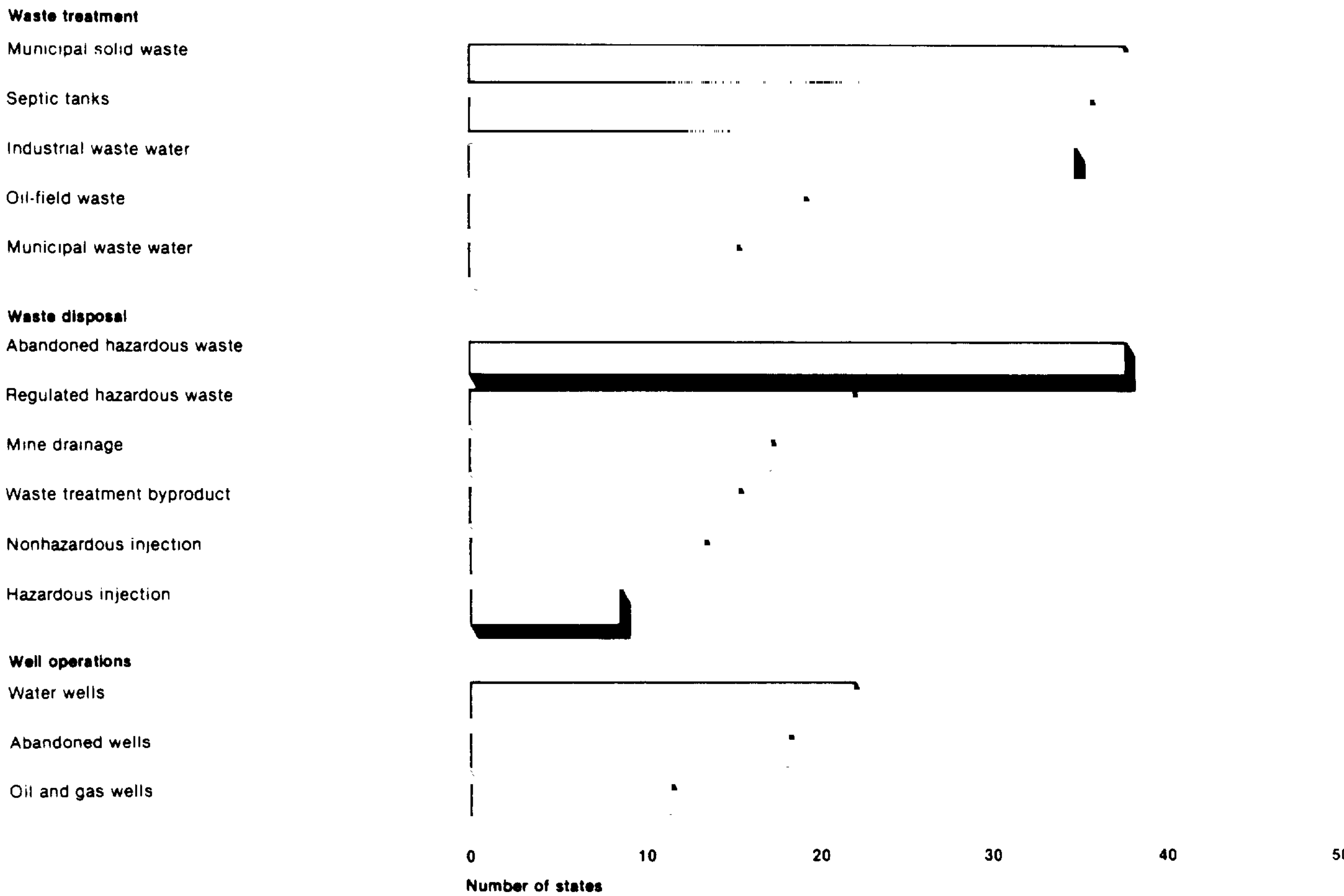
Groundwater Contamination Problems

In its 1984 report entitled Protecting the Nation's Groundwater from Contamination, the Office of Technology Assessment (OTA) stated that contamination by organic and inorganic chemicals, radionuclides, or microorganisms had occurred in every state. OTA said that although only a small portion of the nation's groundwater was thought to be contaminated, the potential effects of contamination were significant. The contaminants found in water were associated with ill health and adverse effects on social, environmental, and economic welfare.

Some contaminants are linked to cancer and to damage to the liver, kidneys, and the central nervous system. That information is not available about the effect of many individual chemicals on health, or of mixtures of chemicals found in groundwater, raises the possibility of other unknown adverse effects on health. The social effect often takes the form of anxiety and fear about exposure to contaminants, which can occur unknowingly, since contaminated groundwater may be odorless, colorless, and tasteless. Environmentally, the quality of soil, air, and surface water may be degraded because of relationships between these media and groundwater that can affect vegetation, fish, and other wildlife. The economic effect includes the costs of detecting, correcting, and preventing groundwater contamination. The costs include decreases in agricultural and industrial productivity, lowered property values, and the necessity of developing alternative water supplies.

In our survey, we asked the respondents to indicate the sources of groundwater contamination that have been identified as significant in their states. We gave them a list of 23 types of problems and the opportunity to identify others they considered significant. Our results are shown in figure 2.1. The predominant problems, reported by about two thirds or more of the 57 respondents, were underground storage tanks (50), municipal solid waste (39), abandoned hazardous-waste sites (39), septic tanks (37), and industrial waste water (36). Lesser problems (cited by 19 to 32 respondents) were contamination arising from abandoned wells, oil-field wastes, regulated hazardous waste, water wells,

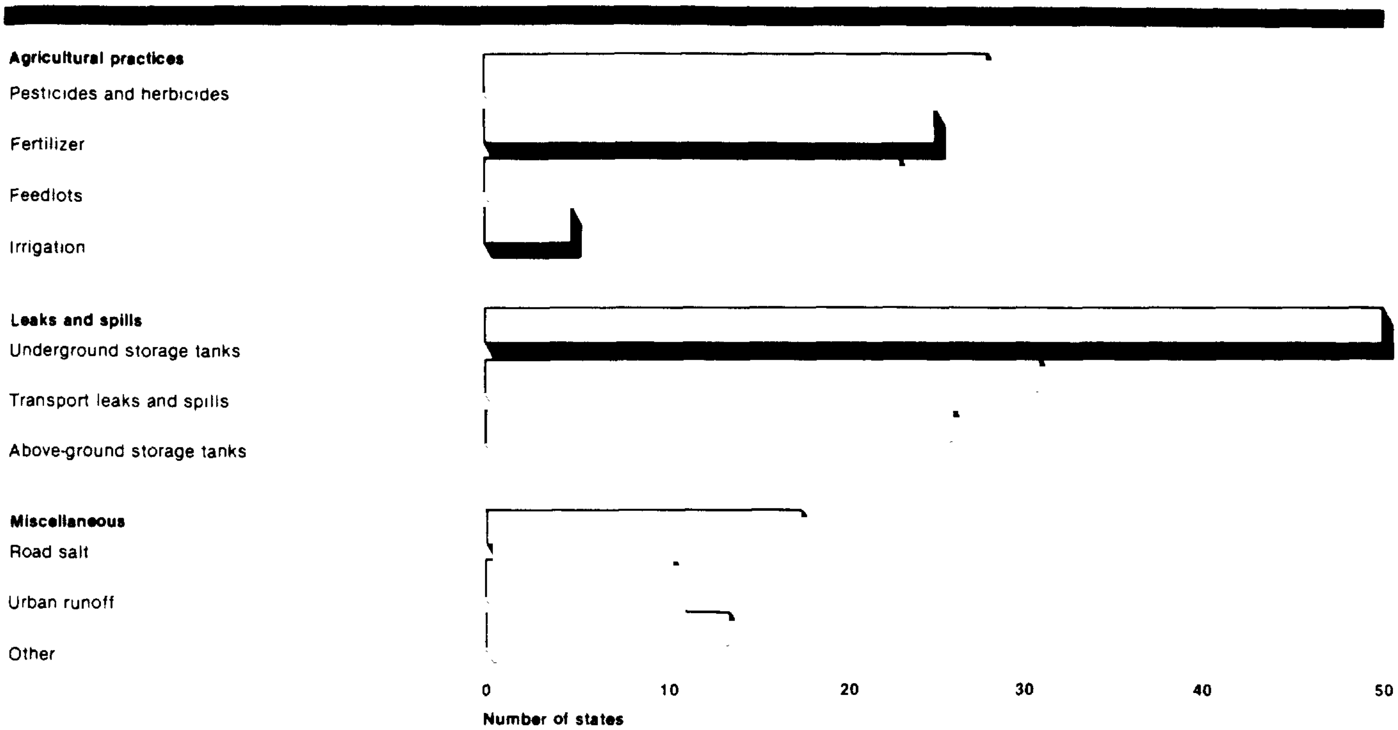
Figure 2.1: Significant Groundwater Contamination Sources[a]



[a]This question was addressed to all 57 state respondents.

animal feedlots, fertilizer, aboveground storage tanks, pesticides and herbicides, and transport leaks and spills. Relatively few state respondents reported significant contamination problems from municipal wastewater, waste treatment byproducts, mine drainage, waste injection wells (either hazardous or nonhazardous), oil and gas wells, irrigation, road salting, or urban runoff.

These results may not indicate the extent of some problems, since the respondents whose states had a well-developed program may have con-



sidered a problem no longer significant. This may be particularly true of injection wells, for example, which are handled by the underground injection control program under the Safe Drinking Water Act, and of oil, gas, and abandoned wells, but it is apparent that some state respondents still thought there was a significant problem with abandoned hazardous-waste disposal sites, even though there is a federal program to deal with them under the Comprehensive Environmental Response, Compensation, and Liability Act. Some problems may not have been fully recognized and others may have been just emerging into prominence.

We found no particular geographic pattern to the contamination sources. There were some regional variations, but they were not as large as might be expected. For example, the disposal of oil-field wastes has significantly contaminated groundwater in oil-producing states, but it was not cited as a problem in the oil-producing states of Colorado and North Dakota. Contamination from road salt would be an expected problem in the "snow belt" states and in general it was, but it was not reported as a problem in Alaska, Montana, and South Dakota, for example.

Table 2.2: Groundwater Protection Legislation in the 57 States

	Type of legislation			
State[a]	**Specific to groundwater**	**General water**	**Quantity of groundwater withdrawn**	**Other**
Alabama		•		
Alaska		•		
American Samoa			•	
Arizona	•[b]			
Arkansas		•		
California		•[b]		
Colorado				•
Connecticut		•		
Delaware			•	
District of Columbia		•		
Florida	•[b]			
Georgia		•[b]		
Guam	•			
Hawaii	•			
Idaho		•		
Illinois		•		
Indiana		•		
Iowa		•		
Kansas		•[b]		
Kentucky		•		
Louisiana		•		
Maine	•[b]			
Maryland		•		
Massachusetts		•		
Michigan		•		
Minnesota		•		
Mississippi			•	
Missouri		•		
Montana	•			
Nebraska	•			

State Groundwater Legislation and Organization

Respondents from all the states and territories reported some legislative authority for dealing with groundwater quality, although most indicated they did not have legislation specifically designed for groundwater protection. We asked each to describe the state's situation with regard to ambient groundwater legislation, and we show the results in table 2.2. All the states apparently had the ability to protect groundwater quality,

	Type of legislation			
State[a]	Specific to groundwater	General water	Quantity of groundwater withdrawn	Other
Nevada		•		
New Hampshire	•			
New Jersey		•[b]		
New Mexico	•[b]			
New York	•[b]			
North Carolina		•		
North Dakota		•		
Northern Marianas				•
Ohio		•		
Oklahoma		•[b]		
Oregon	•			
Pennsylvania		•		
Puerto Rico				•
Rhode Island		•		
South Carolina		•		
South Dakota		•		
Texas		•		
Tennessee		•		
Trust Territory of the Pacific Islands		•		
Utah		•		
Vermont	•			
Virgin Islands		•[b]		
Virginia	•[b]			
Washington		•		
West Virginia		•		
Wisconsin	•[b]			
Wyoming	•[b]			
Total	**15**	**36**	**3**	**3**

[a]This question was addressed to all 57 state respondents

[b]EPA reported specific groundwater legislation in State Ground-Water Program Summaries (Washington, D.C. March 1985)

primarily under general water legislation. Fifteen of the 57 states had specific groundwater legislation. A few states protected quality under quantity legislation—that is, legislation that was designed to control the amount of groundwater that could be withdrawn and was based on the premise that lowering the water table can result in groundwater contamination. Three states, under "other," had authority in several pieces of

Table 2.3: Responsibility for Groundwater Protection in the 57 States

State[a]	Lead agency or steering committee	Diffused authority	No agency responsible
Alabama	•		
Alaska	•[b]		
American Samoa			•
Arizona	•		
Arkansas		•	
California	•		
Colorado	•		
Connecticut	•		
Delaware	•		
District of Columbia	•		
Florida	•		
Georgia	•		
Guam	•		
Hawaii	•		
Idaho	•		
Illinois	•		
Indiana		•	
Iowa		•	
Kansas		•	
Kentucky		•	
Louisiana	•		
Maine		•	
Maryland		•	
Massachusetts		•	
Michigan		•	
Minnesota		•	
Mississippi	•		
Missouri	•		
Montana	•		
Nebraska		•	
Nevada	•[b]		
New Hampshire	•		
New Jersey	•		
New Mexico	•		
New York	•		
North Carolina		•	
North Dakota	•		

State[a]	Lead agency or steering committee	Diffused authority	No agency responsible
Northern Marianas	•		
Ohio	•		
Oklahoma		•	
Oregon	•		
Pennsylvania	•		
Puerto Rico	•		
Rhode Island		•	
South Carolina	•		
South Dakota	•		
Texas		•[b]	
Tennessee	•		
Trust Territory of the Pacific Islands			•
Utah	•		
Vermont	•		
Virgin Islands		•[b]	
Virginia	•[b]		
Washington	•		
West Virginia	•[b]		
Wisconsin	•		
Wyoming	•		
Total	**39**	**16**	**2**

[a]This question was addressed to all 57 state respondents

[b]EPA did not report a lead agency or steering committee in State Ground-Water Program Summaries (Washington, D C March 1985)

legislation, general water legislation, or various environmental laws. No state had no legislation to protect groundwater.

EPA's 1985 study entitled State Ground-Water Program Summaries obtained results somewhat different from ours. The agency identified 14 of 52 states and territories with specific statutes for groundwater. In response to our survey, officials from 6 of these 14 characterized their authorizing legislation differently from EPA, not as specific groundwater legislation but, rather, as general water-quality legislation.[1] In addition to drawing attention to this discrepancy, our respondents in 7 other states characterized the legislation as specific to groundwater. In 5 of these states, the enabling legislation existed prior to the EPA survey.

[1]EPA's study was a compilation from available sources by its regional groundwater representatives. EPA said it was not a comprehensive study of all state groundwater programs and, according to EPA's regional representatives, it was largely based on EPA officials' knowledge of state programs After the information was compiled, EPA contacted state officials to verify the information and to provide missing information.

We observe that amendments to the basic legislation (both specific and general) are being enacted in several states and we expect that this will continue. However, it does not appear from the responses we received that any widespread movement toward specific legislation can be expected; rather, it appears that whatever is deemed necessary will be accomplished under existing specific or general legislation. We explore this issue below.

We asked our respondents to tell us where responsibility for groundwater protection was vested in their states. Table 2.3 shows that 39 states had placed responsibility for their groundwater programs in a lead agency or a steering committee, while 16 states had diffused the authority among more than one agency. These results differ from those in EPA's study, which listed 46 of 52 states as having lead agencies or steering committees.

We believe the differences between our study and EPA's on this issue are the result of how the respondents interpreted the question. In the absence of definitive criteria for classifying the organizational structure, it is impossible to determine whether there is a trend toward lead agencies or whether there is a belief that a groundwater protection program can be operated adequately with diffused responsibility.

State Groundwater Plans, Programs, and Protection Policies

We found that most of the states had developed or were developing written groundwater protection plans, had implemented a number of programs that could assist in protecting groundwater, and had developed some type of formal groundwater protection policy. We asked the state officials whether a groundwater protection plan had been developed in their states, since the existence of a plan has frequently been construed as one indicator of a state's commitment to groundwater protection. About 40 percent (22 of 57) of the respondents reported having a written plan. Of the 35 states without plans, one was being developed in 26 states and one was planned but not yet started in 5 states. Officials reported no intention of developing a plan in only 4 states (Michigan, Montana, New Jersey, and Texas). However, all 4 of these states had either narrative or numeric standards or both.

State governments can implement a wide range of groundwater protection activities, from developing an overall strategy to using specific programs that may afford some protection. The extent to which these activities had been implemented, as reported by our respondents, is summarized in table 2.4.

Table 2.4: The Extent of State Groundwater Protection Activity

Activity[a]	No activity	Extent of activity: Little	Some	Moderate	Great	Very great
Development of groundwater policy and protection strategy	1	6	5	16	15	14
Development of groundwater standards	7	16	10	5	9	10
Aquifer mapping	2	4	10	23	9	9
Control of discharges to groundwater	1	3	7	13	17	16
Groundwater monitoring	1	8	15	16	14	3
Protection of sole-source aquifers	18	15	10	6	4	2
Contamination response program	2	4	8	14	19	10
Septic management program	1	6	11	16	14	9
Above-ground and underground storage-tank program	4	3	12	13	17	8
Agricultural contamination program	6	8	22	15	5	1
Solid-waste and wastewater disposal program	0	2	6	8	22	19
Underground injection control program	8	1	5	11	18	14
Oil, gas, and water well programs	3	4	6	14	14	13
Exchange of information	4	6	21	13	9	3

[a]This question was addressed to all 57 state respondents. Some did not respond for particular activities

Nearly 80 percent of the respondents (45 of 57) said their states had implemented the development of a groundwater policy and protection strategy to a moderate or greater extent. It is likely that the extensiveness of this activity results in part from the financial support from EPA under the Clean Water Act. (Four of the 7 that had little or no activity were the District of Columbia and 3 territories.) In contrast, almost 60 percent of the respondents (33 of 57) characterized the extent to which they had implemented the development of groundwater standards as less than moderate.

More than two thirds of the states had implemented aquifer mapping programs to a moderate or greater extent. Thus, it seems that in these states there is some understanding of the physical distribution of their groundwater resources. It is likely that much of this effort had been accomplished in conjunction with the U.S. Geological Survey. However, in only 12 states did the respondents indicate a sole-source aquifer program under the Safe Drinking Water Act of a moderate extent or greater, and respondents in 18 states reported that their states did not have a program of this type at all. It would seem that the program to protect aquifers critical for drinking water supplies is not yet well-developed.

Perhaps the most significant indicator of the extent to which the states were attempting to protect their groundwater is the response concerning their attempts to control discharges to groundwater. In 80 percent of the states (46 of 57), the respondents said the states had implemented discharge control programs to a moderate or greater extent. Groundwater monitoring programs (which would generally go hand-in-hand with a discharge program) had been implemented to a lesser extent, although in 60 percent of the states, the respondents indicated they had implemented them to a moderate or greater extent.

The range of responses concerning the exchange of groundwater information may indicate that some officials believed there was still a significant lack of coordination among state agencies. Perhaps not coincidentally, most states in which the officials thought they had implemented the process of exchanging information to a moderate or greater extent (18 of 25) also had a lead agency or steering committee to guide their groundwater programs.

It appears that the state programs for contamination response, septic management, storage tanks, agricultural contamination, waste disposal, injection control, and wells corresponded to some extent to the significant contamination problems identified by the state officials and summarized in figure 2.1:

- Thirty-seven state respondents identified septic systems as a groundwater contamination source, and 28 of these states had implemented septic management programs to a moderate extent or greater. Respondents in 20 states indicated they had no septic problems, yet 11 of these states had implemented septic management programs to a moderate extent or greater.
- In 49 states, respondents identified solid-waste or waste water disposal as groundwater contamination sources; 44 of these states had implemented solid-waste and waste water disposal programs to a moderate extent or greater.
- Thirty-seven respondents identified spills, road salt, or mine drainage as groundwater contamination sources, and 30 of these states had implemented response programs to a moderate extent or greater.
- Underground injection wells were identified as a contamination source in 18 states; 13 of these had implemented underground injection control programs to a moderate extent or greater.
- Thirty-one respondents identified oil, gas, and water wells as sources of groundwater contamination, and 22 of these states had implemented oil, gas, or water well control programs to a moderate extent or greater.

