John H. McShane, Yellowstone National Park

Ground Water Quality

Ground water is a vital national resource that is used for myriad purposes. It is used for

- Public and domestic water supply systems
- Irrigation and livestock watering
- Industrial, commercial, mining, and thermoelectric power production purposes.

In many parts of the nation, ground water serves as the only reliable source of drinking and irrigation water. Unfortunately, this vital resource is vulnerable to contamination, and ground water contaminant problems are being reported throughout the country.

This 1998 report represents the second 305(b) cycle of data collection based on ground water guidelines introduced to states as part of the 1996 305(b) reporting cycle.

This chapter presents the results of data submitted by 37 states, 3 territories, 4 tribes, and the District of Columbia in their 1998 305(b) water quality reports. States (a term used to include territories, tribes, and the District of Columbia) reported ground water monitoring data for a total of 146 aquifers or hydrogeologic settings. Based on these results, ground water quality in the nation is good and can support the many different uses of this resource. Despite these very positive results, aquifers across the nation are showing measurable impacts stemming from human activities. Through monitoring, elevated levels of petroleum hydrocarbon compounds, volatile organic compounds, nitrate, pesticides, and metals have been detected in ground water across the nation. The detection of some contaminants in ground water (e.g., metals and MTBE) is relatively new and is increasing. With each successive 305(b) report, emerging trends in ground water contaminants will become evident.

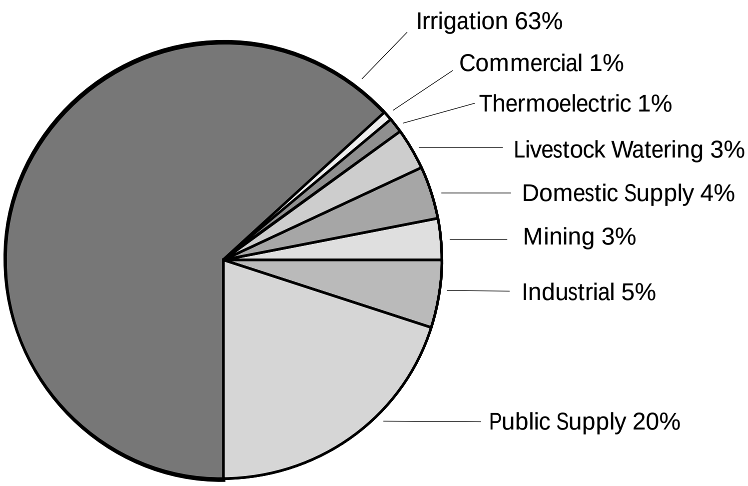
Ground Water Use in the United States

Ground water is an important component of our nation's fresh water resources. The use of ground water is of fundamental importance to human life and is also significant to economic vitality. Inventories of ground water and surface water use patterns in the United States emphasize the importance of ground water. The United States Geological Survey (USGS) compiles national water use information every 5 years and publishes a report that summarizes this information. The latest USGS report was issued in October 1998 for the 1995 water year.

The USGS report shows that ground water provides water for drinking and bathing, irrigation of crop lands, livestock watering, mining, industrial and commercial uses, and thermoelectric cooling

Figure 7-1

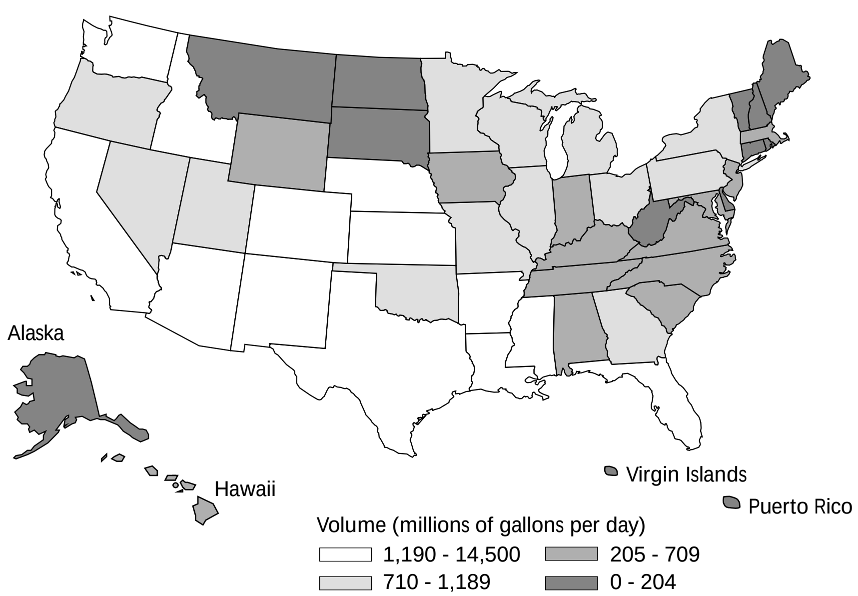
National Ground Water Use



Source: *Estimated Use of Water in the United States in 1995.* U.S. Geological Survey Circular 1200, 1998.

Figure 7-2

Ground Water Withdrawals by State in 1995



Source: *Estimated Use of Water in the United States in 1995.* U.S. Geological Survey Circular 1200, 1998.

applications. Figure 7-1 illustrates how ground water use is proportioned among these categories. As shown, irrigation (63%) and public water supply (20%) are the largest uses of ground water.

About 77,500 million gallons of ground water are withdrawn daily. In 1995, the USGS reported that ground water supplied 46% of the nation's overall population and 99% of the population in rural areas with drinking water. Our nation's dependence on this valuable resource is clear.

Every state uses some amount of ground water. Nineteen states obtain more than 25% of their overall water supply from ground water. Ten states obtain more than 50% of their total water supply from ground water.

Each state uses its ground water differently. Ground water use in individual states is a result of numerous interrelated factors generally associated with geography and climate, the principal types of business activities occurring in the state, and population distribution. Fresh ground water withdrawals during 1995 were highest generally in the western states, primarily to supply an increasing population and to sustain important agricultural activities. Figure 7-2 shows the volume of ground water withdrawn by states. The 13 states that have the greatest withdrawals account for 69% of all ground water that is withdrawn nationally.

Overall, agricultural activities account for the majority of ground water used in the nation. Figure 7-3 shows the volume of ground water used for irrigation. Irrigation is important for maintaining yields from crop land in the western and southeastern states. Generally, 75% or more of harvested crop land in many of the western states is irrigated, which represents an important ground water use. Watering of livestock also accounts for significant withdrawals of fresh ground water. Of all the states, California uses the greatest volume of ground water supplies to support agriculture.