- Agricultural practices were identified as a source of groundwater contamination in 38 states, and 17 of them had implemented agricultural contamination control programs to a moderate extent or greater.
- Fifty respondents identified storage tanks as a source of groundwater contamination, and 33 of these states had implemented storage tank control programs to a moderate extent or greater.

The Characteristics of Groundwater Protection Policies

A groundwater protection policy, as defined in this report, is a policy that guides a state's strategy and indicates the level of intended groundwater protection to be implemented in that state. In the literature on groundwater programs, the existence of such policies has been taken as an indicator of the level of development of state groundwater programs. Therefore, we asked the state respondents to categorize their protection policies.

As these policies have developed, three terms have emerged to characterize them: nondegradation, limited degradation, and differential protection. The following definitions are the ones EPA uses:

- A nondegradation policy protects the quality of groundwater at existing levels. Under a policy of this type, discharges to groundwater are not allowed to increase the concentration of a contaminant beyond the current concentration.
- A limited degradation policy is designed to preserve groundwater quality above a specified standard. Under this type of policy, discharges to groundwater are allowed to increase the existing concentration of contaminants up to the established protection level.
- A differential protection policy focuses on the present and potential uses of groundwater. It is intended to protect groundwater to the extent required to satisfy specific present and future uses. Frequently, the states differentiate groundwater by class to help determine a level of protection, and the classes have differing levels of protection. These classes and the accepted levels of protection for each use vary. For example, some states classify water only for drinking use while others classify it for the use of agriculture, aquatic life, and livestock as well.

The responses of state officials shown in table 2.5 indicate that most of them thought their states had some type of protection policy. The respondents could indicate more than one policy if they thought their policies were different for different locations within a state. More than half the states had a nondegradation policy, and more than a quarter had either a limited degradation policy or a differential protection policy. Five of the states without a policy were developing one, 1 state planned to develop one but had not yet started, and only 1 state had no plans to develop one.

Table 2.5: State Groundwater Protection Policies by Type

	Number of states	
Policy type	**GAO survey[a]**	**EPA[b]**
Any type	50	31
Nondegradation	29	16
Limited degradation	16	17
Differential protection	16	12
Other	2	•
None	7	•

[a]This question was addressed to all 57 state respondents More than one policy type could be identified

[b]U.S Environmental Protection Agency, State Ground-Water Program Summaries (Washington D C March 1985)

EPA identified 31 states that had groundwater protection policies; we identified 50. Respondents from 2 states on EPA's list told us they had no policies. Of the 19 states whose respondents told us they had policies but of whom EPA said they had no policy, 10 had nondegradation policies, 2 had limited degradation policies, 3 had differential protection, and 4 claimed a mixture of policies. Among these states, it appears that the tendency was toward nondegradation policies. With respect to the remaining states, there was agreement between what EPA reported and what we were told for only 10 states. There was a difference between what respondents told us and what EPA reported in 19 states. It appears that more states have adopted groundwater protection policies since EPA conducted its survey, but the difference between our results and EPA's is sufficient to make any conclusion about a trend extremely uncertain.

Summary

In more than half the states, more than 50 percent of the drinking water was obtained from groundwater, but it is likely that more than 50 percent of the population relied at least in part on groundwater for drinking water. Some states relied almost totally on groundwater for drinking water.

In all but 1 state, significant groundwater contamination sources had been identified. Each state was faced with its own unique set of contamination sources. The most significant concern was contamination from underground storage tanks, mentioned by respondents in 50 of the 57 states.

All states had some sort of authority for protecting groundwater quality, 15 of 57 operating under specific groundwater legislation, 36 under general water-quality legislation. Responsibility for protecting groundwater quality was vested in designated lead agencies or steering committees in 39 of the 57 states and was diffused among several state agencies in 16 of the remainder. No trends toward particular legislative or organizational approaches were apparent.

Only about 40 percent of the states (22 of 57) had a groundwater protection plan, but most of the others (31 of 35) had one in development or planned to develop one. Respondents in most states (50 of 57) indicated that some type of groundwater protection policy guided their groundwater efforts.

A wide range of program activities had been implemented for protecting groundwater quality. In some areas, these activities were better developed than others, yet shortfalls were evident. In particular, about 80 percent of the states had made extensive (moderate to very great) efforts to develop groundwater strategies; the extensiveness of this activity may result, at least in part, from the financial support from EPA under the Clean Water Act. About two thirds of the states had made extensive efforts in aquifer mapping and groundwater monitoring, indicating that they were attempting to understand their available resources and contamination problems. However, almost 60 percent of the states (33 of 57) had very limited development of groundwater standards (less than moderate extent). At the time of our survey, the greatest focus for protection was on discharge controls—80 percent of the states had made efforts of moderate or greater extent. That many state programs were still in development may be indicated by relatively little activity (in 31 of 57 states) in the interchange of information pertaining to groundwater (less than moderate extent).

Many program efforts seemed to be focused on the types of problems unique to a state. Although our analysis was limited to a comparison between the reported significance of contamination problems and the extent to which programs had been implemented, we found that the correspondence between contamination problems and program activity was fairly strong. In programs for contamination response, septic management, storage tank controls, agricultural contamination, waste disposal, injection wells, and water well controls, we found that from 45 to 90 percent of the states with extensive programs had identified contamination from these sources as significant.

In summary, it appears that many states have well-developed groundwater protection activities and that those that do not may be moving in that direction. The trend is tenuous, because of possible problems in interpreting data from earlier studies, but appears to be in the direction of increasing activity.

Description of State Standards

The establishment of standards for groundwater quality is one of the most widely used approaches for protecting groundwater resources. In this chapter, we describe the extent to which the states have taken this approach by detailing the states that have set numeric and narrative groundwater standards and the contaminants for which they have been set. In the course of addressing these questions, we identify the types of groundwater to which the standards apply, their correspondence to EPA's drinking water standards, and the stated purposes of the standards.

States That Have Groundwater Standards

In our survey, we focused on ambient groundwater standards, the quality of groundwater in the ground. We learned that almost half the states (26 of 57) had adopted numeric standards and several other states indicated they were considering doing so. Another 15 states had narrative standards, so that about 70 percent of the states (41 of 57) had either numeric or narrative standards. Most of the states with numeric standards also had narrative standards, but 15 (more than 25 percent) had narrative standards without numeric standards. Only 3 states (Alaska, Maine, and Texas) had numeric but not narrative standards. Sixteen states had no standards at all. Table 3.1 on the next page gives a complete listing of the states by type of standard.

During the last few years, the American Petroleum Institute (API), EPA, and OTA have estimated the number of states with numeric groundwater standards. We compared our results with theirs to look for a trend, and we present our results in table 3.2 (on page 35). A trend for the number of states with narrative standards is difficult to ascertain, because whether a particular description constitutes a narrative standard is frequently a matter of subjective judgment. The EPA survey did not specifically identify states with narrative standards; the API survey frequently said that particular states had narrative standards but did not cover them systematically. It appears that no consistent criteria have been applied to the examination of narrative standards.

Table 3.1: Numeric and Narrative Groundwater Standards in the 57 States

State[a]	Numeric	Narrative	Both	None
Alabama				•
Alaska	•			
American Samoa				•
Arizona	•	•	•	
Arkansas				•
California	•	•	•	
Colorado	•	•	•	
Connecticut		•		
Delaware		•		
District of Columbia		•		
Florida	•	•	•	
Georgia	•	•	•	
Guam		•		
Hawaii				•
Idaho	•	•	•	
Illinois	•	•	•	
Indiana		•		
Iowa				•
Kansas				•
Kentucky				•
Louisiana		•		
Maine	•			
Maryland	•	•	•	
Massachusetts	•	•	•	
Michigan		•		
Minnesota	•	•	•	
Mississippi				•
Missouri	•	•	•	
Montana	•	•	•	
Nebraska	•	•	•	
Nevada				•
New Hampshire	•	•	•	
New Jersey	•	•	•	
New Mexico	•	•	•	
New York	•	•	•	
North Carolina	•	•	•	
North Dakota				•
Northern Marianas				•
Ohio		•		

State[a]	Numeric	Narrative	Both	None
Oklahoma	•	•	•	
Oregon		•		
Pennsylvania				•
Puerto Rico				•
Rhode Island				•
South Carolina	•	•	•	
South Dakota		•		
Texas	•			
Tennessee				•
Trust Territory of the Pacific Islands		•		
Utah				•
Vermont		•		
Virgin Islands		•		
Virginia	•	•	•	
Washington		•		
West Virginia		•		
Wisconsin	•	•	•	
Wyoming	•	•	•	
Total	**26**	**38**	**23**	**16**

[a]These questions were addressed to all 57 state respondents

Table 3.2: The Number of States With Numeric Groundwater Standards According to Four Studies

	OTA 1983[a]	EPA 1985[b]	API 1986[c]	GAO 1987
Number of states in the study[d]	50	50	50	50
States the study said had numeric standards	19	21	21	26
Additional states we believe had numeric standards at the time of the study	1	4	4	0
States we believe the study said had numeric standards that did not have them	5	5	1	0
Total (adjusted) number of states with numeric standards at the time of the study	15	20	24	26
States we believe adopted numeric standards after the study	11	6	2	0

[a]Office of Technology Assessment, Protecting the Nation s Groundwater from Contamination (Washington, D C U S Government Printing Office, October 1984)

[b]U S Environmental Protection Agency, State Ground-Water Program Summaries (Washington D C March 1985)

[c]American Petroleum Institute, Guide to State Groundwater Programs and Standards (Washington D C April 1986)

[d]The District of Columbia and 6 territories did not have numeric standards They are excluded from the total here to simplify comparison

Using data collected by API in early 1983, OTA stated that 19 of the 50 states (the District of Columbia and the territories were not included) had numeric standards (5 additional states had narrative standards). We examined the API data state by state along with our determinations of when particular states adopted numeric standards; we believe that there was 1 state that had standards but was not identified as having them and 5 states the study said had standards that did not. Thus, we believe that 15 states had numeric standards in early 1983 and that 11 states had adopted them between then and our survey.

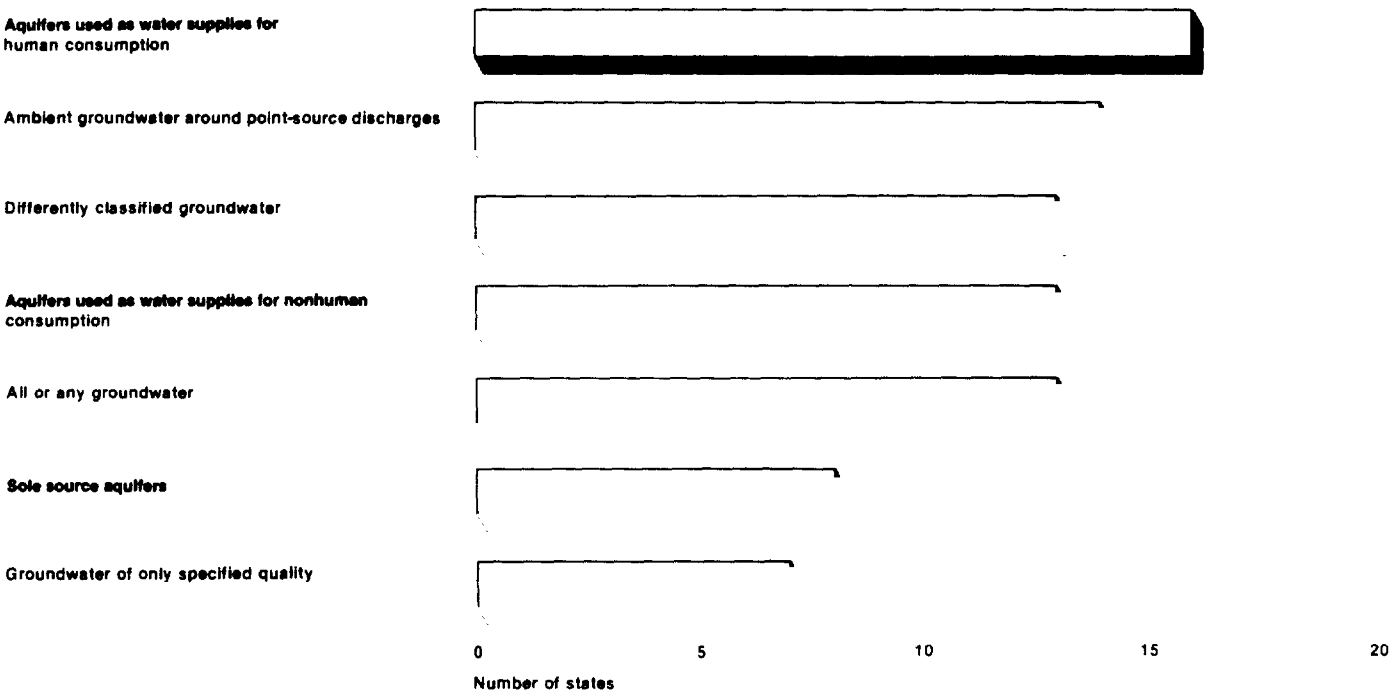
The EPA survey, actually conducted late in 1984, identified 21 states with numeric standards. However, we believe that 4 states had numeric standards at the time of the EPA survey but EPA did not identify them as having them and that 5 did not then and do not now have numeric standards. Thus, we believe that 20 states had numeric standards at the time of the EPA study and that 6 states adopted numeric standards after the EPA survey.

The API survey was conducted primarily during September and October 1985 and identified 21 states with numeric standards. We believe that 1 of these states did not then and does not now have such standards and that 4 states API identified as not having numeric standards did have such standards at that time. Thus, we believe that 24 states had numeric standards at the time of the API study and that 2 states adopted numeric standards after the API survey.

The states can apply groundwater standards uniformly to all groundwater or differently to particular types of groundwater. Given a groundwater classification system, a state may have numeric standards for one class and narrative standards for other classes. The states can also establish different numeric standards for distinct groundwater types, specific aquifers or basins, or groundwater used for specific purposes. Nine states (Alaska, Colorado, Illinois, Minnesota, Missouri, New Jersey, New Mexico, North Carolina, and Wyoming) had distinct numeric standards for one of these categories.

In our survey, we considered six specific types of groundwater that might be protected: sole-source aquifers, groundwater of a specified or known quality, ambient groundwater around point-source discharges, aquifers used as water supplies for human consumption, aquifers used as water supplies for nonhuman consumption, and groundwater for which standards apply to some classes and not to others. These were not

Figure 3.1: The Seven Groundwater Types to Which the States Applied Their Standards[a]



[a]This question was addressed only to the 41 respondents whose states had numeric or narrative standards. Not all respondents answered the question. Respondents could identify more than one groundwater type.

exclusive categories. The states were allowed to indicate other bases if they had them for applying their groundwater standards. Figure 3.1 shows the number of states, of the 41 states with numeric or narrative standards, that applied standards to each of the categories.

The largest number of respondents (16 of 41) stated that their groundwater standards applied to aquifers used as water supplies for human consumption. Almost as many (13 or 14 of 41) said their standards applied to ambient groundwater around point-source discharges, aquifers used for water supplies for nonhuman consumption, and differently classified groundwaters. A large number of respondents (16 of 41) stated that their standards applied not to one of the categories we specified in the questionnaire but, rather, to an additional type specification. Thirteen of these states applied their standards uniformly to protect any or all groundwater resources without regard to type. Only a small number specified that their standards applied to so to water of a specific quality.

Although the states rarely applied groundwater sta to sole-source aquifers, it should be remembered fr only 12 respondents indicated that sole-source aqui been implemented to a moderate or greater extent i the Safe Drinking Water Act and that 18 states did aquifer programs. Only 2 states (Arizona and Mass claimed extensive programs used sole-source aquif of groundwater to be covered by groundwater stan

Contaminants for Which Standards Have Been Set

We asked the states that had numeric standards to standards they had and, from copies of their regul: the specific contaminants that they controlled. We established numeric groundwater standards for 26 characteristics of groundwater and that they fell ir the following categories: physical characteristics; i including metals, nonmetals, and gross measures o nation; radiological characteristics; biological subs compounds, including volatile and nonvolatile, pes measures of organic contamination. (See table 3.3.)

Table 3.3: Contaminants Regulated by the States

Class	Contaminant
Physical characteristic of groundwater	Alkalinity, biochemical oxygen demand, chemical oxygen demand, c dissolved oxygen, odor,[a] pH,[a] taste, temperature, total dissolved sol turbidity[a]
Inorganic compound	
Metal	Antimony, arsenic,[a] barium,[a] beryllium, boron, cadmium,[a] calciun iron,[a] lead,[a] magnesium, manganese,[a] mercury,[a] nickel, potassiu sodium, thallium, zinc[a]
Nonmetal	Ammonia; boric acid, borates, and metaborates as boron; brom fluoride;[a] hydrogen sulfide; nitrate as N;[a] nitrate + nitrite as N; ni
Measure of inorganic contamination	Ammonia nitrogen, foaming agents,[a] specific conductance, total
Radiological activity and substance	Beta particle and photon radioactivity;[a] cesium 134, gross alpha beta particle activity; plutonium 238, 239, and 240; radium 226; r combined;[a] strontium; thorium 230 and 232; tritium, uranium
Biological substance	Coliform bacteria,[a] fecal coliform bacteria

Class	Contaminant
Organic compound	
Volatile	Benzene, carbon tetrachloride; chlorobenzene; chloroform, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, p-dichlorobenzene; 1,1-dichloroethane, 1,2-dichloroethane; 1,1-dichloroethylene; 1,2-dichloroethylene; trans-1,2-dichloroethylene, dichlorofluoromethane dichloropropanes; 1,2-dichloropropene; cis-1,3-dichloropropene, trans-1,3-dichloropropene, 1,3-dichloropropylene; ethylbenzene; ethylene dibromide; hexachloroethane, methyl chloride; methylene chloride; nitrobenzene; styrene; tetrachlorobenzenes, 1,1,2,2-tetrachloroethane; tetrachloroethylene; 1,1,2,2-tetrachloroethylene; toluene; trichlorobenzenes; 1,1,1-trichloroethane, 1,1,2-trichloroethane; trichloroethylene, trichlorofluoromethane; trichlorotrifluoroethanes, vinyl chloride, m-xylene + p-xylene, o-xylene; xylenes, total
Nonvolatile	Acenaphthene; acetone; acrylic acid, acrylonitrile, alkyl dimethyl benzyl ammonium chloride; alkyl diphenyl oxide sulfonates, aminomethylene phosphonic acid salts, aminopyridine; aniline; anthracene; aryltriazoles; azobenzene; benz(a)anthracene, benzidene; benzisothiazole; benzo(b)-fluoranthene; benzo(k)-fluoranthene, benzo(a)pyrene; bis (2-chloroethyl) ether; bromodichloromethane; bromoform; bromomethane; butoxyethoxyethanol; butoxypropanol, butyl benzyl phthalate, butyl isopropyl phthalate; carbon disulfide, chloroethane; 2-chloroethylvinyl ether, chloromethane, 2-chloronaphthalene; 2-chlorophenol, 5-chloro-o-toluidine; chrysene, dibromochloromethane; dibromodichloromethane, 2,2-dibromo-3-nitrilopropionamide, 3 3'-dichlorobenzidene; 2,4-dichlorophenol, diethyl phthalate; n,n-dimethyl aniline, dimethylformamide; dimethyl phthalate; 2,6-dinitrotoluene; di-n-butyl phthalate, di-(2-ethylhexyl)-phthalate (DEHP); di-n-octyl phthalate, diphenylhydrazine, dodecylguanidine salts; dyphylline; ethylene chlorohydrin; ethylene glycol; ethylene oxide; ethylene thiouria, fluoranthene; fluorene; guaifenesin; hexachlorobutadiene, hexachlorocyclohexanes, hexachlorocyclopentadiene; hexachlorophene; 2-hexanone, hydroquinone; 2-(2-hydroxy-3,5-di-tert-pentylphenyl) benzotriazole; 1-hydroxyethylidene-1,1-diphosphonic acid; indeno (1,2,3-cd) pyrene; isophorone; mercaptobenzothiazole; methacrylic acid, methoxyethylbenzene; methylbenz(a)anthracenes; methylene bisthiocyanate; 4-(1-methylethoxy)-1-butanol; 2-methylethyl-1,3-dioxolane; methyl ethyl ketone, methyl isobutyl ketone; methylmethacrylate; methyl-n-butyl ketone; monohydric phenol, naphthalene; naphthalene (total) (PAHs); niacinamide; nitrilotriacetic acid; n-nitrosodimethylamine, phenanthrene; phenols (total); phenyl ether; phenylpropanolamine; polychlorinated biphenyls (PCBs); pyrene, pyridine; 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), tetrahydrofuran; theophylline; o-toluidine; tolyltriazole; tributyltin oxide; trimethylbenzenes; trimethylpyridine; triphenyl phosphate
Pesticide	Alachlor; aldicarb; aldicarb + methomyl; aldrin, amiben, atrazine, benefin, bromacil, butachlor; captan; carbaryl; carbofuran; chlordane, 2,4-D;[a] DDT; diazinon, dicamba; dieldrin; dinoseb; dithane; endrin;[a] ferbam, folpet; guthion; heptachlor; heptachlor epoxide; hexachlorobenzene (HCB); kepone; lindane;[a] malathion; maneb; methoxychlor;[a] 2-methyl-4-chlorophenoxyacetic acid (MCPA); mirex; nitralin; paraquat; parathion, pentachloronitrobenzene (PCNB); pentachlorophenol (PCP); phorate; propachlor; propanil; propazine; simazine; 2,4,5-T; thiram; toxaphene;[a] 2,4,5-TP silvex;[a] trifluralin; zineb, ziram
Measure of organic contamination	Carbon chloroform extract, oil and grease, organic nitrogen, petroleum hydrocarbons, total organic carbon
Other	Total organic halogen, total trihalomethanes[a]

[a]Contaminant also regulated by EPA.

Not all the contaminants were regulated in each state; those that were regulated in each state and their tolerance levels are shown in appendix III.

As we mentioned earlier, many of the state standards were based on EPA's standards for 34 contaminants and characteristics for drinking water. These were included in the 260 contaminants. EPA's drinking water standards consist of 22 primary and 12 secondary standards. The primary drinking water standards are health-based, federally enforceable, maximum contaminant levels—that is, maximum permissible levels at which a contaminant may be present in water delivered to the user of a public water system. The secondary standards are welfare-based, nonenforceable goals intended to control contaminants that primarily affect esthetic qualities such as the color and odor of drinking water and that may also have implications for health. We discuss the extent to which the state groundwater standards followed EPA's drinking water standards in the next section and how they differ from them in chapter 4.

The Numeric and Narrative Standards

Numeric Standards

The number of numeric standards established in the states ranged from 14 in Maryland to 190 in New York; the average was about 41 standards per state. No two states had the same set of numeric standards, except for the states that had adopted the federal drinking water standards. Approximately 62 percent of the 1,019 standards were for contaminants included in EPA's primary and secondary drinking water standards. On the average, each state with numeric standards had adopted about 18 of the 22 primary standards and approximately 8 of the 12 secondary standards. Several states had adopted one or more of these standards at a level different from (higher or lower than) the level set by EPA. The number of primary standards included in a state's standards ranged from 11 in New Mexico to 22 in Arizona, Florida, Georgia, Idaho, Maine, Montana, New Hampshire, and Texas; the number of secondary standards ranged from 0 in Arizona, Georgia, Maryland, and Montana to 12

Table 3.4: The Total Number of Numeric Groundwater Standards by State

State	Primary standards[a]	Secondary standards[a]	Total number
Alaska	21	12	39
Arizona	22	0	22
California[b]	•	•	•
Colorado	20	11	42
Florida	22	12	43
Georgia	22	0	22
Idaho	22	12	35
Illinois	17	10	46
Maine	22	9	33
Maryland	14	0	14
Massachusetts	21	7	28
Minnesota	12	10	25
Missouri	17	6	47
Montana	22	0	25
Nebraska	19	8	28
New Hampshire	22	12	38
New Jersey	16	11	39
New Mexico	11	8	41
New York	16	8	190
North Carolina	20	6	30
Oklahoma	0	0	36
South Carolina	21	12	33
Texas	22	12	35
Virginia	15	4	36
Wisconsin	16	11	63
Wyoming	12	8	29
Total	**444**	**189**	**1,019**

[a]Substances on the list of EPA primary or secondary standards for which the state had a standard

[b]The total number is unknown California's standards are set regionally and do not apply to the entire state California's officials did not provide copies of any standards

in Alaska, Florida, Idaho, New Hampshire, and South Carolina.[1] Some of these states (Alaska, Arizona, Georgia, Maine, Montana, New Hampshire, South Carolina, and Texas) made specific reference to the state's drinking water standards. The total number of standards in states with numeric standards is shown in table 3.4.

[1]Oklahoma is a special case, having adopted none of the primary or secondary drinking water standards as groundwater standards. The reasons for this are discussed in chapter 4.

Several states (Arizona, Georgia, Maryland, Massachusetts, and South Carolina) had no standards for contaminants other than those EPA has prescribed for drinking water, but 20 states had standards for 226 contaminants not on the list of drinking water standards. New York had the greatest number of these additional substances (166); the average was approximately 20 (although it must be kept in mind that this average is influenced considerably by the relatively large number of standards in New York). It is apparent that EPA's primary and secondary drinking water standards have contributed to a large degree to helping the states develop numeric standards. However, it appears that all the states that had adopted numeric standards except Florida, New Hampshire, New Mexico, and New York adopted them at one time—that is, very few standards were added to a state's list after the period in which they were initially adopted, except in New York.[2] In other words, as new contaminants have been identified, few states have adopted standards for them.

We asked the states with numeric standards to identify what they were intended to protect, since these standards may vary by how groundwater is used. Some states clearly specified that they protected other uses in addition to human health. Of the 26 states with numeric standards, 18 respondents indicated the states' intentions were to protect health and 23 indicated that their standards were intended to protect drinking water.[3] Ten respondents said their standards were intended to protect wildlife or the environment; 11 identified the protection of agricultural activities. Nine state officials identified categories other than ones we had included, specifying commercial and industrial activities and recreation and aquatic life, although 3 of these were more general, specifying "all beneficial uses" (Virginia), "surface water uses" (Wisconsin), and "most sensitive use" (Massachusetts).

Narrative Standards

The range and diversity of narrative standards are difficult to characterize, since they had no apparent uniformity among the states and

[2]Some states indicated that they were on a second round of standard-setting and may add several standards to their lists within the next year.

[3]The protection of drinking water was generally based on health considerations but was frequently stated specifically in enabling legislation or regulations because of existing standards that had been developed for drinking water.

there are no federal guidelines. Typically, the narrative standards were used in deciding whether permits should be issued, although in some cases they constituted only statements of goals. In 29 of the 38 states with narrative standards, the standards were used as a basis for granting or denying permits for discharge to groundwater.

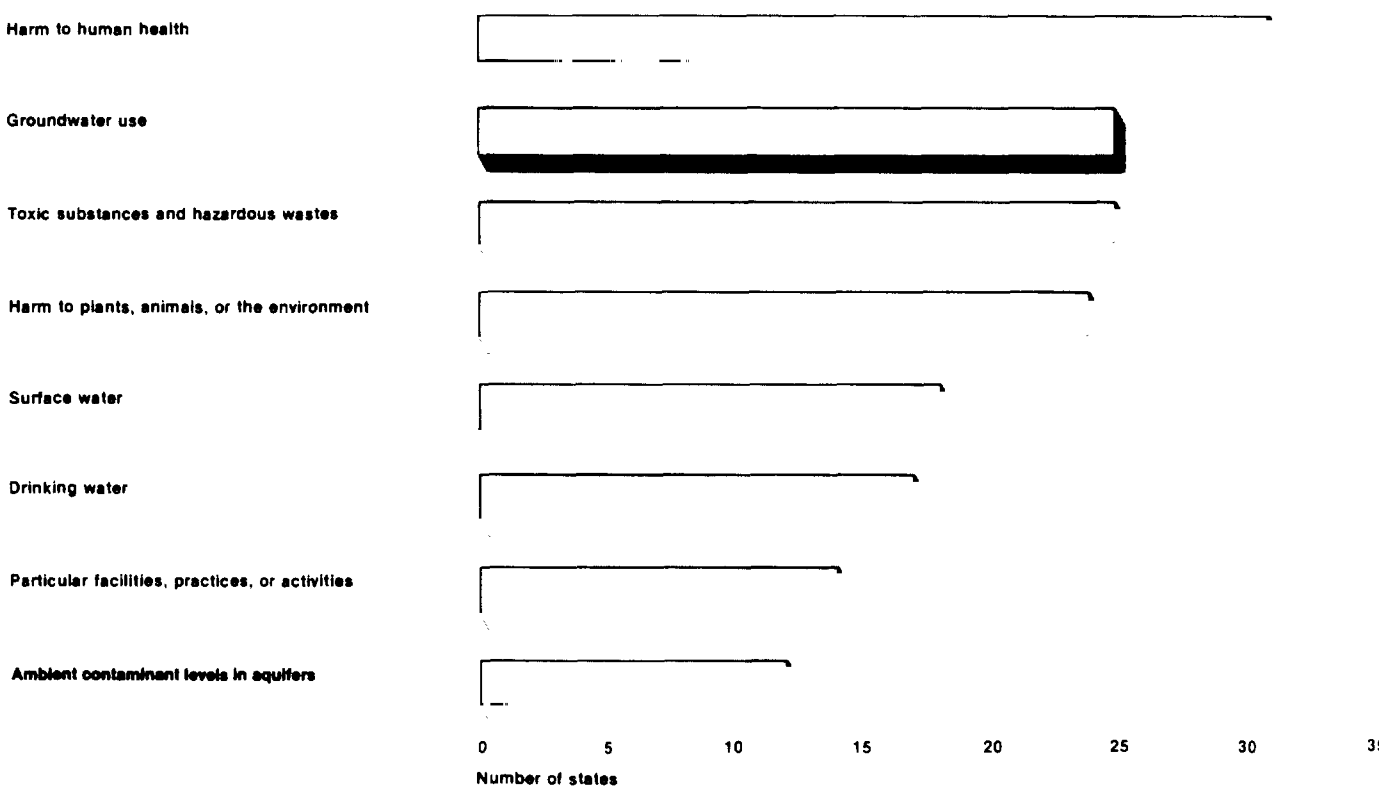
From our review of the literature, we determined that narrative standards establish heterogeneous criteria that provide a state with reference points for judging whether groundwater quality is being protected. Referring to such things as "groundwater uses," "toxic substances," and "drinking water standards," these reference points in effect constitute a statement of the purpose of a narrative standard. We did not count them, because they differed in level of detail, but we did develop a list of the types of their reference points or general criteria. Table 3.5 shows examples of narrative standards for each criterion; appendix IV lists the narrative standards for each state.

Table 3.5: Examples of Narrative Standards for Eight Criteria

Criterion	Example	State
Harm to human health	"A person shall not discharge into the groundwaters any substance that is, or may become, injurious to the public health"	Michigan
Groundwater use	"Maximum allowable concentrations of these substances also must not exceed acute or chronic problem levels which would adversely affect existing beneficial uses or the designated beneficial uses of groundwater of that classification"	Montana
Toxic substances and hazardous wastes	"Disposal of any hazardous waste, radioactive wastes or other waste shall not cause toxic substances to be present in groundwaters of the State in concentrations which are or may be hazardous to public health or which interfere with present and future uses of groundwater"	Arizona
Harm to plants, animals, or the environment	"It is unlawful to deposit . . . any substance or material deleterious to fish, plant life, or bird life"	California
Surface water	"Discharges to ground water which subsequently discharges into surface waters and which would cause a contravention of those surface water quality standards shall not be permitted"	New Jersey
Drinking water	"Class 'GA' waters shall attain the most stringent of . . . maximum contaminant levels for drinking water promulgated under the Safe Drinking Water Act"	New York
Particular facilities, practices, or activities	"No person shall make emergency discharges of hazardous wastes above or into the groundwaters of the state. This prohibition includes chlorinated hydrocarbon solvents, such as TCE . . ."	New Hampshire
Ambient contaminant levels in aquifers	"For substances not specified, the standard is the naturally occurring concentration as determined by the director of the Division of Environment Management"	North Carolina

The types of narrative standards for the 38 states that had them are summarized in figure 3.2. The most common criterion was that groundwater should be protected from contaminant levels that are harmful to human health (31 of 38 states). About two thirds of the states had narrative standards that specified either the protection of groundwater for uses that might be affected by contaminants (25 of 38) or for plants, animals, or the environment (24 of 38) or a prohibition against toxic substances and hazardous waste (25 of 38). About half of these states included reference to drinking water or surface water standards in their

Figure 3.2: Narrative Standards by Criterion[a]



[a]This question was addressed only to the 38 respondents whose states had narrative standards.

narrative standards. About 40 percent of the states included references to specific facilities, practices, or activities, and about one third referred to existing or ambient contaminant levels in aquifers.

Summary

At the time of our survey, 26 states (of 50 states, 6 territories, and the District of Columbia) had numeric standards specifying quantitative levels for contaminants. Narrative standards had been established in 38 states, many of them the same states that had numeric standards. Only 3 states had numeric standards without also having narrative standards, but 15 states had narrative standards without having numeric standards. Sixteen states had neither numeric nor narrative standards.

We found 1,019 numeric standards in 26 states covering 260 distinct contaminants, with as few as 14 contaminants in one state and as many as 190 in another. The contaminants included the physical and radiological characteristics of groundwater, various inorganic compounds, biological substances, and, most prominently, organic compounds, including a large number of volatile organic compounds and pesticides. The list included the 34 contaminants covered by EPA's drinking water standards; in fact, these 34 contaminants constituted, on the average, about 62 percent of the numeric standards in each of the states. On the average, 20 states had standards for 19 contaminants not included in EPA's drinking water standards.

For the most part, the numeric standards were intended to protect human health or drinking water, but in many states they were also intended to protect other uses of groundwater. In some states, different contaminant levels had been established for these different uses.

The states' narrative standards differed considerably, usually specifying some standard of quality or prohibiting some type of contamination. The differences made it difficult to count and compare them. Most of the states used their narrative standards to protect human health or groundwater uses. A substantial number also intended their standards to protect the environment or made a general prohibition against the introduction of toxic or hazardous substances into groundwater (in contrast to the numeric standards' specification of levels of contaminants that were permissible). Some state standards made general reference to EPA's drinking water or surface water standards (and allowed for future standards EPA may adopt) or to existing or background levels of contaminants in ambient groundwater (thereby covering contaminants not naturally present or present at a specific level). The wording of many of these standards seemed to cover the same situations that were encompassed by specific numeric standards.

The groundwater standards were applied to specific groundwater in a variety of ways. Many states simply applied their standards to all groundwater; others specified their application to specific types of groundwater. Many states applied the standards to groundwater as a source of drinking water, while another large group of states seemed concerned most with the groundwater around the places where contaminants were likely to be discharged. Several states based the application of their standards on some classification scheme or applied them only to groundwater of a certain quality or to sole-source aquifers (although this latter group was small, perhaps because the program was new).

Eleven of the 26 states had adopted numeric standards since early 1983, only 2 since late in 1985. Several other states were considering the adoption of numeric standards. It does not appear that states other than Florida, New Hampshire, New Mexico, and New York added to their lists of standards after they were initially adopted. Our data suggest that between 40 and 220 numeric standards were being added each year across all states, with lower numbers in the last 2 years and most of the new standards adopted by states that previously had none. At this rate, it could take as many as 40 years to adopt numeric standards in all states for half of the contaminants now regulated in at least one state. This slowness with which the states are adopting standards raises the question of whether protection from contamination is adequate.

It is not possible to assess the extent to which groundwater resources are indeed protected, given the standards that have been established. It is clear that a large number of contaminants might affect groundwater, and it is difficult to see how the states will be able to deal effectively with this large number by establishing numeric standards. There is little overlap in the contaminants the several states regulate, other than with the EPA drinking water standards. The adoption rate of numeric standards is clearly very slow and seems to have taken place mostly in states where no numeric standards previously existed. Although it appears that the wording of narrative standards in many states can cover a multitude of contaminants when the narrative standards are used in granting or denying permits, it is not known how extensively they are used in this way.

Differences in State Groundwater Standards

In chapters 2 and 3, we presented the context for state groundwater standards and described these standards in an overall way. In this chapter, we state how groundwater standards differ from EPA's drinking water standards, how their standards differ from state to state, and the factors that may account for the variation in their activities. Our focus is on the standard-setting process. The detailed lists of numeric and narrative standards in appendixes III and IV are intended to facilitate the comparisons we make in this chapter.

The States' Numeric Standards Compared to EPA's Standards

As noted in chapter 3, the states with numeric standards followed EPA's drinking water standards to a great extent. However, state numeric groundwater standards differed from the federal drinking water standards in several ways: some states had the primary but not the secondary standards, some had fewer than all the standards, some had most of the standards but at higher or lower levels than the federal level, and some had standards for contaminants other than the contaminants in EPA's standards.

Approximately 62 percent of the 1,019 state numeric standards were for contaminants on the list of federal drinking water standards. The states' numeric standards gave them 81-percent complete coverage with respect to the 22 primary standards. That is, on the average, 18 of the 22 federally restricted contaminants were included in the states' standards. For the most part, the states included EPA's inorganic metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) and nonmetals (fluoride and nitrate). Five or 6 states did not cover EPA's pesticides (2,4-D; endrin; lindane; methoxychlor; toxaphene; and 2,4,5-TP silvex), but the most notable omissions from EPA's list, among about 40 percent of the states, were in the standards for the physical characteristics of groundwater (turbidity), biological contaminants (coliform bacteria), radiological contaminants (beta particle and photon radioactivity, gross alpha particle activity, and combined radium 226 and radium 228), and "other" organic compounds (total trihalomethanes).

For the most part, the standards in few states differed in level of permissible contaminant from the federal levels for the inorganic metals and nonmetals. For some of the pesticides, 5 states had lower levels. We found many more differences in levels in the standards for beta particle and photon radioactivity, fluoride, and coliform bacteria, differences that deserve special note because of the way in which the standards are written.

The federal beta particle and photon radioactivity standard is written to allow measurement directly, by surrogate (gross beta particle activity), or by components (strontium 90 and tritium). Many states included in their standards either the surrogate or the components but did not include the direct measure. Similarly, for coliform bacteria, the federal standard specifies several methods of measurement, all describing "average" counts of coliform bacteria for specific sampling procedures, but some state standards did not specify all these procedures. For fluoride, the federal standard has changed recently. The previous standard was a range that depended on temperature; the present standard is a single value not related to temperature. Some states had adopted the new standard, some had continued the use of the old standard, and, under the old standard, some used only a part of the range and some used only one value from that range.

With respect to EPA's secondary drinking water standards, we found 63-percent completeness overall among the states with numeric standards. That is, on the average, these states adopted 8 of the 12 secondary standards. (However, Arizona, Georgia, Maryland, Montana, and Oklahoma did not include any secondary standards; excluding these states and California, for which we have no detailed data, the percentage rises to 78, or 9 of the 12 secondary standards.) As with the primary standards, the states adopted the standards for inorganic metals (copper, iron, manganese, and zinc) and nonmetals (chloride, sulfate, and foaming agents) almost completely and uniformly.

The biggest gap was in the adoption of standards for the physical characteristics of groundwater (color, corrosivity, odor, pH, and total dissolved solids). The standards for these characteristics generally followed the EPA levels, except for pH, for which there was a considerable variation across the states that appears to reflect natural variation in background levels. Only 7 states had standards for corrosivity, 13 for color, and 11 for odor. A larger number did have standards for pH and total dissolved solids, but there were omissions in 3 states for the former and 6 for the latter (of 20 states).

We found 5 patterns discernible in the way state standards related to EPA's standards. First, several states incorporated their states' drinking water standards by direct reference (Alaska, Arizona, Georgia, Idaho, Maine, Montana, New Hampshire, South Carolina, and Texas). In most of these states, the drinking water standards were not identical to the federal standards, usually differing in one or two standards. In several cases, states adopted only part of federal standards that can be divided into parts (the radiological standards) or that are expressible as ranges (fluoride and pH). It is not clear why these differences exist, but it does raise the question of whether these state standards are complete.

Second, a number of contaminant levels differed from the federal levels in a systematic way in several states (New Jersey, New York, Minnesota, Missouri, and Virginia). In these states, the standards seem based on contaminant assessments prevailing in the late 1970's and are generally more stringent than the drinking water standards. Their levels may not reflect the latest information.

Third, 2 states (New Mexico and Wisconsin) had numeric standards corresponding to many of the drinking water standards but the levels for some contaminants were different, apparently because of specific consideration for the appropriateness of the federal standards for a state. The reasons for the differences included the beliefs that a particular stringency was not warranted (and so should be higher or lower) and that the natural background level of a contaminant was higher than the federal standards (and that the state standard was therefore more realistic). This raises the question of whether states might generally see a necessity for setting levels in their standards that are different from federal levels.