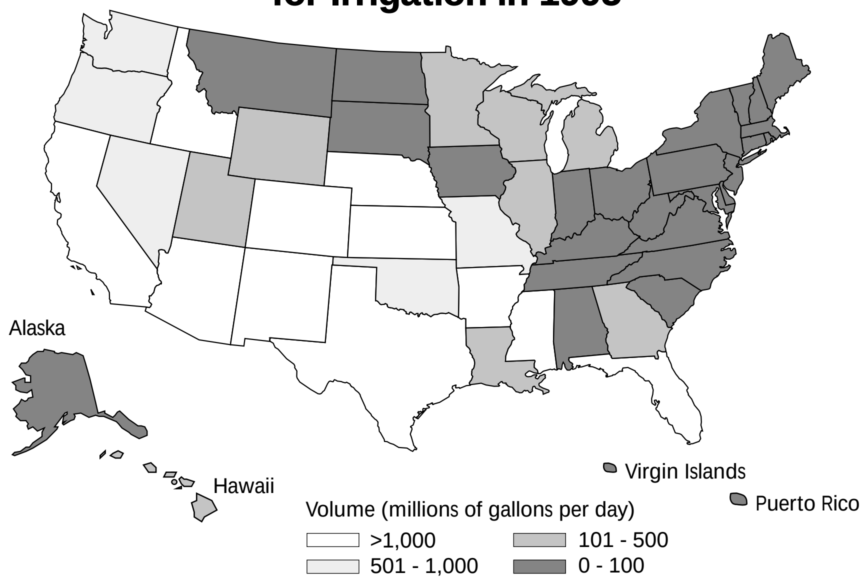
Ground water use trends between 1950 and 1995 generally reflected the observed trends for total water use for the nation (Figure 7-4). From 1950 through 1980, there was a steady increase in fresh ground water withdrawals, which coincided with the steady increase in our nation's total water use. Use of fresh water generally declined after 1980 through 1995, and fresh ground water withdrawals declined in 1995 to nearly 10% less than estimated in 1980. This decline occurred as the nation's population increased 16% over this 15-year period.

The current decline in water use, including ground water use, is attributed primarily to growing recognition in recent years that water is not an unlimited resource. Conservation programs championed by state and local communities lowered public supply per capita use over the same 15-year period.

Two factors are contributing to a lessening demand for water. First, an increase in dry farming practices has decreased the acres of irrigated lands in the west and, thus, has decreased the demand for fresh ground water in this region. Second, improved and more efficient irrigation systems and techniques have contributed to water conservation.

Figure 7-3

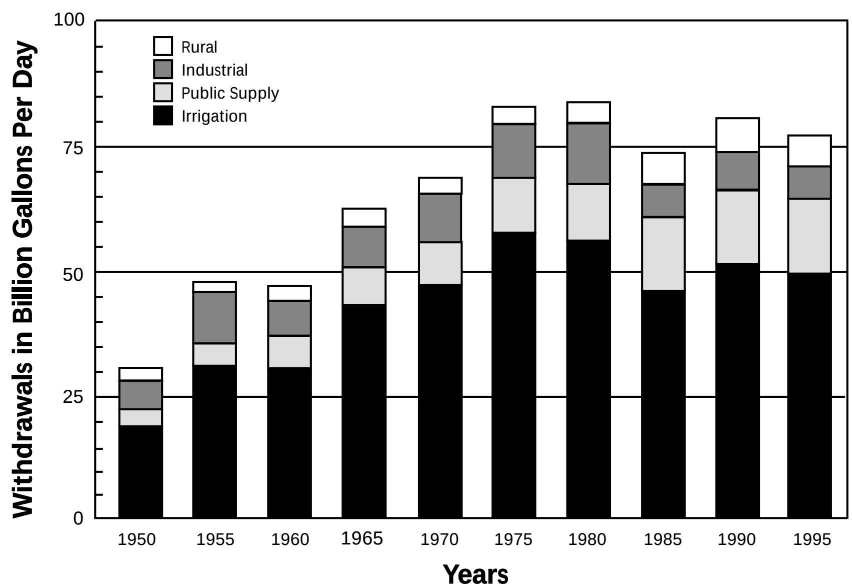
Volume of Ground Water Used for Irrigation in 1995



Source: *Estimated Use of Water in the United States in 1995.* U.S. Geological Survey Circular 1200, 1998.

Figure 7-4

Ground Water Withdrawals in the United States, 1950-1995



Source: http://wwwga.usgs.gov/edu/earthgwusetrend.html

Industry has also improved the efficiency of its manufacturing operations by focusing on water conservation. For example, water recycling practices by industries, adopted to reduce discharges as well as operating costs, have been one important development in the conservation of water in industry.

Ground water continues to be an important component of our nation's water supply. The demand for ground water to meet the nation's needs must be coupled with supply-management practices to conserve this valued resource.

Ground Water Quality

The evaluation of our nation's ground water quality is complex. In evaluating ground water quality under Section 305(b) of the Clean Water Act, our goal is to determine if the resource meets the requirements for its many different uses. Ground water quality can be adversely affected or degraded as a result of human activities that introduce contaminants into the environment. It can also be affected by natural processes that result in elevated concentrations of certain constituents in the ground water. For example, elevated metal concentrations can result when metals are leached into the ground water from minerals present in the earth. High levels of arsenic and uranium are frequently found in ground water in some western states.

Not too long ago, it was thought that soil provided a protective "filter" or "barrier" that immobilized the downward migration of contaminants released on the land surface. Soil was supposed to prevent ground water resources from being contaminated. The detection of pesticides and other contaminants in ground water demonstrated that these resources were indeed vulnerable to contamination. The potential for a contaminant to affect ground water quality is dependent upon its ability to migrate through the overlying soils to the underlying ground water resource.

Ground water contamination can occur as relatively well-defined, localized plumes emanating from specific sources such as leaking underground storage tanks, spills, landfills, waste lagoons, and/or industrial facilities (Figure 7-5). Contamination can also occur as a general deterioration of ground water quality over a wide area due to diffuse nonpoint sources such as agricultural fertilizer and pesticide applications. Ground water quality degradation from diffuse nonpoint sources affects large areas, making it difficult to specify the exact source of the contamination.

Ground water contamination is most common in highly developed areas, agricultural areas, and industrial complexes. Frequently, ground water contamination is discovered long after it has occurred. One reason for this is the slow movement of ground water through aquifers, sometimes as little as fractions of a foot per day. This often results in a delay in the detection of ground water contamination. In some cases, contaminants introduced into the subsurface decades ago are only now being discovered. This also means that the environmental management practices of today will have effects on ground water quality well into the future.

Sources of Ground Water Contamination

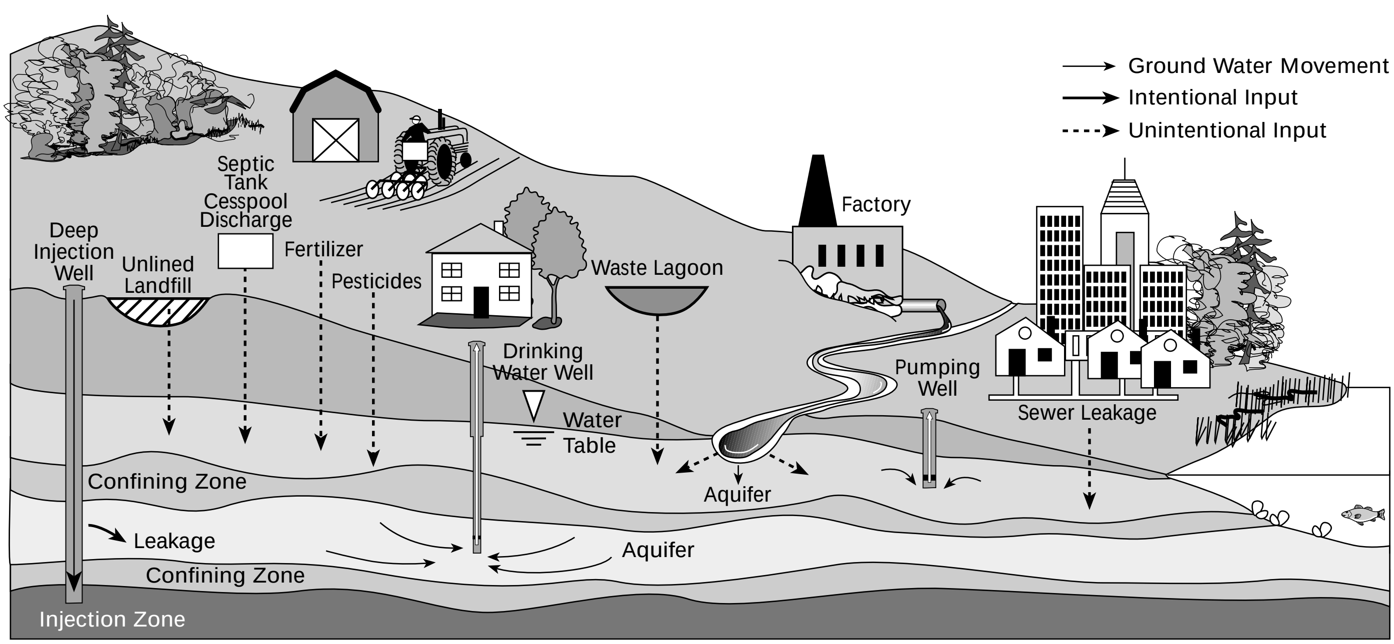
Ground water quality may be adversely impacted by a variety of potential contaminant sources. It can be difficult to identify which sources have the greatest impact on ground water quality because each source varies in the amount of ground water it contaminates. In addition, each source impacts water quality differently.

An EPA/state workgroup developed a list of potential contaminant sources and requested each state to indicate the 10 top sources that potentially threaten their ground water resources. States added sources as was necessary based on state-specific concerns. When selecting sources, states considered numerous factors, including

- The number of each type of contaminant source in the state
- The location relative to ground water sources used for drinking water purposes
- The size of the population at risk from contaminated drinking water
- The risk posed to human health and/or the environment from releases
- Hydrogeologic sensitivity (the ease with which contaminants enter and travel through soil and reach aquifers)
- The findings of the state's ground water assessments and/or related studies.

Figure 7-5

Sources of Ground Water Contamination



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Ground Water and Surface Water – A Single Resource

Traditionally, surface water and ground water have been treated as separate entities in the management of water resources. More recently, however, it has become apparent that all waterbody interaction is interrelated. Water in lakes, wetlands, and streams recharges ground water reservoirs, and ground water discharges back into lakes, wetlands, and streams, providing baseflow maintenance. A recent report by the USGS, *Ground Water and Surface Water – A Single Resource*, summarizes these interactions (USGS Circular 1139, 1998).

Ground water contributes to most streams, thereby maintaining streamflow during periods of low flow or drought. The ground water component of streamflow is variable across the country. In one USGS study, 24 regions were delineated on the basis of physiography and climate. Ground water and surface water interactions (i.e., ground water contribution to streamflow) were considered to be similar in each of these regions. Fifty-four streams, with at least two streams in each region, were selected to study ground water and surface water interactions. Daily stream flow values for the 30-year period, 1961 to 1990, were used for the analysis of each stream. The analysis indicated that an average of 52% of all the streamflow in the nation was contributed by ground water. Ground water contributions ranged from 14% to 90%. The ground water contribution to streamflow for selected streams is compared in Figure 1.

Development of surface water resources can affect ground water resources and vice versa. Large withdrawals of ground water can reduce the amount of ground water inflow to surface water and significantly reduce the supplies of surface water available to downstream users. Increased demands on our water resources prior to the 1980 water year (USGS Circular 1200, 1998) caused many surface water supplies to be depleted, particularly in some western states. The use of large volumes or amounts of ground water for irrigation was often identified as the cause of drying river beds and wetlands. Today, conservation and changes in agricultural practices are restoring flow to these rivers and also to ecologically important wetlands areas.

The water quality of each of these resources can also be affected by their interactions. Water quality can be adversely affected when

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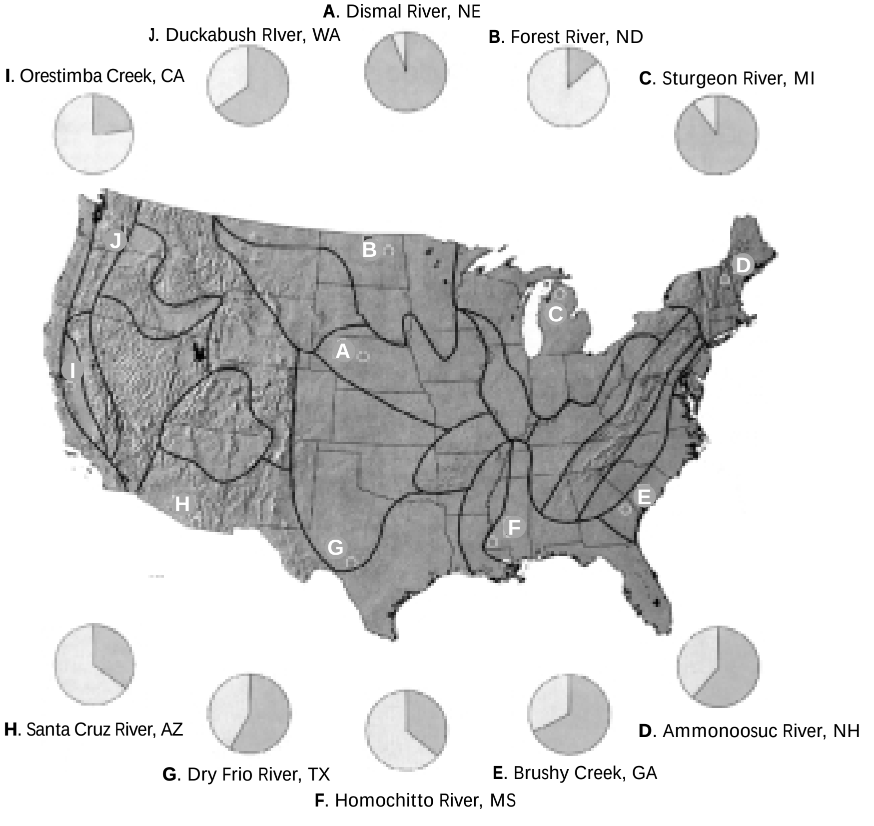
nutrients and contaminants are transported between ground water and surface water. For example, contaminants in streams can affect ground water quality during periods of recharge and flooding. Polluted ground water can affect surface waterbodies when contaminated ground water discharges into a river or stream. Because contamination is not restricted to either waterbody, both ground water and surface water must be considered in water quality assessments.