North Carolina and Wisconsin set relative standards for pH; pH was the only federal standard for which a relative standard was set. The standard in these states was not an absolute level but was stated as the permissible variation from the natural background level. Wisconsin also set relative standards for contaminants not in EPA's list.

Finally, Oklahoma stands out because it had 36 numeric standards but had adopted no form of the federal drinking water standards. The apparent belief was that groundwater need not be separately protected against contaminants that are covered by drinking water standards. The idea is that any groundwater used for drinking water will be treated and that ambient contamination does not by itself pose any problems.

To gain insight on the issue of using federal standards, we asked the state officials in our survey for their opinions on whether federal drinking water standards should be used as ambient groundwater standards. One third of the respondents thought that federal drinking water standards should be adopted as groundwater standards, and more than half thought they probably should be (responding "yes" or "probably yes"). A quarter thought they probably should not be (responding "no" or "probably no"), and approximately a quarter were undecided (see table 4.1). Interestingly, these responses did not seem related to whether a state had either numeric or narrative standards. In other words, having numeric or narrative standards did not predict how respondents would answer this question.

Table 4.1: State Opinion on Whether Federal Drinking Water Standards Should Be Used as Ambient Groundwater Standards

		Standards in the state			
		Numeric		Narrative	
Response	Number of responses[a]	Yes	No	Yes	No
Yes	19	10	9	14	5
Probably yes	11	5	6	6	5
Undecided	14	7	7	9	5
Probably no	2	1	1	2	0
No	11	3	8	7	4
Total	**57**	**26**	**31**	**38**	**19**

[a]This question was addressed to all 57 state respondents

We discussed these responses in detail with several of the respondents, mostly to understand the reasons why they were against using federal drinking water standards. We describe the essence of their responses, recognizing that they may not constitute a consensus. The drinking water standards may be a reasonable starting point for the development of groundwater standards. Since much groundwater, particularly in rural areas, is used for drinking water, it is important to ensure its quality.

However, groundwater can be used for many other purposes, for which drinking water standards may not be appropriate. Some uses, such as for fish and other aquatic life, may require higher levels of quality; other uses may permit less stringent standards. In making such a decision, it may be relevant to take into account the natural condition of the groundwater, particularly if the quality for the use in question is better than drinking water quality. Using drinking water standards in this situation might give a license to pollute up to that level—a permission that would run counter to nondegradation policies.

Moreover, a different type of management may be involved with groundwater, perhaps because drinking water quality is concerned with the point at which it is used, whereas groundwater quality depends on discharges into it. In this context, it may be important to account for the costs associated with ensuring that groundwater quality is not degraded. Perhaps, in some instances, social or economic benefits may have to be considered.

Differences Across States

To a large extent, the differences in numeric standards from state to state are accounted for in their differences from EPA's drinking water standards. As we mentioned in chapter 3, the states have adopted 1,019 standards, 386 of which were in 20 states for 226 contaminants that were not on EPA's list. This is an average of 1.7 standards for each of the additional contaminants; hence, there was relatively little duplication across the states. Notwithstanding this, several patterns seem to emerge.

One is that the additional standards in several states that appear to have adopted their standards some time ago (Illinois, Minnesota, Missouri, New Jersey, and Virginia) were relatively similar. They included ammonia, sodium, phenols, a few pesticides (aldrin, chlordane, DDT, dieldrin, heptachlor, kepone, and mirex), and several organic compounds, such as oil and grease and petroleum hydrocarbons. In Minnesota, for example, the standards seem to be drinking water guidelines from the early 1960's and have continued unchanged since then, despite changes in the drinking water standards.[1] Missouri also had a group of organic compounds that were prominent earlier.

New York had adopted its standards about 10 years ago, adding later a large number of contaminants for regulation under "guidance values." According to a state official, these did not have the legal force of standards, but in practice they functioned that way. To prove a violation of a guidance value, it had to be demonstrated that a contaminant level was harmful; this does not have to be proven for the standards. We have construed these "guidance values" as having the weight of standards. The 166 contaminants that New York regulated in addition to those on EPA's list accounted for more than 43 percent of the states' 386 additional standards, and New York included a large number of nonvolatile organic compounds and pesticides not regulated in any other state.

Several western states (Alaska, Colorado, Montana, and Wyoming) had adopted radiological standards beyond federal standards that generally reflected mining activity. Several states scattered across the country (Florida, New Mexico, New York, Oklahoma, and Wisconsin) had

[1] Although Minnesota's regulations specify that updates to these standards are automatically adopted, recent lists of applicable standards include only the earlier numeric standards.

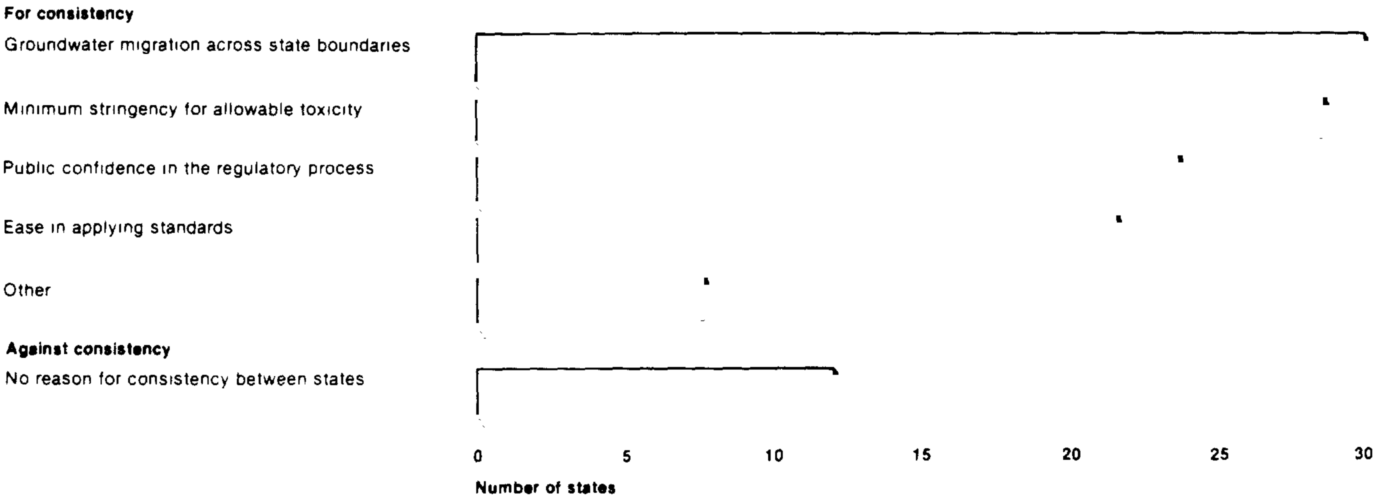
adopted standards for several volatile organic compounds with apparent concern for them as subjects of national regulatory concern. Finally, Wisconsin had adopted several standards not for contaminants per se but for certain natural constituents or properties of groundwater. The standards were not absolute but, rather, relative to the natural background and were considered indicators of contamination, specifying maximum increases in particular substances that were allowed before regulatory action would be initiated.

In general, except for the contaminants referred to in the paragraph above, standards for many of the 226 additional contaminants seem to have been adopted without specifically identifying them as actual groundwater contaminants. It appears that they were identified as contaminants of surface water and then incorporated as groundwater standards by reference. It appears that the states no longer look to surface water regulations for their application to groundwater. Those that recently adopted groundwater standards adopted drinking water standards or slight variations of them or added to their standards contaminants that they believed had a distinct likelihood of contaminating the groundwater.

Very few of the 226 contaminants covered by state standards beyond EPA's were used in more than 1 or 2 states. We asked the state officials to tell us any reasons they thought consistency should be required between the states on ambient groundwater standards. Their responses are shown in figure 4.1. The states could give more than one answer to this question, and as can be seen, the respondents indicated several reasons for consistency and relatively few (12 of 57) thought that there was no justification for it. The largest number (about half) thought that groundwater migration was a sufficient justification. Almost as many thought that the ability to set minimum stringency for toxicity levels was an important reason to have consistency. About 40 percent of the state officials gave two other reasons—improving public confidence in the standards set in the state and ease in applying the standards—as important justifications for consistency also. This manifestation of an interest in consistency occurs against the backdrop of a reality in which no 2 states had the same numeric standards, except for those that had adopted the federal standards.

The variation in state narrative standards was much more pronounced—perhaps not surprisingly, since there has been no federal model for narrative standards. To some extent, the differences are described in figure 3.2, showing the criteria specified in the standards.

Figure 4.1: Reasons For and Against Consistency Between the States on Ambient Groundwater Standards[a]



[a]This question was addressed to all 57 state respondents. If a respondent's position was for consistency, more than one reason could be given.

However, the differences are seen more concretely when it is recognized that all the narrative standards were specific versions of a generic standard: discharges in amounts of substances into groundwater affecting its use. The variations in terminology across the states were differences in which parts of this generic standard were used and how a part was specified. The discussion below is based on the narrative standards listed in appendix IV.

Many narrative standards referred to discharges of substances from particular facilities, practices, or activities. These discharges might be covered simply by saying "no discharge" or they might be specifically identified as sewage, industrial waste, or refuse from particular types of operations such as distilleries or refineries. In some states, the type of discharge might be included in a standard by reference or it might be specifically identified. It appears that many of these standards emanated from concerns about surface water, since they addressed discharges into "waters" that were taken to include groundwater.

In many of these standards, the amount of a discharge, substance, or contaminant was included by reference, either generally or by citing specific sources. An amount might be specified by direct reference to drinking water standards, surface water standards, ambient levels of contaminants, natural background levels, or some other source such as standards for radiation established elsewhere. An upper limit on the amount might be identified by reference to particular conditions that might result from excessive amounts—for example, amounts not harmful to humans, animals, or aquatic life or not affecting drinking water, industrial, agricultural, or other particular uses of the groundwater.

The type of substances encompassed by the narrative standards were also identified either generally or specifically. Some standards simply made reference to any "substance," "contaminant," or "material." Other standards used terminology such as "toxic," "deleterious," "hazardous," or "corrosive." Some of these standards in effect defined what these terms meant by reference to a result, such as "toxic materials that may be harmful to health."

All the narrative standards made some sort of reference to the type of groundwater encompassed by a standard. In many states, this reference was very general, the standard referring only to "waters of the state," defined elsewhere in a state's laws or regulations to include groundwater. In some of the standards, the term "groundwater" was specifically included and was sometimes even characterized: discharges below the "water table" or into the "zone of saturation," "mixing zones," or "aquifers" of a particular type or classification, for example.

Finally, many narrative standards were constructed in terms that referred to the use of the groundwater. These standards generally prohibited levels of contamination that interfere with the possible uses of groundwater, which were identified either generally or specifically. The general wording usually referred to such things as "existing water uses," "beneficial uses," and "commercial uses." In some standards, the wording referred to the result of using groundwater. In these cases, the type of health effect was identified generally, such as "injurious to the public health," or more specifically, by identifying what might occur, such as "cancer, causing mutations, or causing behavioral abnormalities."

As can be seen, the narrative standards followed a general pattern of wording but varied considerably. In many cases, the wording was sufficiently general that groundwater might be protected but there could be no confidence that it would be. One respondent said that the narrative standards provided a backup but had never been used in denying a permit. In contrast, there was a belief that narrative standards provided a better approach to dealing with groundwater contamination than attempting to regulate all possible contaminants through numeric standards.

Factors in the Variation of State Activities

In the remainder of this chapter, we discuss how the presence of numeric standards relates to the presence of narrative standards and how the presence of different types of standards relates to reliance on groundwater for drinking water, types of legislation, and policy commitments. A major issue concerning groundwater is whether the states are protecting it from the various contaminants that threaten it. Setting maximum ambient contaminant levels has generally been viewed as the approach necessary for ensuring this protection. Thus, it would seem that the number of states with numeric groundwater standards is an indication of the extent to which groundwater is being protected. Since only 26 states had numeric standards, it is useful to compare these states with those that did not have numeric standards.

The Relationship Between Numeric and Narrative Standards

The first issue is whether the presence of numeric standards should be taken as the sole indicator of whether a state is protecting groundwater. Table 4.2 shows that most states (23 of 26) that had numeric standards also had narrative standards; however, a significant portion of the states that had narrative standards (15 of 38) did not have numeric standards. As we mentioned in chapter 3, the number of states with numeric standards has increased by 11 since 1983 and 2 since 1985, raising the question of whether the states believe that narrative standards can protect groundwater resources. It shows also that 28 percent

Table 4.2: The Number of States With Both Numeric and Narrative Standards

	Narrative standards		
Numeric standards	**Yes**	**No**	**Total**
Yes	23	3	26
No	15	16	31
Total	**38**	**19**	**57**

of the states (16 of 57) had neither numeric nor narrative standards, raising the question of why some states did not have any standards. These questions led us to look in more detail at the states with only narrative standards and those without standards.

The Relationship Between Groundwater Standards and Drinking Water

The extent to which a state relied on groundwater for its drinking water supplies did not seem to play a major role in determining whether it established groundwater standards at all or, if it did, what type of standards they were (numeric or narrative or both). Table 4.3 shows the relationship between the states' reliance on groundwater for drinking water supplies and the types of groundwater standards that protected their groundwater resources.

Table 4.3: State Reliance on Groundwater for Drinking Water by Type of Standard

	% of reliance on groundwater				
Type of standard	**0-20**	**21-40**	**41-60**	**61-80**	**80-100**
Numeric only	0	0	1	2	0
Narrative only	2	3	4	5	1
Numeric and narrative	1	4	11	4	3
None	0	5	5	2	4
Total	**3**	**12**	**21**	**13**	**8**

Some states had established groundwater standards and yet relied on groundwater for a relatively small percentage of their drinking water (less than 40 percent), while others relied almost exclusively on groundwater for their drinking water and had not established any groundwater standards. Of the 15 states whose reliance on groundwater ranged from 0 to 40 percent, 10 had either numeric or narrative groundwater quality standards. Of the 42 states that used groundwater more extensively, 31 had groundwater standards. Of the 11 states in this category that had neither numeric nor narrative standards, 1 (Hawaii) had a 90-percent reliance on groundwater for drinking water. The expectation was that the percentage of states with standards would increase as reliance increased, but the data do not show that this happened.

The Enabling Legislation for Groundwater Standards

Table 4.4 presents our data on how the existence of numeric and narrative standards in the states was related to the type of state legislation that provided the basis for protecting groundwater quality. Most of the states with legislation specifically designed for the protection of groundwater (11 of 15) had numeric standards. In states that protected groundwater quality under the authority of general water legislation, only 14 of 36 had numeric standards, and 23 of 36 had narrative standards. It would appear that the states that had enacted specific legislation for groundwater protection had provided for numeric standards. However, since a substantial proportion of the states without such legislation had also established numeric standards (14 of 26 states with numeric standards), specific legislation is clearly not a prerequisite for establishing numeric standards, as has been suggested in some of the literature on groundwater programs.

Table 4.4: Numeric and Narrative Standards by Type of Legislation

	Standards in the state				
	Numeric		Narrative		
Type of legislation	Yes	No	Yes	No	Total
Specific groundwater protection	11	4	13	2	15
General water-quality legislation	14	22	23	13	36
Groundwater consumption	0	3	1	2	3
Protection diffused among many laws	1	2	1	2	3
No protection	0	0	0	0	0
Total	**26**	**31**	**38**	**19**	**57**

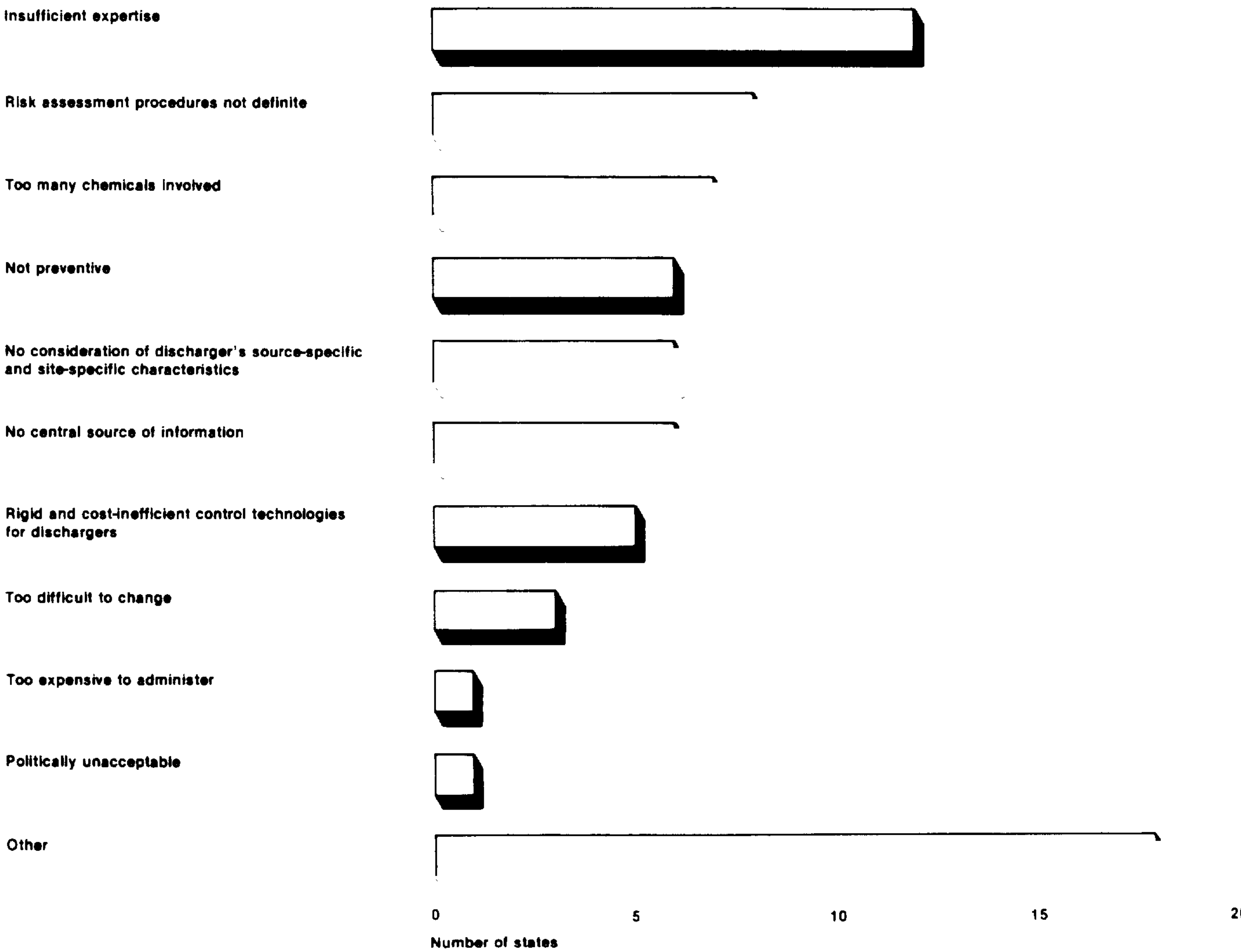
We also examined these data from the standpoint of states that did not have numeric standards. Seven respondents to our survey indicated that the lack of legal authority constrains a state's ability to set standards. None of these states had specific groundwater legislation—they relied only on general water quality legislation to protect groundwater quality—and none had numeric standards. Table 4.4 shows 22 states with these characteristics. Hence, the 7 states constrained by not having enabling legislation constituted about a third of the states with general water quality legislation for protecting groundwater but without numeric standards. Three of these states were territories and 3 indicated that they had insufficient expertise in setting standards. Thus, it would seem that the lack of enabling legislation and lack of resources, both a reflection of political will, help determine whether a state establishes groundwater standards.

Finally, it is interesting to note that no state respondent indicated a total absence of authority to protect groundwater quality. While it may be possible to infer that the states with specific groundwater legislation were doing more than those with general water legislation to protect groundwater, it does not seem possible to infer the extent of protection from either type of legislation.

Reasons for Not Having Numeric Standards

Of the 31 states without numeric standards, 2 respondents (both from territories) did not give us their reasons for not having them. The responses we did receive were widely diverse. The expense of administration, difficulty of change, and political unacceptability were not fre-

Figure 4.2: Reasons for Not Having Numeric Standards[a]



[a]This question was addressed only to the 31 respondents whose states did not have numeric standards. Respondents from 2 territories did not answer the question

quent reasons. Technical or information problems in developing numeric standards may have been behind reasons such as the number of chemicals involved, insufficient expertise, the lack of a central source of information, and other responses. About half the respondents gave one or more of these reasons, which seem to indicate that the state of the art and an information shortage were the major reasons for the absence of numeric standards. These data are in figure 4.2. About 60 percent of the state respondents (18 of 29) identified reasons not specified in our question. Seven of these indicated that standards were either being developed or under consideration.