Coordination between surface water and ground water programs will be essential to adequately evaluate the quality and quantity of our nation's drinking water. Ground water and surface water interactions have a major role in affecting chemical and biological processes in lakes, wetlands, and streams, which in turn affect water quality throughout the system. An understanding of these interactions is critical in our water protection and conservation efforts. It is evident that protection of ground water, as much as protection of surface water, is of major importance for sustaining uses such as drinking water supply, fish and wildlife habitats, swimming, boating, and fishing.



U.S. Geological Survey Circular 1139, 1998.

Figure 1. This map compares ground water contribution to streamflow for selected streams.

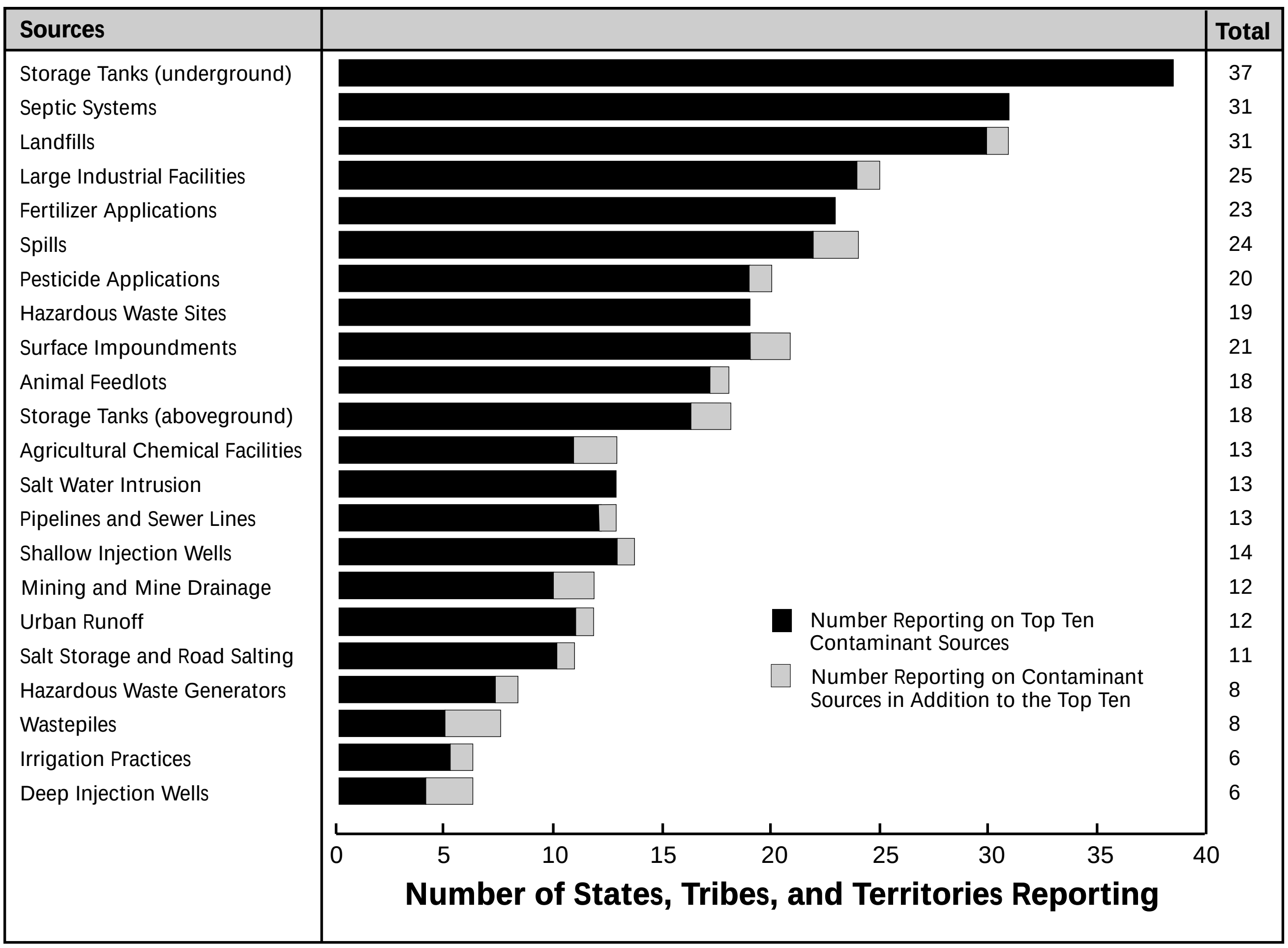
For each of the 10 top sources, states identified the specific contaminants that may impact ground water quality. Figure 7-6 illustrates the sources most frequently cited by states as a potential threat to ground water quality. Leaking underground storage tanks (LUSTs) are the greatest potential source of ground water contamination. Septic systems, landfills, industrial facilities, and fertilizer applications are the next most frequently cited sources of concern. These findings are consistent with state reports during previous 305(b) cycles.

If similar sources are combined, four broad categories emerge as the most important potential sources of ground water contamination:

- Fuel storage practices
- Waste disposal practices
- Agricultural practices
- Industrial practices.

Figure 7-6

Major Sources of Ground Water Contamination



Fuel Storage Practices

Fuel storage practices include the storage of petroleum products in underground and aboveground storage tanks. Although tanks exist in all populated areas, they are generally most concentrated in the more heavily developed urban and suburban areas of a state.

Storage tanks are primarily used to hold petroleum products such as gasoline, diesel fuel, and fuel oil. Leakages can be a significant source of ground water contamination (Figure 7-7). The primary causes of tank leakages are faulty installation or corrosion of tanks and pipelines.

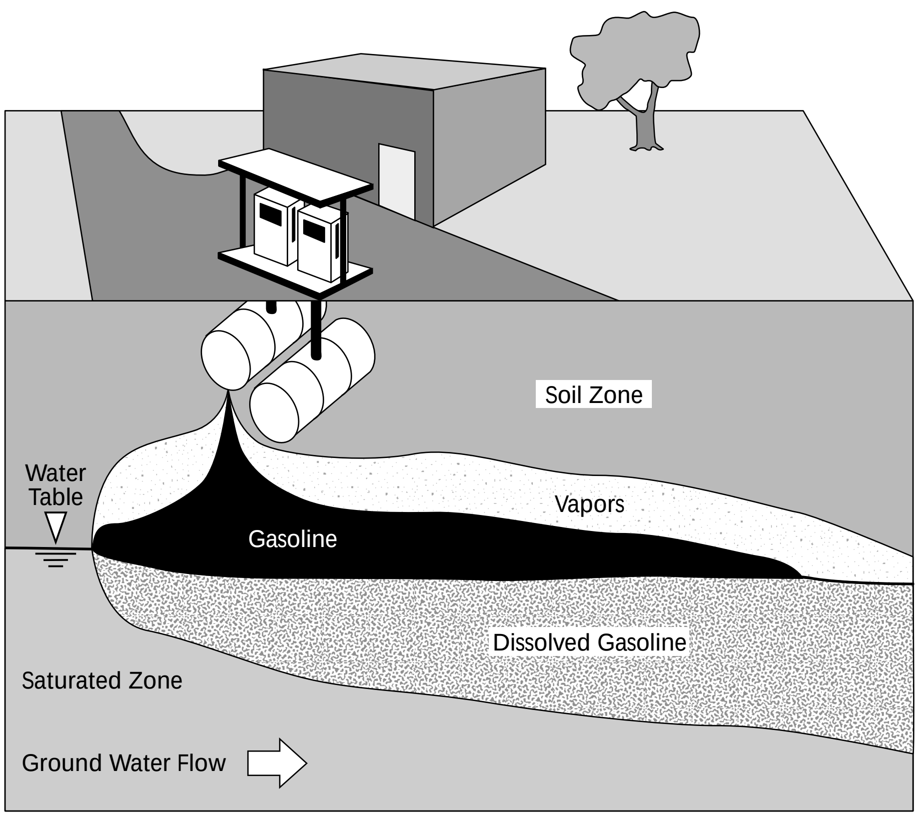
Petroleum products are actually complex mixtures of hundreds of different compounds. Over 200 gasoline compounds can be separated in the mixture. Compounds characterized by a higher water solubility are frequently detected in ground water resources. Four compounds, in particular, are associated with petroleum contamination: benzene, toluene, ethylbenzene, and xylenes. Petroleum-related chemicals threaten the use of ground water for human consumption because some (e.g., benzene) are known to cause cancer even at very low concentrations.

Compounds are added to some fuel products to improve performance. For example, methyl tert-butyl ether (MTBE) is added to boost octane and reduce carbon monoxide and ozone levels. Unfortunately, this compound is highly water soluble and incidents of MTBE contamination in ground water are widely reported across the nation. States report that MTBE is frequently being added to the list of compounds monitored at petroleum release sites. Thus, a new threat to ground water quality has been identified just in the past 5 years.

States report that the organic chemicals associated with petroleum products are common ground water contaminants. Petroleum-related chemicals adversely affect ground water quality in aquifers across the nation. The most significant impacts occur in the uppermost aquifer, which is frequently shallow and often used for domestic purposes.

Figure 7-7

Ground Water Contamination as a Result of Leaking Underground Storage Tanks



Efforts to Fight Air Pollution Create a Water Quality Concern

What began as an effort to fight air pollution became a water quality concern that necessitated dozens of costly studies and created a public health risk. Although methyl tert-butyl ether (MTBE) helps lower tailpipe emissions, it also contaminates ground water supplies. MTBE is more soluble in water and less likely to be degraded than other common petroleum constituents. It is also tentatively classified as a possible human carcinogen by EPA. In studies conducted by the USGS, MTBE was the second most commonly detected volatile organic compound (VOC) in water collected from urban wells and the seventh most commonly detected VOC in urban stormwater. Although frequently detected, only 3% of the urban wells sampled were characterized by concentrations of MTBE that exceeded EPA's draft drinking water health advisory level of 20 micrograms/liter. All of the concentrations measured in urban stormwater were less than the health advisory level.

Waste Disposal Practices

Waste disposal practices include

- Septic systems
- Landfills
- Surface impoundments
- Deep and shallow injection wells
- Wastepiles
- Waste tailings
- Land application
- Unpermitted disposal.

Any practice that involves the handling and disposal of waste has the potential to impact the environment if protective measures are not taken. Contaminants most likely to impact ground water include metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), nitrates, radionuclides, and pathogens. States report that current laws and regulations go a long way toward preventing releases and that many instances of present-day ground water contamination are the result of historic practices.

Improperly constructed and poorly maintained septic systems are believed to cause substantial and widespread nutrient and microbial contamination to ground water. In Montana, approximately 126,000 individual onsite septic systems are used by 252,000 people, and ground water monitoring has shown elevated nitrate levels near areas of concentrated septic systems. Widespread nitrate contamination by individual septic systems and municipal sewage lagoons is a significant ground water contamination problem reported by Colorado and Arizona.

Landfills have long been used to dispose of wastes and, in the past, little regard was given to the potential for ground water contamination in site selection. Landfills were generally sited on land considered to have no other uses. Unlined abandoned sand and gravel pits, old strip mines, marshlands, and sinkholes were often used. In many instances, the water table was at, or very near the ground surface, and the potential for ground water contamination was high. Not surprisingly, states consistently cite landfills as a high-priority source of ground water contamination. Generally, the greatest concern is associated with practices or activities that occurred prior to establishment of construction standards for landfills. Present-day landfills are now required to adhere to stringent construction and ground water monitoring standards.

Generally, discharges to surface impoundments such as pits, ponds, and lagoons are underregulated. In Indiana, many surface impoundments neither discharge to surface water nor have designed outfalls; as a consequence, they have the potential to leach metals, volatile organic compounds, and semivolatile organic compounds to ground water. In Colorado, wells located downgradient from tailings ponds or cyanide heaps associated with mining operations often exhibit high concentrations of metals. Arizona also identified surface impoundments and leach fields as significant sources of volatile organic compounds.

Class V injection wells include shallow wastewater disposal wells, septic systems, storm water drains, and agricultural drainage systems. Class V injection wells are used to dispose of wastewaters directly into the ground. Because they are not designed to treat the wastewaters released through them, ground water supplies can become contaminated. The large number and diversity of Class V injection wells pose a significant potential threat to ground water. The state of Indiana indicated that they are targeting these installations for further legislative controls.

Agricultural Practices

Agricultural practices that have the potential to contaminate ground water include

- Animal feedlots
- Fertilizer and pesticide applications
- Irrigation practices
- Agricultural chemical facilities
- Drainage wells.

Ground water contamination can be a result of routine applications, spillage, or misuse of pesticides and fertilizers during handling and storage, manure storage/spreading, improper storage of chemicals, and irrigation return drains serving as a direct conduit to ground water. Fields with over-applied and/or misapplied fertilizers and pesticides can introduce nitrogen, pesticides, cadmium, chloride, mercury, and selenium into the ground water. States report that agricultural practices continue to be a major source of ground water contamination.

Animal feeding operations can pose a number of risks to water quality and public health, mainly because of the amount of animal manure and wastewater they generate. Animal feedlots often have impoundments from which wastes may infiltrate to ground water. Livestock waste is a source of nitrate, bacteria, total dissolved solids, and sulfates.

Livestock is an integral component of many states' economies. As a consequence, concentrated animal feeding operations occur in many states. The high concentration of manure in feedlot areas causes confined animal feedlots to be a concern for contributing to ground water contamination.