We did not expressly ask the 15 states that had only narrative standards why they chose them instead of numeric standards, but their reasons for not having numeric standards may provide an insight into this question. Respondents from 6 of these states said that numeric standards were not preventive, that risk assessment procedures were not definite, that numeric standards lead to rigid control technologies, that they allow no consideration of the characteristics of dischargers of contaminants, or that they are too difficult to change. These 6 states also seemed to emphasize control over dischargers of contaminants rather than ambient contaminant levels. Of the remaining 9 states with only narrative standards, 3 were developing or considering numeric standards and 2 seemed to use narrative standards because of the information problems noted above.

Policy Commitments to Groundwater Protection

Besides numeric standards as an indicator of the extent to which a state is protecting groundwater, three other indicators are whether responsibility for groundwater protection has been assigned to a lead agency, whether the state has developed a groundwater protection plan, and whether the state has established a groundwater protection policy. We found as expected that states with numeric (18 of 26) or narrative (28 of 38) standards had generally assigned responsibility for protection to lead agencies or steering committees. However, many states assigned responsibility to lead agencies or steering committees in the absence of both types of standard (10 of 16), implying that even in states without standards there is some level of official concern about groundwater protection. (See table 4.5.) In addition, it seems that the states believe they can effectively protect groundwater by spreading responsibility among several agencies; 10 of the 16 states that did so had either numeric or narrative standards.

The majority of states with a plan for protecting ambient groundwater have groundwater standards (19 of 22), but more states (22) that have standards do not have a plan (see table 4.5). Thirteen of the 16 states without standards do not have a groundwater protection plan. However, it would seem that a state does not need a plan to develop some sort of standard. Accentuating this point, the 4 states that did not intend to

Table 4.5: State Groundwater Organizational Responsibilities, Plans, and Policies

	Standards in the state[a]				
	Numeric		Narrative		
	Yes	No	Yes	No	Total
Organizational responsibility					
Lead agency or steering committee	18	21	28	11	39
Diffused among several state agencies	8	8	9	7	16
None of the above	0	2	1	1	2
Total	**26**	**31**	**38**	**19**	**57**
Existence of a plan					
Has a protection plan	13	9	19	3	22
Has no protection plan	13	22	19	16	35
Total	**26**	**31**	**38**	**19**	**57**
Type of protection policy					
Nondegradation	12	17	18	11	29
Limited degradation	11	5	15	1	16
Differential protection	9	7	13	3	16
Other	2	0	2	0	2
No policy	0	7	2	5	7
Total[b]	**34**	**36**	**50**	**20**	**70**

[a]These questions were addressed to all 57 state respondents

[b]Totals add to more than the number of states in each category and overall since a state can have more than one protection policy

develop a plan (as we mentioned in chapter 2) had numeric or narrative standards. A plan may help a state develop an overall approach to groundwater protection, but it does not seem essential to the development of standards.

No clear relationship emerges from the data comparing state groundwater protection policies by type with whether a state has numeric or narrative standards. Table 4.5 suggests that states with numeric standards or narrative standards had established a protection policy. Also, most states without standards had protection policies, although it is not immediately evident how or whether such policies are implemented. Finally, it appears that either numeric or narrative standards can be used in implementing a state's protection policy.

Summary

Each state with numeric standards seems to have relied to a great extent on the federal drinking water standards. Approximately 62 percent of the states' numeric standards corresponded to federal drinking water standards. However, adopting the federal standards was not viewed as an absolute rule. On the average, states with numeric standards adopted 18 of the 22 federal primary standards and 8 of the 12 secondary standards. The most notable differences from the federal list were the states' omission of EPA's biological, radiological, and physical standards. Five states with numeric standards did not include any of EPA's secondary standards.

We found several differences from the levels of contamination permitted in the federal standards, including some in states that adopted groundwater standards by reference to their drinking water standards. Many differences appeared in the states that adopted their standards some time ago and have not updated them; the levels set in these states may not reflect the latest information on the contaminants. Notwithstanding, some states have based levels that are different—higher for some standards and lower for others—on the specific consideration of the appropriateness of the federal standards to conditions in the states (such as the natural background level). In general, state officials believed that the federal drinking water standards could be used as the basis for ambient numeric groundwater standards, if some consideration were given to uses of groundwater other than for drinking water, natural background conditions (particularly to protect high-quality groundwater), and social and economic costs in protecting groundwater to a specified level.

Across the 20 states that adopted standards for contaminants not included in the federal drinking water standards, we found very little consistency as to which other contaminants were included. Beyond those on EPA's list, an additional 226 contaminants were included in 386 state standards, an average of fewer than 2 standards per contaminant. In most of the states, it appears that the additional standards were not based on the actual detection of contaminants. There is apparently a much greater likelihood that the standards that were adopted more recently were based on contaminants actually detected or posing a real threat. A large proportion of these recently adopted standards regulated volatile organic compounds and, in some western states, certain types of radiological substances. No 2 states had the same set of numeric standards (except states that incorporated the federal standards by reference). Despite this, a large majority of state officials were, for a variety of reasons, in favor of interstate consistency for groundwater standards.

A similar variability appears widespread with respect to narrative standards, for which the states have no federal example to follow. These standards provide case-by-case criteria, and the criteria vary considerably from state to state. Nonetheless, narrative standards do seem to adhere to an overall structure, specifically covering the discharge of certain amounts of contaminants into groundwater and affecting how the groundwater can be used. These standards give the states considerable flexibility for protecting groundwater but may be unevenly applied.

No factor seems directly linked to the establishment of numeric or narrative standards or both. The existence of standards—or, conversely, the absence of standards in 16 states—did not seem to be related to the types of groundwater problems within a state or the extent to which a state relied on groundwater for its drinking water. The best reason, one that has been posited in the literature, is that the development of standards is based on the political will of a state. In other words, it appears that a concern about potential groundwater contamination leads to the implementation of protective measures that invariably reflect some standard of acceptable groundwater quality.

Most states that had numeric standards also had narrative standards but not vice versa, raising the question whether there might be a trend toward using narrative standards rather than numeric ones. The states generally had the authority to develop groundwater standards and did not seem to need specific legislation in order to enact groundwater standards, particularly numeric standards. Some states were in the process of developing or considering the development of standards, although some had been slowed by technical or informational constraints. However, some states seemed to believe that numeric standards are not the best choice and that narrative standards should be used instead.

A relationship between standards and indicators that some have considered important in measuring the extent of groundwater protection within a state is not supported by our data. Groundwater programs with standards appeared in states where responsibility for groundwater protection was not assigned to a lead agency, where groundwater protection plans had not been developed, and independent of the groundwater protection policy that had been established. These indicators may well describe what is happening within a state, but they do not appear to be prerequisites for developing groundwater standards.

The States' Standard-Setting Processes

Having focused on the groundwater standards themselves, we turn to three questions on standard setting: how the states establish their standards, how this differs across the states, and the types and sources of information that form the basis for their standards, emphasizing the types of information they rely on from the federal government. In this chapter, we describe the steps the states use in setting numeric standards, including some distinctive processes in some states, but we do not discuss narrative standards, since standard-setting activities for them are not very elaborate. The complexities of narrative standards arise in their application and are discussed in the next chapter.

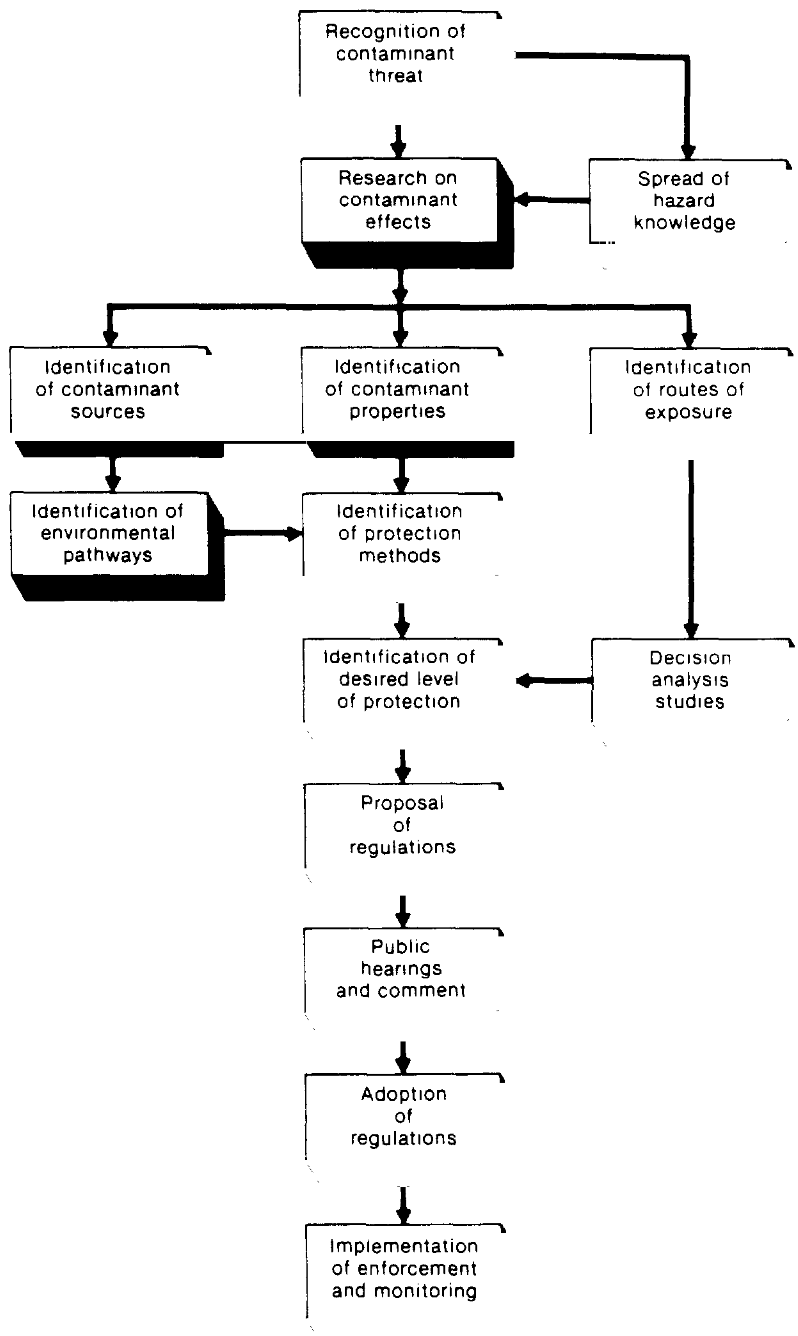
A Framework for Examining Standard Setting

A contaminant might be recognized as posing some type of threat to humans or the environment in several ways. One unfortunate method is that the medical community sometimes observes adverse health in the general population but only later can establish a link to some specific contaminant. Fortunately, the recognition of such incidents has led to the development of some screening programs that analyze specific types of chemicals as potential contaminants (frequently identified by analogy) in various laboratory and animal tests.

Once a contaminant has been recognized, knowledge about it is published in the popular or scientific literature, and it comes to the attention of concerned citizens or government regulators. As time goes on, the knowledge spreads, eventually becoming the basis for legislation or regulations. Efforts to regulate a contaminant usually begin with attempts to understand its effects on the health of the humans exposed to it, the levels at which this effect occurs, and potential effects on the environment, agriculture, industry, and various other human activities, collectively known as the effect on public welfare. The effort to understand these effects often leads to several years of research and many research studies.

Figure 5.1 is a flow chart of the general steps in setting standards that might be used to establish an acceptable level of human or environmental exposure to contaminants. This framework is based on a review of the pertinent literature describing the standard-setting processes in several federal programs. We use it to describe how standards have been established in the states. It is neither definitive nor exhaustive.

Figure 5.1: A Framework for Setting State Standards



One area of investigation underlying a standard concerns the physical and chemical properties of a contaminant, its sources, the pathways by which it comes to pose a threat, and the point at which it is no longer considered a threat. Two types of information are of crucial importance here: (1) its routes of exposure and (2) its environmental fate. With these types of information usually comes an understanding of the sources of the contaminant and the processes of its deleterious effects.

Having information on the effects and the fate of a contaminant makes it possible to take steps to deal with the problems a contaminant poses. These steps might include assessing the sources of the contaminant and, perhaps, estimating human and environmental exposure. Efforts could then be made to determine what is necessary to prevent exposure, such as technological safeguards and how to implement them. Decision analysis studies, such as benefit-cost and risk-assessment studies, might be performed to ascertain an appropriate level of protection.

Using all the information outlined above, government regulators might then identify the maximum levels of allowable contamination that would provide some intended level of protection. Proposals to establish such levels as standards would incorporate justifications for them, and the proposals would be opened to public discussion, usually involving hearings and other means by which individuals, businesses, and others would be able to comment on the evidence, the proposed levels of protection, and the ways in which the standards would be implemented.

How the States Set Groundwater Standards

We asked the states the extent to which they used nine procedures in setting and applying ambient groundwater standards.[1] We supplemented the survey information with documents from several states that seemed to have more elaborate procedures for setting and applying standards. The results are presented in table 5.1. To discuss the results, we grouped them into four primary areas: the extent to which the states carried on primary investigations of the effects of contaminants, the extent to which they relied on existing federal or other state investigations, the extent to which they involved the public in the standard-setting process, and the effort they invested in determining how to apply the standards. We discuss these areas below.

[1] We addressed this question only to the 41 states that had numeric or narrative standards. Many of the respondents in states with only narrative standards chose not to answer this question, because they did not believe their states' activities included the procedures described in the question. However, several respondents in states with only narrative standards thought that their states did perform these procedures in support of their narrative standards.

Table 5.1: The Number of States Using Nine Procedures in Setting and Applying Standards

Type of procedure	Extent of use[a] Little or none	Some	Moderate	Great	Very great
Identify possible additions to a list of contaminants	10	6	5	4	5
Assess risks, including effects on health, costs and benefits, and technical feasibility and practicability	7	8	6	4	5
Obtain information on the environmental source and fate of a substance and measures for minimizing its concentration in groundwater	5	7	11	4	3
Develop proposed standard from existing federal or state standards	3	0	3	8	15
Develop a standard from medical evidence, such as dose response	11	8	4	2	4
Prepare a document proposing a standard, present evidence, and request public comment	10	3	5	3	7
Hold public hearings or otherwise obtain public comment	4	4	5	5	11
Develop conditions for permits to ensure a standard is not exceeded	3	2	6	10	9
Develop responses to exceeding a standard	4	2	9	10	5

[a]This question was addressed only to the 41 states with numeric or narrative standards. Many of the states with narrative standards only chose not to respond to this question. Thirty respondents answered the question.

Primary Investigations

We were initially concerned with the amount of primary work that the states performed in identifying new contaminants and in conducting such studies as reviews of primary medical evidence for the deleterious effects of a contaminant, health-effects assessments, risk assessments, benefit-cost studies, and studies of the technical feasibility and practicability of implementing standards. Table 5.1 shows that half or fewer of the respondents thought that their states undertook these activities to a moderate or greater extent (the first, second, and fifth items in the table). Respondents from only 6 states thought their states relied on primary medical literature to a great or very great extent. Respondents in 14 states believed their states had extensive (moderate or greater extent) procedures for identifying new contaminants to add to their lists of contaminants in their states. Fifteen states seemed to perform assessments of the hazards posed by a contaminant and the possible implications of regulating it (to a moderate or greater extent). In general, it seems that few states presently perform all the types of primary investigations in developing their standards. These steps require considerable technical expertise, perhaps not often available.

Some states that did examine primary information used it mainly to develop permit conditions and make appropriate responses when contamination occurred. Some states used this information in developing general models of the environmental fate of a contaminant for conditions peculiar to their states or in determining the likely sources of contamination, the better to apply the standards for permits. Overall, however, the states seemed willing to rely fairly substantially on contaminant identifications by the federal government and others and then apply that information to their particular circumstances.

Reliance on Other Standards

The respondents from 22 of the 26 states with numeric standards indicated that their states used existing federal or other state standards to a moderate or greater extent in developing their own proposed standards (the fourth item in table 5.1). When we examined the state numeric standards, we did so particularly to determine how they related to federal drinking water standards. In chapters 3 and 4, we showed that state standards relied considerably on the federal standards and differed from them for several reasons related to conditions specific to each state. We interpret the issue of the reliance on federal or other state work (in table 5.1) as a further indication of the strength of this relationship. It appears that the states tend not to initiate the development of new standards but, instead, rely as much as possible on obtaining the necessary information from elsewhere.

Public Involvement

Twenty-one of the 30 respondents indicated that their states involved the public in their standard-setting processes to a moderate or greater extent. However, while all 21 did this by holding hearings, only 15 of these prepared documents for public comment. However, it appears that public hearings and comment did not contribute directly to setting standards; rather, they helped ensure that the public was appropriately apprised of proposed standards.

Determining How to Apply Standards

In table 5.1, the third, eighth, and ninth items pertain more to how numeric standards are used than to how they are developed, and they have an intended emphasis on the use of technical information. The third item indicates something about the extent to which a state attempts to develop a full understanding of how a contaminant moves through the environment, eventually reaching groundwater. Respondents from 11 states indicated that they had implemented such procedures to a moderate extent, and only 7 thought they had done so to a great or very great extent. From the eighth item, concerned with developing the use of permits to ensure that standards are not exceeded, we learned that 19 of 30 states had implemented such procedures to a great or very great extent. The ninth item, on the development of responses to be made when a standard is exceeded, revealed that 15 of 30 states had implemented procedures to a great or very great extent. Our interpretation is that the states have placed more emphasis on the use of technical information for permits and for responding to incidents of contamination than on theoretical studies of a contaminant's environmental fate.

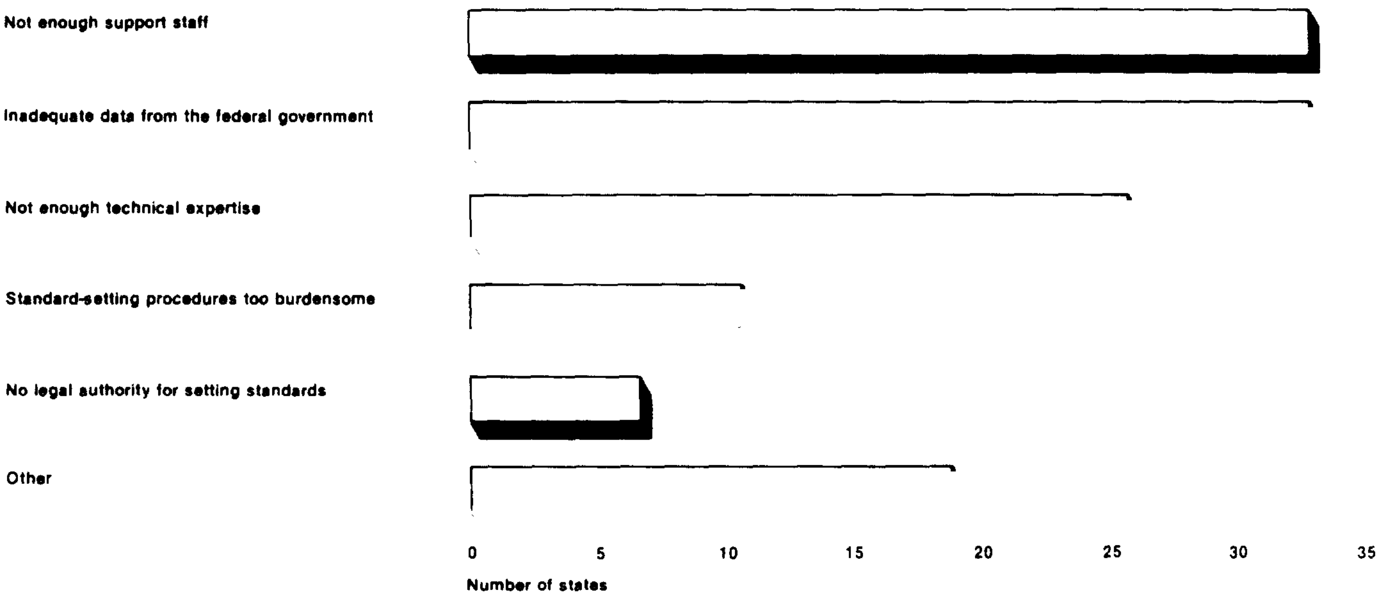
In our discussions with state officials, we learned that many states have required holders of permits to demonstrate that their discharges will not lead to groundwater contamination beyond a certain zone of discharge. Frequently, the applicants for permits have had to set up monitoring systems to show that such contamination was not occurring. Reliance on the permit holders may enable the states to focus less on the information on environmental fate associated with particular contaminants. However, it appears that some problems have sufficient significance to a state that it must go beyond permit holders in dealing with local conditions. For example, in Florida, it appears that environmental fate information is frequently used in developing models that pertain to the special conditions there in which salt intrudes when the water table is drawn down.