Shallow unconfined aquifers in many states have become contaminated from the application of fertilizer. Crop fertilization is the most important agricultural practice contributing nitrate to the environment. Nitrate is considered by many to be the most widespread ground water contaminant. To help combat the problems associated with the overuse of fertilizers, the U.S. Department of Agriculture's Natural Resources Conservation Service assists crop producers in developing nutrient management plans.

Human-induced salinity also occurs in agricultural regions where irrigation is used extensively. Irrigation water continually flushes nitrate-related compounds from fertilizers into the shallow aquifers along with high levels of chloride, sodium, and other metals, thereby increasing the salinity of the underlying aquifers.

Risk of Multiple Contaminants

In a recent study by the University of Wisconsin-Madison, researchers noted that common mixtures of pesticides and fertilizers can have biological effects at the current concentrations measured in ground water. Specifically, the combination of aldicarb, atrazine, and nitrate, which are the most common contaminants detected in ground water, can influence the immune and endocrine systems as well as affect neurological health. Changes in the ability to learn and in patterns of aggression were observed. Effects are most noticeable when a single pesticide is combined with nitrate fertilizer. Research shows that children and developing fetuses are most at risk. EPA is developing an approach to deal with mixtures under the cumulative risk policy. The initial step is to deal with mixtures on a case-by-case basis beginning with the organophosphate pesticides as a group. Dealing with mixtures of chemicals under the Food Quality Protection Act and Safe Drinking Water Act will continue to be a challenge in the future.*

*Porter et al. 1999. *Toxicology and Industrial Health* 15, 133-150.

Metals in the Environment

Metals may be present in industrial and commercial process waste streams. These metals tend to be persistent with little to no potential for degradation. Predicting their mobility and toxicity is complex due to the large number of chemical reactions that can affect their behavior. The scientific community is only just now beginning to unravel the intricacies involved in predicting metals behavior in the environment.

Pesticide use and application practices are of great concern. The primary routes of pesticide transport to ground water are through leaching or by spills and direct infiltration through drainage controls. Pesticide infiltration is generally greatest when rainfall is intense and occurs shortly after the pesticide is applied. Within sensitive areas, ground water monitoring has shown fairly widespread detections of pesticides, specifically the pesticide atrazine. Many states are developing or have developed specific management plans to better control pesticide application rates and frequency to lessen the impacts on the resource.

Industrial Practices

Raw materials and waste handling in industrial processes can pose a threat to ground water quality. States noted that industrial facilities, hazardous waste generators, and manufacturing/repair shops all present the potential for releases. Storage of raw materials at the facility are a problem if the materials are stored improperly and leaks or spills occur. Examples include chemical drums that are carelessly stacked or damaged and/or dry materials that are exposed to rainfall. Material transport and transfer operations at these facilities can also be a cause for concern. If a tanker operator is careless when delivering raw materials to a facility, spills may occur.

The most common contaminants are metals, volatile organic compounds, semivolatile organic compounds, and petroleum compounds. States reported releases of each of these contaminant types in association with industrial practices in their 1998 305(b) reports as both a current and potential threat to ground water quality.

Cyanide spills associated with ore processing continue to affect ground water quality in Montana. Ground water contamination extending beyond mine properties has occurred at nine ore processing facilities. Water supplies have been affected by at least three spills. Thirty-eight ore processors are known to have used cyanide at some point during their operation, and, of these facilities, four remain active. Cyanide will continue to affect the quality of Montana's ground water in these mining areas from past releases as well as from the potential threat of future accidental releases.

Spills are a source of grave concern among states. The state of Indiana reported that about 50 spills occur per week. In 1996, 41 million gallons of chemicals, industrial wastes, and agricultural products were spilled in Indiana. Montana reports an average of 300 accidental spills each year. On average, approximately 15 of these spills require extensive cleanup and followup ground water monitoring. One of these was the 1995 derailment of railroad tanker cars in the Helena rail yard that threatened to contaminate ground water with 17,400 gallons of fuel oil. Followup monitoring demonstrated that rapid response actions had prevented the majority of the contaminants from reaching local aquifers.

Volatile organic compounds associated with solvent spills and leaks from electronics, aerospace, and military facilities that use these chemicals as degreasing agents were identified by Arizona as major sources of ground water contamination. South Carolina determined that accidental spills and leaks are the second most common source of ground water contamination, and, as in Arizona, these releases can usually be associated with petroleum-based products attributed to machinery maintenance or manufacturing. Spills will never become entirely preventable, but industry, local governments, and states are cooperating to control spills when they do occur so that the impact to the environment is minimized

Development of new technologies and new products to replace organic solvents is continuing. For example, organic biodegradable solvents derived from plants are being developed for large-scale industrial applications. Environmentally responsible dry cleaning technologies are being developed that eliminate the need for perchloroethylene. Legislation is being considered in New York and by other local governments and states that would ban the use of perchloroethylene by the dry cleaning industry.

State Overview of Contaminant Sources

States inventory the types and numbers of contaminant sources having the potential to impact ground water quality in selected aquifers. This type of information serves three purposes:

- To identify contaminant sources with the greatest potential to impact ground water quality based on sheer number of sites

- To determine the number of sites actually having impacted ground water resources

- To determine the remedial actions being taken to address the contamination and the degree of success.

For 1998, 26 states reported contaminant source information for specific aquifers. Table 7-1 summarizes contaminant source information for those 26 states. Many states do not yet track this type of information in an easily accessible format.

As shown in Table 7-1, underground storage tanks (USTs) represent the highest number of potential sources of ground water contamination. These findings are consistent with data reported during the 1996 305(b) cycle. Over 85,000 UST sites were reported in 72 hydrogeologic settings in 22 states. Of these tanks, 57% were characterized by confirmed contaminant releases to the environment and 18% had releases that adversely affected ground water quality. These sites are slowly being cleaned up and restored. Nearly 21,500 (25%) of these sites have been remediated as of late 1998. Much of the money that supports cleanup operations is provided by State Underground Tank Remediation Funds. Eighteen states reported that they have fully established Remediation Funds.

States ranked underground injection sites as second on the list of potential sources of contamination. More than 31,000 underground injection sites exist in the 72 settings evaluated. The percent with confirmed ground water contamination is less than 5%, suggesting that underground injection sites are less of a threat than leaking USTs.

State sites include unregulated chemical spills or historic sites for which there is no responsible party. These sites are not covered by an EPA regulatory program. State sites accounted for over 12,000 sites present in 34 hydrogeologic settings. Of these sites, over 50% have confirmed contaminant releases and over 25% have confirmed ground water impacts.

For each of the sources listed in Table 7-1, states attempted to identify the types of contaminants most likely to be present. Although contaminants ranged from asbestos to radionuclides, the most frequently cited contaminants were

- Volatile organic compounds
- Petroleum compounds
- Metals
- Pesticides
- Nitrate.

Volatile organic compounds and petroleum compounds were each cited as contaminants of concern in 60% of the hydrogeologic settings for which states reported data. Metals were measured in ground water collected from 52% of the hydrogeologic settings. Pesticides and nitrate were cited 31% and 22% of the time, respectively.

Table 7-1. Summary of Contaminant Source Type and Number

Source Type	Number of States Reporting Information	Number of Aquifers or Hydrogeologic Settings for Which Information Was Reported	Total Sites	Number of Sites with Confirmed Releases		Number of Sites with Confirmed Ground Water Contamination	
				Number	Percent of Total	Number	Percent of Total
LUST	22	72	85,067	48,320	57	15,436	18
Underground Injection	17	72	31,480	1,313	4	172	<1
State Sites	17	34	12,202	6,199	51	3,139	26
DOD/DOE	17	54	8,705	4,470	51	286	3
CERCLA (non-NPL)	19	59	3,506	1,381	39	802	23
RCRA Corrective Action	19	50	2,696	538	20	267	10
Nonpoint Sources	8	29	2,030	44	2	31	<2
Landfills	6	26	1,356	110	8	110	8
NPL	22	66	307	275	90	249	81

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
DOD/DOE = Department of Defense/Department of Energy.
LUST = Leaking Underground Storage Tank.
NPL = National Priority List.
RCRA = Resource Conservation and Recovery Act.
— = Not available.

Ground Water Assessments

The 1998 305(b) reporting cycle was the second cycle for which states reported quantitative ground water monitoring data on an aquifer-specific basis. Data reporting increased in uniformity in 1998 as states became familiar with the revised Ground Water Guidelines and began developing methodologies to report the data in the format requested. Increased consistency in the way data were submitted allowed for more meaningful comparisons of reported data.

Thirty-one states reported ground water monitoring data that were used in this assessment. Ten states and tribes reported ground water monitoring data for the first time in 1998. Additional data from 14 states were also received, but the data were not compatible with the 305(b) data format and could not be used in the national summary. Figure 7-8 shows the states that submitted ground water data for the 1998 305(b) reporting cycle.

States that achieved full state coverage in 1996 reported their most recent monitoring results for 1998. States that implemented rotating monitoring plans reported data for additional aquifers within the state.

Texas is an example of a state that uses a rotating monitoring design. The Texas Groundwater Protection Committee is the

Hydrogeologic Settings

This term describes the geologic-related ground water and surface water factors that affect and control ground water movement into an area. Factors—such as depth to ground water, soil type, and the amount of recharge—can be used to map areas with common characteristics. It is possible then to make generalizations about the vulnerability of the setting to potential contaminants.

Aller et al. 1987. *DRASTIC — A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings.* EPA/600/2-87/035. U.S. Environmental Protection Agency.

Number of Sites with Active Remediation		Number of Sites with Cleanup Completed	
Number	Percent of Total	Number	Percent of Total
3,044	4	21,438	25
61	<1	452	<2
753	6	3,242	27
1,717	20	1,937	22
229	7	316	9
95	4	67	3
5	<1	3	<1
2	<1	—	—
83	27	33	11

coordinating entity for Texas ground water issues. The Texas Water Development Board performs ambient ground water monitoring on a selected number of Texas aquifers each year so that all major and minor aquifers of the state are monitored within a 5-year period.

Major and minor aquifers underlie approximately 76% of Texas' 267,338 square miles of land surface. Major aquifers produce large quantities of water in a larger area of the state. Minor aquifers produce significant quantities of water within smaller geographic areas or small quantities in large geographic areas. Nine major aquifers and twenty minor aquifers have been delineated within the state.

Approximately 4,200 domestic and agricultural water wells are sampled as part of this 5-year program.

Figure 7-8

States Reporting Ground Water Data

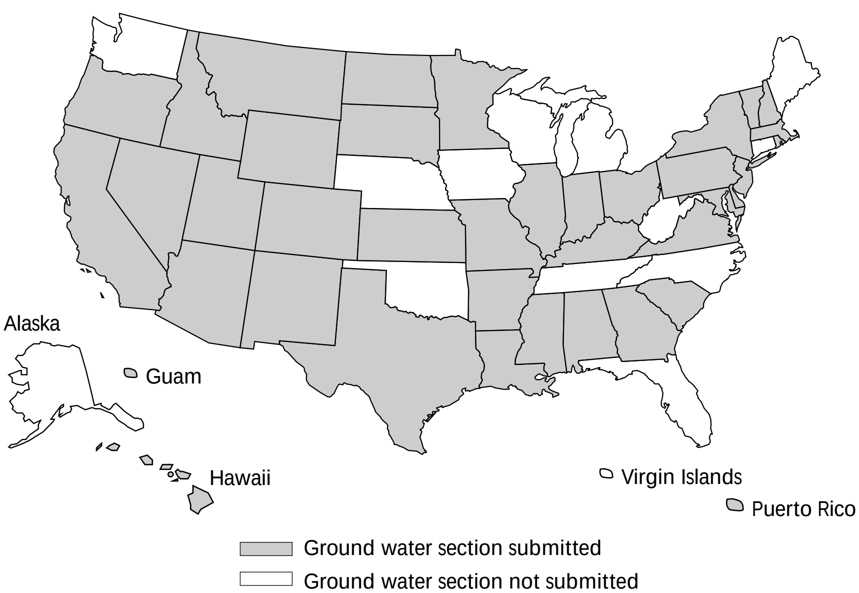


Figure 7-9 illustrates the aquifers assessed during the first three monitoring cycles. The remaining Texas aquifers will be assessed for 2000 and 2001.

Texas' goal is to completely assess all major and minor aquifers every 5 years. After this first 5-year cycle is complete, a historical analysis of ambient ground water quality will begin as the state repeats the cycle.

Hawaii provides yet another plan for implementing statewide ground water assessment. Hawaii designed a three-phased plan. Phase I uses existing information from the Department of Health aquifer research program and wellhead protection assessments. These data are compared with ground water contamination maps of detected organic chemical contamination in the state. Together these data provide an overlay of the location of aquifers in the state, locations where contaminants have been detected, and specific aquifer/wellhead areas that have been assessed for vulnerability to contamination. Phase I assessments were submitted as part of the 1998 305(b) cycle.

Phase II assessments will be reported as part of the 2000 and 2002 305(b) cycles. They will be based on data from the Hawaii Source Water Assessment Program (HISWAP). Phase II information will provide comprehensive data on public drinking water sources and will identify

■ Source water protection areas

■ Sources of contamination

■ Susceptibility of source water to contamination.