Constraints

We asked officials from all states, not just those with numeric or narrative standards, to identify financial, technical, or legal constraints that affect their states' ability to set groundwater standards. Their responses are shown in figure 5.2. Respondents from 11 states indicated that their standard-setting processes were too burdensome. Seven of the 11 did not have numeric standards, so this response perhaps reflects an unwillingness or a difficulty in implementing a standard-setting process. Two of these states (Connecticut and Michigan) had narrative standards that relied strongly on numeric contaminant levels, and their answers appear to reflect a commitment to the use of narrative standards rather than the regulation of individual contaminants. Respondents from the 4 states in this group that did have numeric standards may have viewed their standard-setting processes as burdensome for this reason.

A lack of data also increases the burden on a state when it attempts to set standards. A majority of the respondents (33 of 57) thought that their states were not receiving adequate support in this regard from the federal government. We discuss this issue later in this chapter.

Figure 5.2: Constraints on Setting Groundwater Standards[a]



[a]Respondents could indicate more than one type of constraint.

An even larger majority of the states (37 of 57) indicated they had inadequate expertise or not enough support staff for dealing with groundwater standards. This problem has been frequently documented in other studies. Many of the states answering "other" to this question indicated financial constraints. The states also cited practical considerations, a high turnover of technical staff because of low compensation, compared to the private sector or federal government, and bureaucratic or political difficulties. Most of these reasons indicate resource problems.

The Adequacy of Existing Procedures

We asked the state officials whether their states could establish 100 numeric ambient groundwater standards in 3 years if they maintained their current procedures for setting standards and the necessary information on each contaminant were available in criteria documents. Their responses, shown in table 5.2, were quite mixed. There was a slight tendency toward the belief in the ability to do so, but 32 states expressed considerable doubt. As might be expected, respondents from states with no standards (14 of 16) tended to be somewhat pessimistic about their states' abilities to set 100 standards. Respondents from states with numeric standards were somewhat optimistic (18 of 26), and respondents from states with narrative standards (21 of 38) were somewhat less optimistic. It appears that the gradation of opinion was related to whether and what types of standards a state had.

Table 5.2: The Ability of the States to Set 100 Numeric Ambient Groundwater Standards

	Standards now in the state[a]						
	Numeric		Narrative		Either		
Response	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Total**
Yes	6	4	8	2	8	2	10
Probably yes	12	3	13	2	15	0	15
Undecided	4	12	8	8	9	7	16
Probably no	1	5	2	4	2	4	6
No	3	7	7	3	7	3	10
Total	**26**	**31**	**38**	**19**	**41**	**16**	**57**

[a]This question was addressed to all 57 state respondents

When we discussed this issue with the respondents, some—especially those with reasonably well-developed standard-setting processes, such as New York—seemed to think adopting 100 standards would pose no problem because they could propose and adopt 100 standards at one time as a class of standards. For other states whose standard-setting processes were not so well established or streamlined, the adoption of 100 standards could be very burdensome. Interestingly, the respondents who claimed that their standard-setting procedures were burdensome or not well-developed and those who claimed that they were well developed for specific components of the process provided generally mixed answers to this question.

Differences Between States

The standard-setting procedures of the states do not differ significantly from one another and are quite rudimentary. Our review of these processes was limited to the 26 states with numeric standards, but we did not conduct a case study in each state to determine the precise steps that led to numeric standards.[2] Since EPA's drinking water standards were the basis for most state groundwater numeric standards, we thought that most of the states' processes consisted essentially of the wholesale adoption of the drinking water standards, with some minor

[2]California's standard setting is not characterized, since we did not have sufficient information to characterize it.

modifications in a few states. With striking uniformity, 20 of the 26 states with numeric standards followed this path; for these, we merely validated our hypothesis and describe these results below.

Five states seemed to have more substantial standard-setting procedures. For the most part, they were increments to the basic procedures for adopting the drinking water standards. Most of them were still in the formative stages, but it may be possible to discern a trend in what is necessary in the absence of a federal groundwater program and significant federal leadership.

Adopting Drinking Water Standards as Ambient Groundwater Standards

As we noted above, 20 of the 26 states with numeric ambient groundwater standards had adopted either EPA's drinking water standards, by reference or by implication, or their own surface water standards by including groundwater in definitions of "waters of the state." In 8 states, the use of the drinking water standards was explicit. Changes to the drinking water standards are adopted automatically as new or revised ambient groundwater standards. These states had no overt standard-setting process for adopting standards on their own.

Ten states had adopted the drinking water standards implicitly, with no direct reference to them. The contaminants and their levels were identical to those for the drinking water standards (except as noted in chapter 4). In these states, it appears that the individual standards were considered separately and few were not adopted.

The 2 remaining states in this group of 20 seemed to have relied substantially on surface water standards and adopted these as ambient groundwater standards either directly or indirectly. The contaminants and their levels were generally identical to the levels set in developing the surface water standards. In these states, the standards were not changed automatically nor were there any procedures for setting ambient groundwater standards in any separate process. Changes in the groundwater standards occurred only in connection with the mandated review of surface water quality standards under the Clean Water Act every 3 years. Revisions to the groundwater standards have presumably been made at such times, without any distinct process for their revision, since groundwater standards are not explicitly covered by the act.

Identifying Contaminants for Numeric Standards

It appears that Florida, New Mexico, New York, and Wisconsin and, to some extent, Oklahoma had procedures for using the evidence of the presence of additional contaminants in groundwater to include them in their numeric standards.[3] Officials from some of these states expressed the attitude that it is easier to set numeric standards for contaminants actually found in groundwater than it is to set them for potential contaminants. None of these 5 states had a program specifically for recognizing the existence of new contaminants. Awareness of and knowledge about contaminants usually came from other sources.

The way Florida, New York, and Wisconsin generally identified the presence of a contaminant was to ask dischargers what chemicals were included in their effluents. This was usually done through a state's permit program and was made a condition for granting a permit, frequently through the state pollution discharge elimination system under the Clean Water Act. When one of these states learned that a particular contaminant was being discharged, it either established a numeric standard or, as in Florida, regulated it under narrative standards and included numeric levels in a permit.

These states also had some sort of ambient monitoring network through which new contaminants that had been observed were considered for regulation or permit controls. The extent to which new contaminants can be identified in this manner depends on the coverage and analytical capabilities of the monitoring system. New York examined the use of chemicals throughout the state in order to identify the industries that used broad classes of chemicals and to further develop appropriate monitoring strategies. Similarly, Florida had a program for predicting specific types of contamination that used a computerized analysis of state land-use rolls. For example, in areas of considerable agricultural activity, the state would know that its monitoring system in those areas should particularly focus on pesticides. Information developed would then be subjected to "ground-truthing" to determine if hypothesized patterns are realized.

Several state agencies may be involved in identifying new contaminants. In Wisconsin, various regulatory agencies with particular facilities, practices, and activities related to their regulatory domain and that

[3]This section is based on only these states. Since our efforts in this part of the study were illustrative and not exhaustive, we do not claim to have identified all the states with particular procedures

could be sources of contaminants were responsible for identifying substances that might decrease groundwater quality. In addition, any person could petition that a substance be added to or removed from lists of identified or potential contaminants.

Most of these states had some more or less formal system for ranking the priority of identified contaminants. In Wisconsin, a contaminant was put into one of three broad categories, depending on its actual detection and the existence of a federal contaminant level. It was then ranked according to its risk, based on available information, and categorized as to the concern it caused about health and public welfare. After this, the substance was subjected to the degree of scrutiny that was deemed appropriate.

Medical Evidence

Once a contaminant has been identified, evidence of the hazard it poses is usually examined in order to establish an appropriate numeric standard for it. The amount of investigation is inversely related to the availability of information. We found that where federal standards had been set, the states used the information that had helped establish those standards. Otherwise, the states generally used information from whatever sources were available. The states did not generally support or perform basic research into the effects of a contaminant on health, but they used the results of such research, including the work of the National Cancer Institute, the National Academy of Sciences, and the like.

It appears that only New York and Wisconsin had specific procedures in their regulations for using whatever information was available, New York providing a greater level of detail. Similar procedures seem to have been followed in some other states, particularly Florida and New Mexico, where they were not codified. Oklahoma used some of these procedures, but they did not seem to go as far as those in New York and Wisconsin.

In New York, a fully developed set of regulatory guidelines had been promulgated, and in Wisconsin, such guidelines had been codified.[4] The numeric values for contaminants with no federal standards were derived from methodologies and procedures described in the regulations. If a contaminant was thought to cause cancer, risk assessments, incorporating uncertainties in the available data, were used to establish the

[4]In New York, these guidelines had been developed for use with surface water-quality contaminants but were also applied to groundwater contaminants.

standard on some level of acceptable risk.[5] If the contaminant was thought not to cause cancer, standards were based on an "acceptable daily intake," using certain assumptions about the level of exposure for an average person. If information for such assumptions was not available, a standard was based on information for a similar chemical for which a standard had been developed. Additional numeric standards are sometimes developed to account for various effects on animals, particularly for fish, fish propagation, and other aquatic life, taking into account the possibility of a contaminant's persistence and increase in the environment—that is, bioaccumulation.

It is clear that considerable effort is required to establish a standard for contaminants for which information is not available from federal sources. At the time of our survey, this effort was apparently duplicated at least in Florida, New Mexico, New York, and Wisconsin. It seems likely that more states will experience pressure to implement such procedures when they find it necessary to adopt standards for substances present in their groundwater. Any such effort by more states will add to the duplication.

Vulnerability Assessments

Further techniques might be used in a state where the amount of effort required to establish a standard is unacceptable and the state chooses to control contaminants through permits. EPA has recommended that the states assess the vulnerability of aquifers in order to determine the level of controls that might be appropriate in granting permits. This approach seems to have been implemented to the greatest extent in Florida, where several unique hydrogeological conditions have apparently made it necessary.[6]

Basically, Florida was attempting to establish the vulnerability of aquifers throughout the state with a technique known as DRASTIC that was developed by the National Water Well Association for EPA. The acronym came from the names of the principal factors in developing the vulnerability measure:

[5] In some states, the levels that had been set were the lowest limits of detection, either some specific level or the level at which the contaminant was "not detectable."

[6] Connecticut followed a similar approach in making land-use decisions about permissible activities, given the underlying hydrogeology of particular areas. Vermont protects its water supplies by limiting activities that pose a risk, and Wisconsin may base decisions for the protection of particular facilities on the natural susceptibility of the groundwater. In addition, our survey results pertinent to the development of groundwater classification systems (discussed in chapter 6) indicate that 7 other states assess the vulnerability of aquifers.

- Depth to the water table,
- Recharge rate,
- Aquifer media,
- Soil media,
- Topography (slope),
- Impact of vadose zone (the zone above the water table), and
- Conductivity of the aquifer.

The measure developed with these factors can be applied to the specific conditions of a permit holder. In Florida, this was intended to ensure continuity and consistency in evaluating permit applications.

This technique, along with other analytical and computer studies, can be used, as in Florida, in examining such things as the effectiveness of best management practices in preventing groundwater contamination, the use of shallow sewage-effluent-disposal wells, methods for modeling the quality of water given the various constituents of industrial effluents, the use of computer models in predicting the time it takes contaminants to enter the groundwater, and the relationship between land use and groundwater quality, particularly to determine the diffusion of contaminants as it relates to background and the degradation caused by human activities.

Public Involvement

The manner in which the public is involved in setting groundwater standards may be essential to the establishment of numeric standards. The development of numeric standards generally included the opportunity for public hearings or other public comment. The general public was not expected to provide scientific expertise directly pertinent to the identification of the appropriate contaminant level. Instead, it appeared to indicate the magnitude of public support for standards.

In Connecticut, the public was involved rather directly, since setting standards there was in a sense inextricably related to land-use decisions. Strictly speaking, Connecticut did not have groundwater standards. Instead, the groundwaters of the state were classified and "compatible" discharges were established for each class. The classification system was based on use, with a primary distinction between groundwater suitable for drinking water, with various subclasses, and groundwater suitable for waste disposal practices.

The process of classifying groundwater resources was the determinant of policies for approving sites for municipal and industrial facilities that might discharge waste. A decision on groundwater classification was tantamount to a land-use decision and could thereby involve the public in what amounted to a land-use debate. Permit applications were assessed from the standpoint of the "compatibility" of discharges with the classification of the site. Applicants could request a change in the classification, although this was nearly the same as requesting a zoning decision.

Narrative Standards

Narrative groundwater standards were generally implemented by means of the permits case by case. Applicants had to demonstrate that a particular discharge would not contaminate the groundwater. In other words, the burden for providing information necessary to establish a de facto standard was primarily on permit applicants. Although the application of narrative standards was not "standard setting" per se, the development and enforcement of appropriate permit conditions was essential in the protection of groundwater and was very similar to the establishment of numeric standards.

In Wisconsin, the regulatory agencies seemed to go beyond a simple review of permit applications. As in all states with narrative standards, each regulatory agency had to take whatever steps were necessary to ensure that the activities, practices, and facilities under their responsibility complied with the standard. In addition, the agencies in Wisconsin had to develop rules defining the design and management practices that would minimize the level of contaminants in the groundwater and maintain compliance to the extent economically and technically feasible. The agencies had to take into account considerations of risk and benefit, hydrogeology, and management and practice. It is quite possible that this requirement will have a broader applicability with the continued growth of groundwater protection programs.

Sources and Types of Information Used in Setting Standards

Several survey questions were designed to gain some understanding of how states used information in setting standards. We asked our respondents the extent to which they used various general sources of information in developing ambient standards. We wanted to find out what types of information they actually received from the federal government and how they rated the importance of receiving those types of information from the federal government. We also asked state officials to identify constraints affecting their ability to set standards; several of the answers had some relevance to the use of information in setting standards. Finally, we asked whether criteria documents would be useful to them. The responses to these questions gave us a general picture of how the states would piece together various types of information in setting groundwater standards.[7]

Primary Sources

OTA's 1984 Protecting the Nation's Groundwater from Contamination may be considered a benchmark on information sources used by the states; we summarize some of its pertinent findings before presenting the results of our survey. OTA reported that state standards were based on available literature; that the states had not conducted their own research on toxicology, risk, and effect; and that some standards were based on the detection limits of instrumentation rather than on the appraisal of risks associated with different concentrations of individual substances. OTA said that when federal standards were available, the states often did not rely on them and that although they were not required to by federal law, most states had developed or were developing groundwater quality standards. Finally, OTA reported that some states had established drinking water standards for substances in addition to those covered by federal regulations and applied more stringent standards to some of the substances for which the federal government has developed standards.

In our survey, we found that nearly all the states (31 of the 32 respondents answering this question) used EPA's drinking water standards to a moderate or greater extent and used other federal information contained in EPA's health advisories and surface water quality criteria to a much smaller extent. Similarly, few of the states used information from federal programs under the Resource Conservation and Recovery Act and Superfund, which might be expected to have some information useful for groundwater protection. The relative nonuse of these other programs is another indication that in identifying contaminants to regulate, the states emphasized the use of the drinking water standards. Many of the states whose respondents indicated more significant use of health advisories, surface water quality criteria, or programs under the two acts were states that regulated more contaminants than merely those identified in the drinking water standards. Table 5.3 shows these results.

[7] The questions concerning use of information in developing standards and information received from the federal government were addressed only to officials in the 41 states with numeric or narrative standards: some of them thought a response was inappropriate. The remaining questions (rating importance of information from the federal government, constraints on setting standards, and opinion on criteria documents) were addressed to all 57 respondents and are discussed in this section

Table 5.3: State Use of Information in Developing Standards

Information source	Extent of use[a] Little or none	Some	Moderate	Great	Very great
EPA's drinking water standards	1	0	3	10	18
EPA's health advisories	15	2	5	5	5
EPA's surface water criteria	11	2	6	8	5
EPA's identification of hazardous wastes under the Resource Conservation and Recovery Act	19	6	2	2	3
Substances defined in the Comprehensive Environmental Response, Compensation, and Liability Act	19	9	2	0	1
State expertise	4	7	9	8	4
Expert consultants	21	4	0	4	2
Epidemiological data	22	3	2	2	2
Data on the detection limits of particular substances	13	7	6	2	3
Comments from public hearings	6	10	7	3	6

[a]This question was addressed only to the 41 respondents whose states had numeric or narrative standards. Only 32 respondents chose to answer the question.

For the most part, our results agree with OTA's findings. However, there are some significant differences. Our results seem to indicate that the states have relied to a much greater extent on federal numbers than OTA reported. Our results also seem to show that the states have not based their contamination levels on detection limits but have taken risks from contamination into account. These differences may reflect the experience the states have had in dealing with groundwater issues since OTA conducted its survey.

Few respondents indicated that their states used expert consultants or epidemiological data in their standard-setting process to a moderate or greater extent, while 21 of the respondents indicated that they used their own expertise to a moderate or greater extent. This supports OTA's view that the states did not conduct their own toxicological, health risk, or health effects research, seemingly relying on the information they obtained from EPA and other federal sources and their own expertise.

There was some indication that the states that had groundwater standards benefited from public comments: 16 states used information from public hearings to a moderate or greater extent. Eleven respondents indicated that in setting standards their states used information on the detection limits of particular substances to a moderate or greater extent. Few respondents identified sources of information other than those listed in the survey question. The 7 respondents who did identified the occurrence of a particular contaminant in groundwater as a source of information or referred either to general health-related literature and data or to publications of groups such as EPA's carcinogen assessment group, the International Agency for Research on Cancer, the National Academy of Sciences, and the National Institute of Environmental Health Sciences.

When comparing these results with the observations made in connection with the standard-setting processes of the states that had more elaborate procedures, it is possible to discern some trends. The states with more elaborate procedures made heavier use of a wide variety of federal and other sources, engaged in greater public discussion, based their standards in part on the observation of contaminants, and relied less on detection limits than on concretely estimated contaminant levels. The trend that might be expected from this is that as the states gain experience with their programs, they will use a greater variety of sources in setting standards.

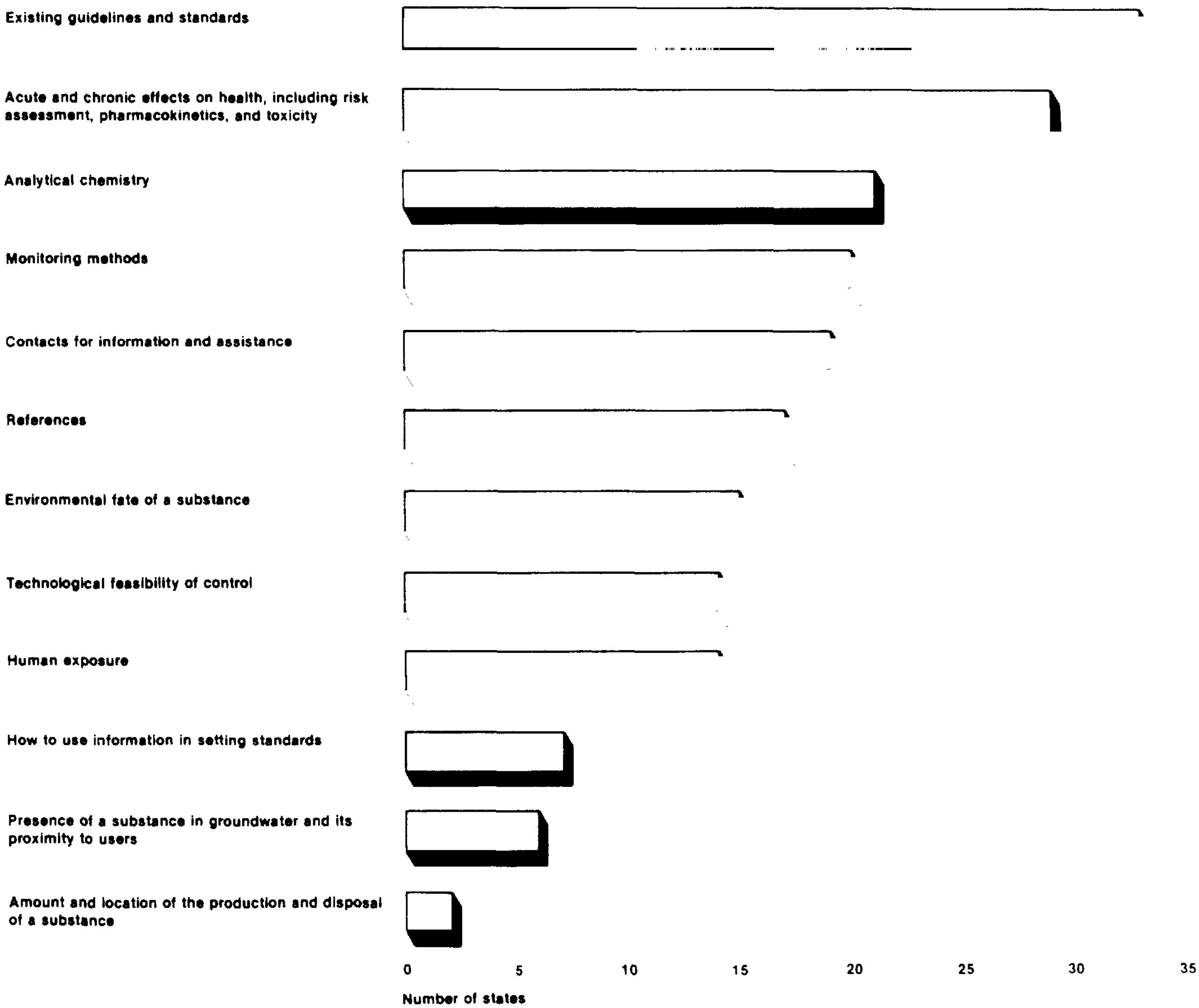
The Federal Government as a Source

We had expected that the states would use information from federal sources to a very great extent, so we wanted to get a more specific description of that information. We asked the officials whose states had numeric or narrative standards what specific types of information they thought their states had received from the federal government; the results are shown in figure 5.3 on the next page.

In general, it appears that many state officials, given the number of items they checked, had particular views of the helpfulness of the federal government in providing information. The 37 respondents answering this question fell into three primary groupings. Several (16) thought they had received very little information from the federal government, checking only 1 to 4 items; 4 of these indicated they had received information only on existing guidelines and standards. A second group (13) checked 5 to 8 items. A third group (8) checked 9 to 12 items; these respondents apparently thought that the federal government was more helpful.

Most of the respondents (33 of 37) reported receiving information about existing guidelines and standards. Nearly as many indicated they had received information on the acute and chronic effects of contaminants. The responses for the remaining items were somewhat fewer. About 50 to 60 percent of the respondents reported receiving information about analytical chemistry, monitoring methods, and references and contacts

Figure 5.3: Information States Received From the Federal Government[a]



[a]This question was addressed only to the 41 respondents whose states had numeric or narrative standards; 4 respondents did not answer the question.

for additional information and assistance. This dropped to about 40 percent for information on environmental fate, the technological feasibility of controlling contaminants, and human exposure. Less than 20 percent reported receiving information on how to use the information in setting groundwater standards, on state activities that give rise to contaminants, and on the locations where contaminants may be present.

Information the States Want From the Federal Government

The other side of the question about information the states received from the federal government is what they thought it should provide. We asked the respondents to tell us how important it was for the federal government to provide the types of information shown in table 5.4. In addition to examining these responses item by item, we created a measure of the respondents' overall assessment of the importance of each item, so that we could compare the items to one another. Ranking each item in degree of importance from 5 for essential to 1 for little or no importance, we multiplied the number of responses for each degree of importance for each item and added these products for each item. Then, we looked at the importance each respondent attached to the item in relation to whether the respondent received that type of information from the federal government (figure 5.3). We addressed this question to all respondents, but a few chose not to answer specific items.

The most important type of information that the officials wanted the federal government to provide was information on the effects of contaminants on health, 53 of the 55 individuals who responded indicating that this information was essential or very important. This corresponds fairly well with the percentage of respondents (78) who thought they were receiving this type of information. However, given the importance they attached to this type of information, there was apparently some gap between what they received and what they wanted to receive.

The type of information next in importance was guidelines and standards, 44 of the 56 respondents considering this information essential or very important and another 11 considering it moderately important. Since 33 of 37 respondents thought they were receiving this information from the federal government, it appears that their need was satisfied.

Next in importance were the environmental fate of the contaminants, analytical chemistry, human exposure, the technological feasibility of controlling contaminants, and monitoring methods. All these items were given similar responses: a large number of respondents rated the type of information essential or very important, roughly half indicated each

Table 5.4: The Importance of Federal Information[a]

Type of information	Essential	Very Important	Moderately important	Somewhat important	Little or no importance
Existing guidelines and standards	26	18	11	1	0
Acute and chronic effects on health, including risk assessment, pharmacokinetics, and toxicity	36	17	2	0	0
Analytical chemistry	15	26	7	2	5
Monitoring methods	14	23	11	4	3
Contacts for information and assistance	13	21	19	3	0
References	12	18	21	5	0
Environmental fate of a substance	23	25	4	1	2
Technological feasibility of control	15	26	9	3	2
Human exposure	21	18	9	4	3
How to use information in setting standards	10	17	11	17	1
Presence of a substance in groundwater and its proximity to users	7	7	10	8	22
Amount and location of the production and disposal of a substance	1	4	12	16	21

[a]This question was addressed to all 57 state respondents. Some chose not to respond to specific items

degree of importance, and most of the remainder considered the category moderately important. (Technological feasibility, monitoring methods, and analytical chemistry differed slightly in that almost two thirds characterized the information only very important.) For these types of information, the correspondence between need and satisfaction was generally not close. Analytical chemistry was the third most frequent type of information the states said they received, but the percentage was only about 60. Only about 40 percent received the other types from the federal government.

These first six categories of information appear to define what the states did in setting groundwater standards. With the information on effects on health, the states ascertained that particular contaminants were a problem about which something must be done. With information on existing guidelines and standards, they obtained a perspective on the levels considered unsafe. They could proceed to establish regulations with this information. The responses on these items seem to reflect a belief among the states that they cannot develop these types of information and would like to rely on the work of others for them. This corresponds with the responses about the sources of information they used. The other types of information (except for information on human exposure) seemed to provide the details the states needed to implement and enforce regulations through permits. Our judgment that a gap exists between what the states receive and what they want is based on a belief that the absence of particular types of information makes it impossible for the states to establish standards using their current procedures.

Next in importance were contacts and references for further information and assistance and how to use information in setting groundwater standards. The responses seemed to cluster around "very important," with slightly more for moderately important than for essential. This seems to accord reasonably well with what the respondents reported receiving. That is, approximately half the states received this type of information, except that less than 20 percent received information on how to use information in setting standards. These responses suggest that the states were generally able to find additional information when they needed it but that there was still some uncertainty about how the information could best be used. This may help explain the diversity of regulatory approaches across the states—that is, their uncertainty about the best method for protecting groundwater resources.

The items rated lowest in importance were information on how to set standards, the presence of substances in groundwater, and the amount and location of the production of contaminants within a state. The states seldom mentioned receiving the two latter types of information, apparently because of the belief that this information is primarily local and therefore should not be the responsibility of the federal government.

Thirteen respondents also mentioned other items of information they thought the federal government should provide, but overall there was no pattern to these answers. Specific items they mentioned (none by more than one respondent) were the vulnerability of aquifer systems, assistance in risk analysis, "alternative-pathways" information, relative risks (for comparison with nongroundwater risks), handling jurisdictional disputes for interstate groundwaters, and technical and economic ways of treating water at the point of use. Two respondents mentioned better information transfer. Several seemed to want better guidance from the federal government on the contaminant levels that constitute a threat. They wanted precise information on the levels significant for human health, on what the states are not likely to know on particular contaminants, on valid criteria among conflicting ones, and on drinking water limits. Two respondents called for federal standards, one calling for regulation of the use and handling of groundwater contaminants.

In our question about constraints in setting groundwater standards, one of the possible responses was whether the information from the federal government was adequate. In figure 5.2, we showed that 33 of the 57 respondents indicated that it was inadequate. On the average, 22 of these 33 reported having received less information than the respondents from the other states. The gap between the information these 21 states wanted to receive from the federal government and what they did receive was greater than for the other states.

We also asked the state officials whether criteria documents for ambient groundwater, similar in structure to EPA's surface water criteria documents, would be useful. This question supplemented our question about the specific components that usually make up criteria documents. The preponderance of the states (47 of 57) believed that criteria documents on groundwater contaminants would be useful. Some commented that such documents were needed to provide basic health research information as guidance and support, particularly because they did not have the resources to develop such information. Overall, this seems to indicate that the states need information systematically, such as what the criteria documents provide.

Summary

Most of the states with numeric standards did not have well-developed procedures for setting their standards by themselves. Respondents from only a few states indicated that their states' procedures could be considered well-developed, the remainder indicating that they relied substantially on the federal government or others for primary information concerning contaminants. Most of the states involved the public in their standard-setting activities, primarily to ascertain whether there were sufficient public support for the establishment of standards. For most of the states, the major activity seemed to be the development of conditions for permits and responses to contamination incidents. In this regard, it appears that the states relied to a great extent on permit holders to demonstrate that their activities would not violate standards.

The major limitations on the standard-setting process were resource constraints, including insufficient finances and technical and support staff along with a perceived inadequacy of information from the federal government. For these reasons, the officials from some states believed their states would have a difficult time implementing standards for 100 contaminants, as proposed in some legislation.

It appears that 20 of the 26 states with numeric standards had relatively minimal standard-setting processes and relied primarily on federal drinking water or surface water standards, substantially incorporating them as state numeric groundwater standards either by reference or without referring to groundwater. Five of the 6 remaining states seemed to have considerably more-developed standard-setting procedures.

In the more advanced states, procedures for identifying new contaminants to add to the list of numeric standards were fairly consistent. They relied to a great extent on the detection of contaminants through monitoring. At least 2 states made use of such information as data on the use of chemicals and land-use records to augment their ability to identify likely contaminants. Once the threat of particular contaminants had been recognized, these states based their priorities for setting standards on an assessment of their relative threat. These states used federally developed evidence for setting levels for standards when such information was available. When it was not, they set the levels themselves, using procedures specified in regulations or laws and usually taking uncertainty factors into account. There would be considerable duplication of effort across the states in developing this information for contaminants for which information was not available from other sources.

The lack of available information for setting standards seemed to form one of the biggest problems for the states. They did not seem to have the resources to gather primary medical and chemical information on contaminants. They seemed much more active in obtaining and using this than other types of information and seemed to believe that much of this type of information should be provided by the federal government, preferably through a single source, such as a criteria document. They did not believe that the information they were presently receiving was adequate and in many cases thought that the federal government had a primary responsibility for providing specific information.

The most important information for the states to receive was on the effects of the contaminants on health and existing guidelines and standards pertaining to these contaminants. The states did not have the resources or the technical skills to develop toxicological data or information on risks to health or effects on health, seemingly relying as much as possible on federal sources, preferably guidelines and standards. The respondents to our survey viewed as important other information specific to contaminants, including information on the environmental fate of contaminants, analytical chemistry, human exposure, the technological feasibility of controlling contaminants, and monitoring methods. Most of our respondents seemed to believe that criteria documents would be a useful vehicle for these types of information. However, they also seemed to believe that the states can obtain necessary information on the potential sources of contaminants and assessments of their threats within the states. The gap between what the states needed when we made our survey and what they received seemed to be fairly large.

The Application of Standards

The areas we cover in this chapter include the purposes of numeric standards as stated in statutes and regulations, their use (along with narrative standards) in permit and monitoring programs, and how they are incorporated into groundwater classification systems, which in many states have regulatory implications. In these discussions, we identify several areas where information on the usefulness and effectiveness of standards is lacking.

The Purposes of Numeric Groundwater Standards

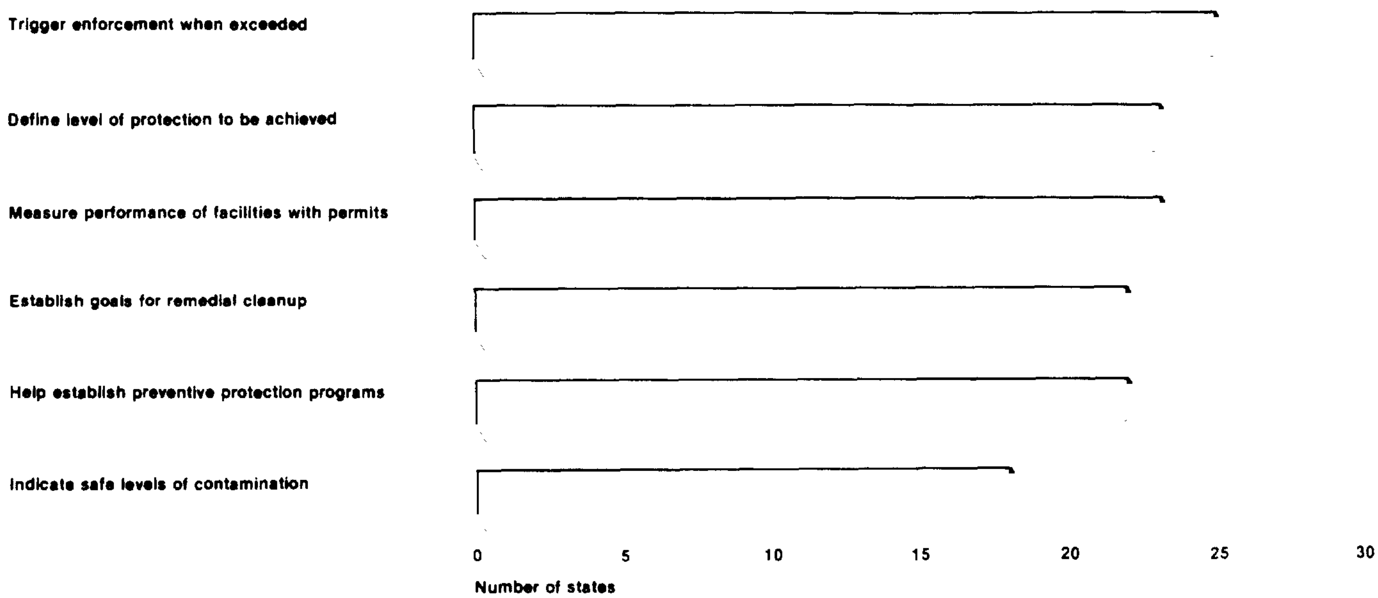
Because the extent and severity of groundwater contamination are largely unknown, it is very difficult to assess the extent to which various federal and state programs protect groundwater. The effectiveness of some of the many programs that have some role in protecting groundwater could be assessed, but this would provide no overall picture. For the most part, discussions in the literature on this topic seem to present only lists of the various federal programs that have some protective value. There is little discussion on what the state programs may be accomplishing. Discussion has focused instead on various incomplete indicators, such as whether the states have numeric standards, relevant legislation, lead agencies, and protection policies.

To move beyond this discussion stage, we asked the 26 states with numeric standards to identify the ways they used them—that is, their purposes—since these are the reference points for assessing the effectiveness of groundwater programs. This type of information is admittedly very basic, but it seems to be what is available. Figure 6.1 shows the responses to our question. As can be seen, each purpose we included was mentioned by at least two thirds of the states. On the average, the states mentioned 5 of the 6 purposes.

Numeric standards were used in 25 of the 26 states to trigger enforcement actions when contaminant levels were exceeded. Our question, however, did not permit us to learn anything about how often the levels were exceeded or observed, how long enforcement actually took, or the extent to which contamination was present or was eliminated as a result of enforcement. Next in frequency (23 of the 26 states) were using standards to measure conformity to permits and defining the level of protection to be achieved. The significance of the former is considered in detail in the next section.

The remaining purposes did not reveal equally measurable goals, but they did indicate the overall intent of the states' groundwater standards. Of course, each state would be likely to interpret this intent and

Figure 6.1: State Use of Groundwater Standards[a]



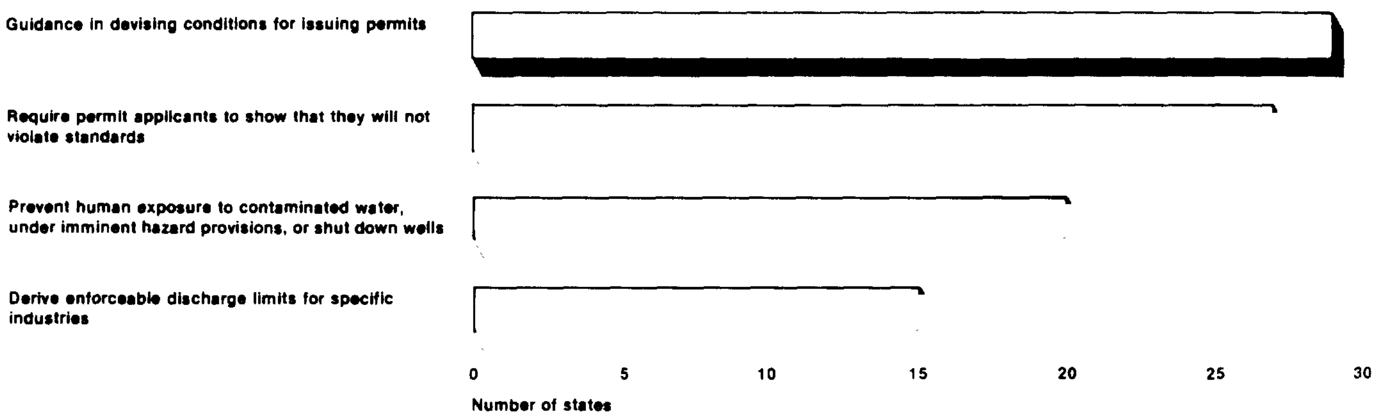
[a]This question was addressed to the 26 states that had numeric standards.

implement activities for achieving its purposes in its own ways. It would be useful to have greater detail about what the states do to achieve their goals in order to describe groundwater protection activities more clearly than the indicators mentioned above do.

The Relationship of Standards to Discharge Permits

We expected that a state's groundwater standards would bear a strong relationship to its programs to control discharges, since discharge control programs were one of the major vehicles the states used to protect groundwater. We asked the state officials to indicate how their permit programs related to their states' standards. The responses shown in figure 6.2 bear out the points in chapter 5 about standard-setting procedures in some states, particularly that standards are developed with their use in permit programs in mind. Of the 23 states that indicated using numeric standards to measure the performance of facilities with permits (see figure 6.1), 19 indicated that their permit programs used standards as guidance in devising conditions for issuing permits (of the 29 respondents checking this answer in figure 6.2). Two of the 3 states with numeric standards that did not use their standards to measure facility performance did indicate that their permit programs used the standards in devising permit conditions. Thus, the mutual substantiation between these 2 questions supports strong linkages between permits and numeric standards.

Figure 6.2: State Use of Standards in Permit Programs[a]



[a]This question was addressed to the 41 states that had numeric or narrative standards; 6 did not answer.

It also appears that the states that claimed they put a substantial effort into their permit programs placed the burden of proof on the permit applicants to demonstrate that the standards would not be violated under the permits. They relied significantly on applicants to determine whether contaminants could be released from a facility and to perform the studies necessary to ensure that the contaminants would not escape the facility's boundaries.

Narrative standards can also be used in permit programs, although they were apparently used case by case rather than providing definitive standards for the permit holders. In a separate question, we asked the states whether their narrative standards could be used as a basis for granting or denying permits to discharge into groundwater. Respondents from more than three quarters of the states with narrative standards said that they used their narrative standards this way; only 9 states with narrative standards did not.

Narrative standards can be phrased in a number of different ways, even though they generally follow a pattern. Their general wording is likely to be used in different ways in different states. Even if they could be used to grant or deny permits, the states could choose to apply them in different ways. In some states, they could conceivably be used very strictly to control many more sources of contamination than numeric standards might cover. In other states, there might be little application of the standards. We have no way of judging at this time how the states have implemented these standards.

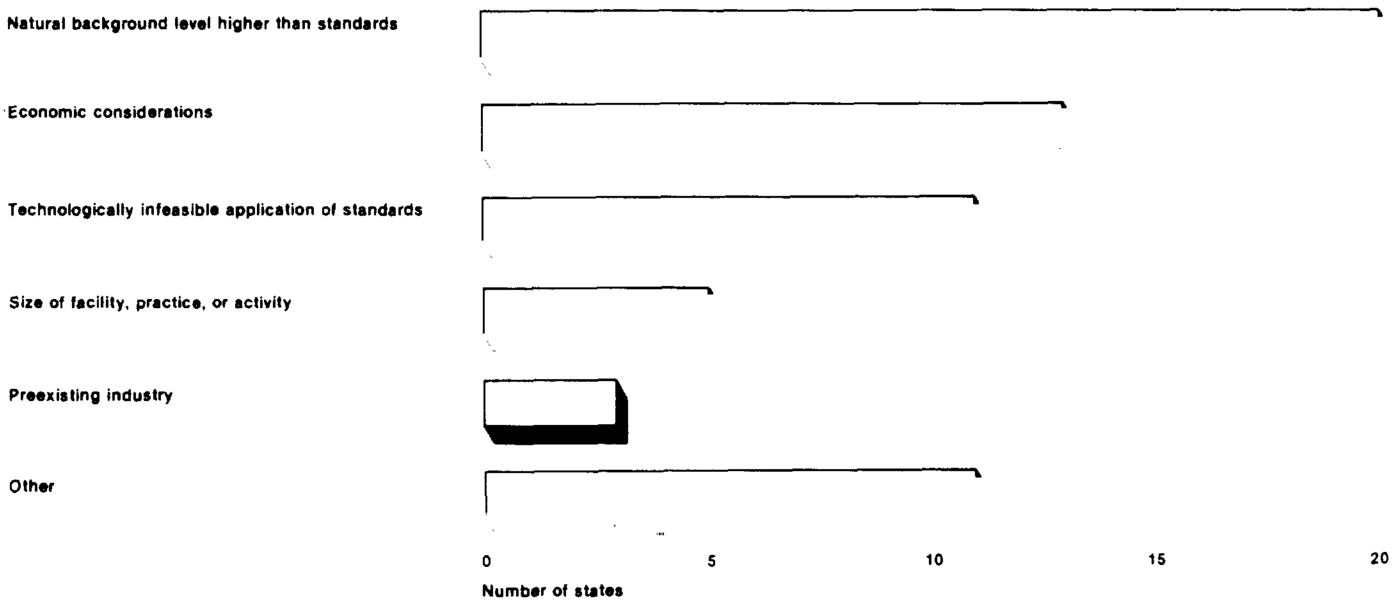
Respondents from about 70 percent of the states with either narrative or numeric standards said they used them for guidance in devising the conditions for permits. For example, an applicant might have to submit documentation showing that even though a contaminant might be discharged, it would not leach into groundwater aquifers or move beyond a specific zone of discharge. The permit holder might also be required to install a monitoring system to help ensure that the contaminant would not get into the groundwater.

The states used groundwater standards less for other purposes related to permits. Twenty states used them to prevent human exposure to contaminated water or as a basis for shutting down wells, and 15 used them to develop discharge limits for specific industries.

It was not possible to determine the extent to which the permit programs were effective in protecting groundwater. An important factor that would have to be considered is the extent to which permit holders could obtain variances. We asked the state officials to indicate the bases they used for granting variances; the results are shown in figure 6.3.

Respondents from 29 of the 31 states answering this question and with numeric or narrative standards said their states granted variances in some circumstances. The predominant reason was that a contaminant's natural background level was higher than its standard. A large number of states also allowed variances for economic and technological reasons. The "other" reasons cited included existing pollution and whether EPA's primary drinking water standards would be exceeded. It appears that variances could conceivably be very significant in judging the effectiveness of a state's groundwater protection program. This would, of course,

Figure 6.3: The Reasons States Granted Variances[a]



[a]This question was addressed to the 41 states that had numeric or narrative standards; 2 states indicated that no variances had been granted, and 10 did not answer.

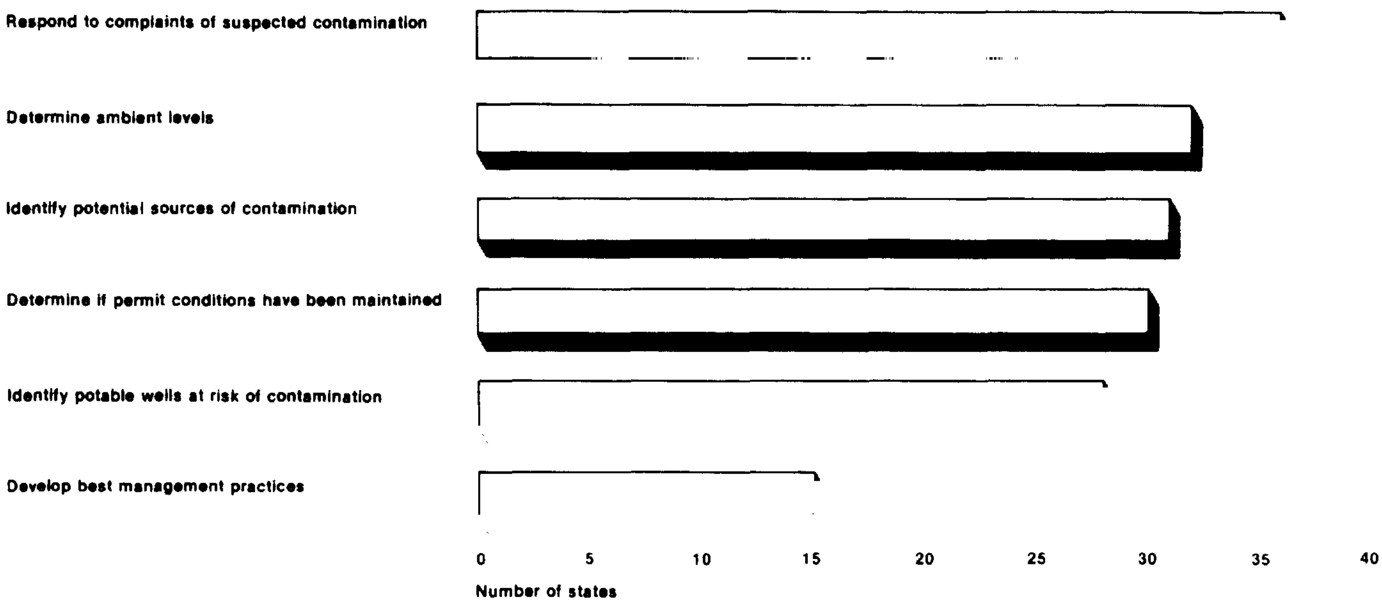
depend on the number of variances granted and the amount or degree of variance permitted.

The Use of Standards in State Monitoring Programs

As we mentioned in chapter 2, a large number of states complemented their discharge control programs with monitoring programs, although their number and extent were not as great as those of the discharge programs. Seventeen of the 57 respondents reported that their states had implemented monitoring to a great or very great extent, compared to 33 states with similarly extensive discharge control programs. Respondents from nearly all the states with groundwater standards reported that their states had monitoring programs. To gain some insight into these programs, we asked the respondents from the states with standards to indicate how they used their monitoring programs. The responses are shown in figure 6.4.

Officials from 39 of the 41 states responded, and more than 75 percent of them monitored for at least four purposes. Although most of the

Figure 6.4: The Purposes of Groundwater Monitoring Programs[a]



[a]This question was addressed to the 41 states that had numeric or narrative standards; 2 did not answer.

states used monitoring for responding to suspected contamination incidents, a very large number used it to support their permit programs, as indicated by those that used it for determining whether permit conditions were being followed and for identifying potential sources of contamination. As we noticed in chapter 5, this way of identifying sources of contaminants may frequently go hand-in-hand with standard-setting activities. Nevertheless, given the program implementation strengths the states reported, the respondents to our survey apparently believed the states had further to go in strengthening their monitoring programs.

The Use of Standards in Defining Classification Systems

In EPA's 1984 Ground-Water Protection Strategy, the development and use of a classification system was viewed as a basic framework for guiding the protection of groundwater resources. EPA proposed a three-tiered classification system and indicated that it would encourage the states to adopt its basic criteria for determining which groundwater deserved the most protection. The three tiers of the system were the present and potential uses of particular groundwater, its vulnerability, and whether it was too contaminated to ever be of use. One measure of contamination was a total dissolved solids level greater than 10,000 milligrams per liter. EPA expected that further criteria using such factors as geologic setting, hydrogeological characteristics, climate, and physiography would be developed.

In its 1985 survey of state groundwater programs, EPA identified 22 states that either had instituted or had proposed classification systems. In our survey, we wanted to determine the status of classification systems and to learn how groundwater standards related to them and the criteria that were used for their bases. The responses indicated that 25 states had classification systems, 3 more states than EPA identified. However, only 17 of the states were the same on both surveys. We have reconciled the two lists and believe that 4 states adopted classification systems after EPA issued its Ground-Water Protection Strategy in 1984.

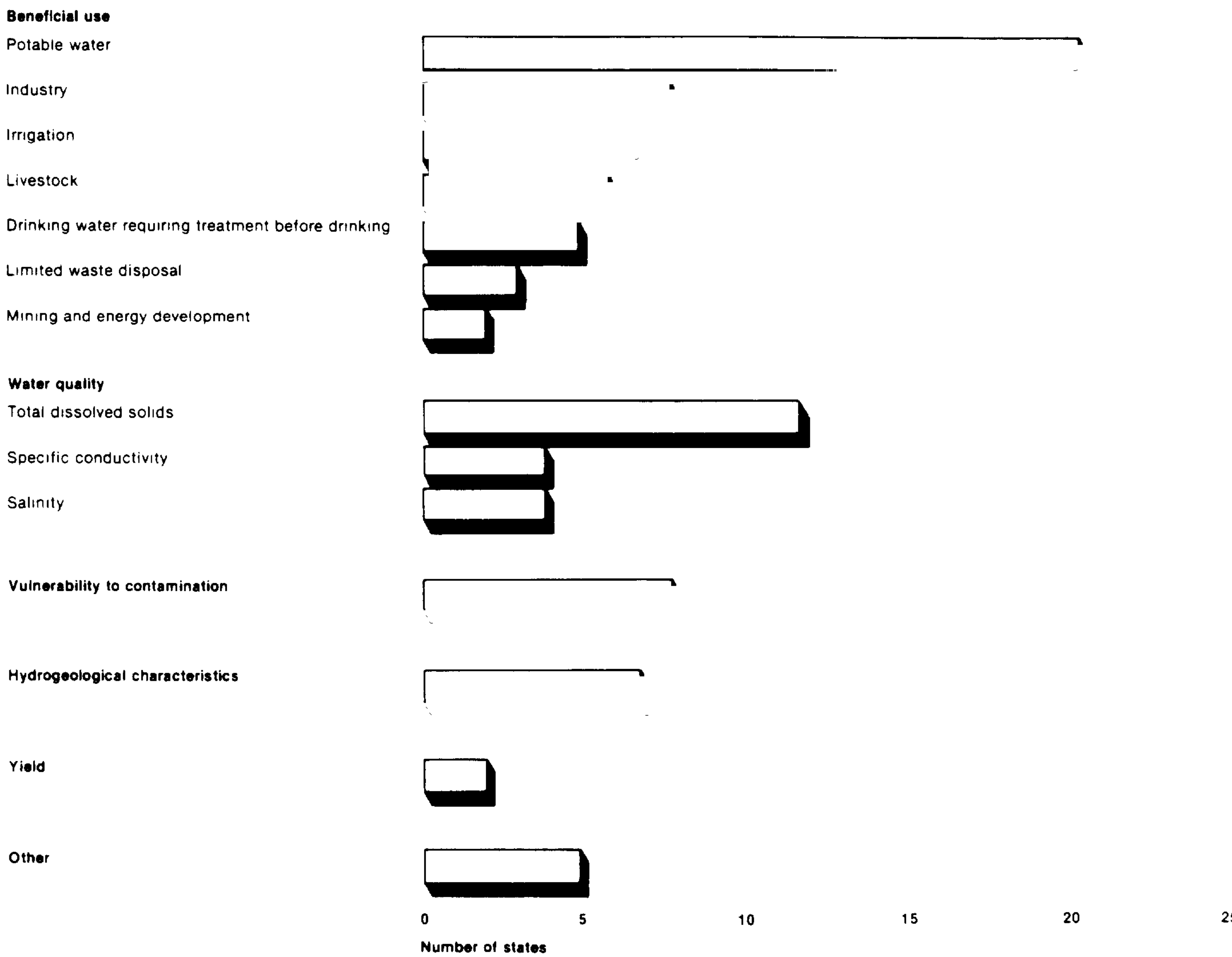
Respondents from 22 of the 25 states said their systems related in some way to their standards. Eleven said specific classes of groundwater had to meet groundwater standards, 12 said their standards differed by classification, 6 said standards applied in other ways, and 1 said there was no relation to standards.[1]

We asked the respondents to identify the bases they used in developing their systems. As can be seen in figure 6.5, we included the EPA categories—present and potential uses, aquifer vulnerability, and water quality—but also broke these down, given our observations of the state classification systems.

Although many of the states used the categories proposed by EPA, they often went beyond them. In particular, many included several specific categories of beneficial use. A large number of the states established the category "suitable as potable water," but a few states did not go beyond "water requiring treatment before drinking," assuming that treatment would remove the contaminants. A few considered other possible uses of their groundwater such as for irrigation and industry, and a few made a specific class for waste disposal, apparently assuming that contaminated groundwater could never be used for other purposes. A fairly large number of states based their classification systems on total dissolved solids, following EPA's lead. A few states were using vulnerability

[1] The total does not add to 25 because the states could provide more than one response. One state did not respond to this question.

Figure 6.5: The Bases for State Classification Systems[a]



[a]This question was addressed to the 25 states that had numeric or narrative standards and a classification system.

to contamination as the basis for classification, but as we saw in Florida's use of the DRASTIC system, this approach can require considerable effort.

Respondents from two thirds of the states that did not have classification systems reported that they either had one under development (12 states) or intended to develop one but had not yet started (10 states). Respondents from 10 states said they had no intention of developing a groundwater classification system. Except for these 10, it appears that the states were acting on EPA's recommendation that they establish a classification system as part of a groundwater protection strategy.

Summary

It is very difficult to know precisely how the states' standards were used. At best, we can identify only the principal areas where they were used. The standards were used in most states to trigger enforcement and to assess permit performance for those who might discharge contaminants. In addition, the standards were used to define the level of protection a state intended to achieve, indicate safe levels of contamination, establish preventive programs, and establish goals for remedial action. However, how the states actually implemented these objectives in state programs and how well the objectives were met is completely unknown at the present time.

Groundwater standards were used in most states as a guide for permit applicants and for those who established allowable levels of contamination under permit programs. The standards were also sometimes used in establishing discharge permits and in shutting down wells to protect the public. However, in many states, variances to standards were allowed for specific reasons; the extent to which variances weakened the force of the groundwater standards or permit conditions is unknown.

The extent to which standards are used in permit programs makes it important to determine the extent to which permits cover discharges that may affect groundwater, how these permits are used in conjunction with other programs that control discharges, and the extent to which standards used in this way prevent or mitigate groundwater contamination. A significant question raised by this last point is whether states with standards experience less contamination than states with narrative standards or states without any standards.

Most of the states with groundwater standards seemed to have monitoring programs, apparently recognizing that groundwater standards would be largely meaningless without monitoring. Groundwater standards had also been incorporated into groundwater classification systems, in states that had both, either by requiring specifically classified groundwater to meet these standards or by setting up different standards for different categories. The incorporation of standards into classification systems provided a concrete guide for the states in determining the value of particular groundwater. The evolution of a classification system apparently goes hand-in-hand with the evolution of a state's groundwater standards.

Conclusions

Present federal policy views groundwater protection as primarily a state and local responsibility. Consequently, no current federal program provides comprehensive leadership for protecting groundwater quality. We have presented information that describes state perspectives on the development of groundwater standards and on whether the federal role, particularly in providing information, is adequate.

State Organizational Status

The states vary widely in their reliance on groundwater and in their contamination problems. Every state has some organizational structure to deal with these problems. Some of these structures may not be fully developed, but we believe that for the most part there is no need for federal guidance in establishing the necessary organizations. The states seem to have no lack of impetus to address the issue of groundwater contamination. In addition, EPA's financial support of the development of groundwater protection strategies under the Clean Water Act is clearly of much benefit in helping the states deal with the problem of groundwater contamination.

State Standards

Despite the absence of a federal initiative for using standards to protect groundwater, most states are clearly active in the development and application of some numeric and narrative standards. We believe that all states will eventually be using standards, in one form or another, as a basic and essential component of their overall groundwater strategies, although the adoption rate for standards programs and for controls on specific contaminants is very slow.

The 26 states with numeric standards have generally adopted, as a minimum, the federal drinking water standards as their groundwater standards. However, they go much further, covering 226 distinct contaminants in addition to the 34 covered by federal drinking water standards. The state standards also protect uses of groundwater other than for drinking water. It is clear that the states are concerned about a larger number of groundwater contaminants than those regulated by EPA's drinking water standards.

In several states, the number of contaminants is apparently considered too large for the swift and technically defensible development of individual numeric standards. Protection in these states is sometimes sought through the use of narrative standards, which provide some legal authority for prohibiting groundwater pollution and give the states some flexibility in deciding the levels that are dangerous. The states have no federal leadership to follow in adopting narrative standards; as a result, these standards have little uniformity across the states. No data are available with which to empirically compare the effectiveness of narrative and numeric standards.

Differences in State Standards

State standards tend to follow federal standards, although there are departures from them. The existence of a federal numeric standard seems to facilitate the states' adoption of standards and makes it easier for a state to determine whether it wants some difference from the federal level. Nevertheless, state action is often slow, so that state levels may not reflect current federal knowledge about degrees of hazard.

State standards for contaminants not on the list of federal drinking water standards have little consistency from state to state, either in the contaminants covered or in the levels established. The list of standards for all the states in appendix III makes this point graphically clear. However, the majority of the state officials we interviewed thought the standards should be consistent across the states.

Standard-Setting Processes

It is evident from our findings about the processes by which state standards are established that developing numeric standards is challenging. Of the 26 states with numeric standards, only 5 have what their officials consider to be well-developed procedures for developing groundwater standards. The others rely substantially on information from the federal government as to the levels that ought to be established for individual contaminants. Most of the state officials with whom we spoke believe that resource constraints, both financial and technical, along with a perceived inadequacy of information from the federal government are the major limitations to the states' standard-setting activities.

We believe the reasons for the technical and informational limitations can be seen in the complex processes followed in the states whose standard-setting activities are well developed. These states have elaborate procedures for identifying the presence of contaminants in groundwater that include well-developed contaminant monitoring programs and the surveillance of economic activities. Movement toward the development of a standard proceeds only when there is a reasonable likelihood that groundwater might be contaminated. When that point is reached, the information needs increase dramatically to include medical and chemical information concerning a contaminant. The states use this information to determine the effects of the contaminant on health and whether some standard is required; the methods used may involve health-effects analysis, risk assessment, and benefit-cost studies.

The state officials whom we interviewed perceive these information requirements as being more than the states can handle. They believe that the federal government has a substantial responsibility in this area, perhaps in large part because this effort is potentially duplicative and wasteful when it is performed by each state. Moreover, they believe there is a gap between the information they need and the information they are receiving from the federal government. They believe this gap could be filled by some formal mechanism similar to the criteria documents developed in the surface water program. We are addressing this issue from a federal perspective in a second report, in which we intend to examine (1) the extent to which the data the states need for developing standards are available through the federal government and (2) the role, if any, the federal government might play in developing information on groundwater contaminants and disseminating it to the states.

The Use of Standards

Our examination of how the states apply groundwater standards turned out to be somewhat preliminary. We found that the standards are integral parts of state programs controlling discharges that might enter groundwater and that they play important roles in other groundwater activities such as monitoring and establishing groundwater classification systems. However, these uses raise many questions for which answers are lacking. The most important one is how effective groundwater standards are in enabling the states to deal with groundwater contamination. Given the prominence of standards in discharge control programs, another significant question is how useful they are in aiding the effectiveness of these programs. An answer to this question requires an understanding of the precise role of standards in permit programs and the extent to which variances granted in these programs may reduce their effectiveness.

Recommendation

This report contains no recommendations. As mentioned above, we plan to issue a second report that will address the federal role in providing the states with information for the development of groundwater standards.

Agency Comments

EPA thought that the report is a comprehensive and useful reference. The agency had a number of comments pertaining to one general point—that groundwater standards are only tools for protecting groundwater—and to specific passages in the draft. Except for EPA's noting financial support of the development of state groundwater strategies, its comments do not bear on the adequacy of the present federal role. EPA's comments are reproduced in appendix V and are followed by our responses.