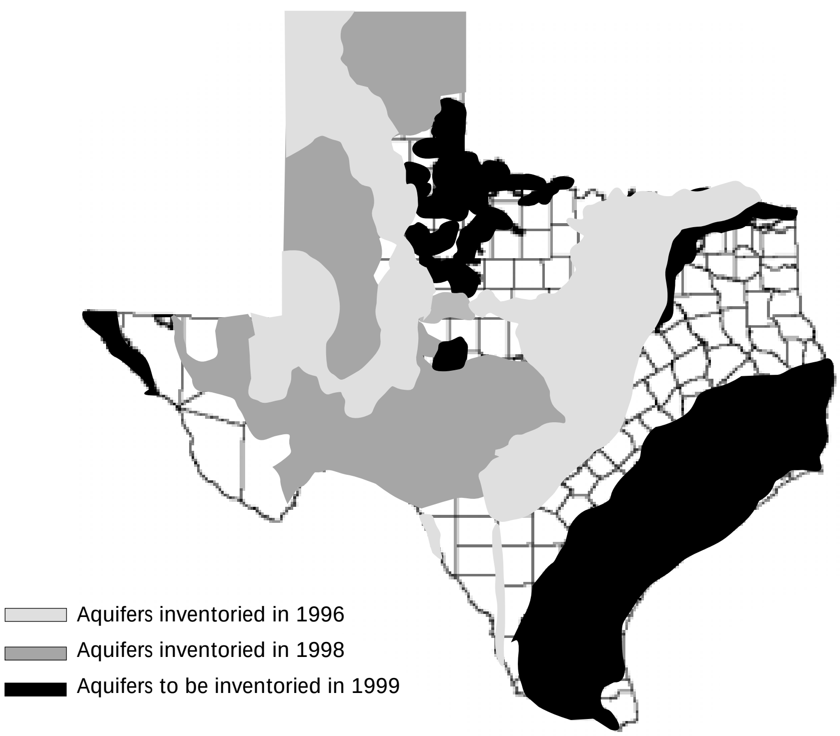
Phase III assessment will include all completed HISWAP assessments and any ambient ground water data collected and/or analyzed. Phase III will produce a comprehensive database of public drinking water sources and ambient ground water data. Implementation of this phase will depend on pending policy and budget decisions.

Ground Water Quality Data

For the 1998 305(b) cycle, states assessed ground water quality using three primary sources of data: ambient ground water monitoring data, unfinished water quality data, and finished water quality data (Figure 7-10). Furthermore, states reported results for a smaller suite of analytes relative to the 1996 305(b) cycle, focusing primarily on volatile organic compounds, semivolatile organic compounds, and nitrate. Emphasis on these three parameter groupings is warranted because the presence of

Figure 7-9

Texas Water Quality Inventory



Framework for Compiling State Data

Assessment of ground water quality under the 305(b) program is evolving, and many changes have been implemented over the past decade to develop an accurate representation of our nation's ground water quality. One of the most significant changes was the request that states begin reporting ground water monitoring data for specific aquifers or hydrogeologic settings within the state. As the states began reporting monitoring data for multiple hydrogeologic settings, EPA responded by developing a database to compile and maintain the large volume of ambient ground water quality data being reported as part of the 305(b) program. This database provides a framework for state-reported ground water quality data.

Currently, the dataset contains ground water monitoring data for 243 hydrogeologic settings, representing data reported by states for the 1996 and 1998 305(b) cycles. Obviously, this set of data provides limited national coverage, and only a limited assessment of ground water quality on a national basis is possible at this time. However, a framework for reporting and compiling data on a biennial basis has been established, and, as states report new data with each successive 305(b) cycle, the data set will mature. With continuing efforts, an accurate and representative assessment of our nation's ground water resources should emerge.

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Tribal 305(b) Submittals

Four Native American tribes submitted ground water information in their 305(b) water quality reports in 1998. They are

- La Jolla Band of Indians of Pauma Valley, California
- Twenty-Nine Palms Band of Mission Indians of Coachella, California
- Torres-Martinez Desert Cahuilla Indians of Thermal, California
- Agua Caliente Band of Cahuilla Indians of Palm Springs, California.

La Jolla Band of Indians is located in the San Luis Rey River Ground Water Basin and the other three tribes are located in the Coachella Valley Groundwater Basin. The Coachella Valley Water District has undertaken extensive studies to estimate ground water production and overdraft in the Valley. Recent estimates indicate that ground water is in an overdraft situation with more water being pumped out of the Valley than is entering as recharge. Estimates of overdraft in the lower Valley range from 50,000 to 150,000 acre-feet per year. Approximately half of the overdraft is attributed to agriculture and half is attributed to municipal and recreational uses.

Anthropogenic sources of ground water contamination include agricultural chemical facilities, fertilizer applications, irrigation and drainage practices, wastepiles, deep and shallow injection wells, septic systems, underground storage tanks, and industrial facilities. The overdraft situation in the Valley causes higher hydraulic gradients and increases the potential for ground water contaminants to affect ground water resources. One very common contaminant that is detected in ground water on the reservations is nitrate. All four tribes assessed ground water quality using nitrate as an indicator parameter.

Natural sources of contamination also impact ground water quality. Fluoride-bearing minerals present in the aquifer substrate contribute high levels of fluoride to ground water. Arsenic and radionuclides may also be present in ground water through leaching of natural

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sources. All four tribes assessed ground water quality for fluoride. Three of the four tribes assessed arsenic and either gross alpha or uranium concentrations as well. Arsenic and radionuclide data were not available to the La Jolla Band of Indians.

Ground water assessments were conducted by reviewing historic water quality data of operating wells, monitoring the quality of water from springs, and collecting supplemental ground water quality data in the vicinity of the reservations. The number of wells sampled ranged from five wells (La Jolla Band of Indians) to 47 wells (Agua Caliente Band of Cahuilla Indians). Common parameters monitored on the reservations included nitrate, arsenic, fluoride, radionuclides, volatile organic compounds, and semivolatile organic compounds. Monitoring data were compared to federal drinking water standards to assess whether the ground water met beneficial uses such as drinking water, agricultural supply, and/or industrial supply.

Nitrate is present at detectable concentrations in ground water collected from all four reservations. However, the maximum contaminant level, or MCL, for nitrate is rarely exceeded. Fluoride and arsenic are also present at detectable concentrations. Radionuclides are measured at concentrations that are generally representative of background conditions.

Fluoride was the most frequently detected constituent at concentrations exceeding the drinking water standard in ground water collected from the 29 Palms Reservation. Fluoride was measured at concentrations exceeding one-half the drinking water standard in ground water collected from the Torres-Martinez Reservation. In contrast, nearly 30%, or 20 out of 71 samples, exceeded the MCL for arsenic in ground water collected from the Torres-Martinez Reservation. MCL exceedances were rarely observed in ground water collected from the Agua Caliente Reservation. Of the three tribes that tested for volatile organic compounds or semivolatile organic compounds, no concentrations exceeded the MCL. Hence, although some water quality issues may exist on the reservations, these water quality impacts do not seem to be caused by anthropogenic sources. Rather, most of the observed MCL exceedances can be traced back to natural sources.

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Different Types of Monitoring Settings

Thirty-one states reported data summarizing ground water quality. In total, data were reported for 146 aquifers or other hydrogeologic settings for the 1998 305(b) cycle. States that were unable to report ground water quality data for specific aquifers assessed ground water quality using a number of different hydrogeologic settings, including statewide summaries, counties, watersheds, basins, and sites or areas chosen for specific monitoring purposes. A brief description of several ground water assessment methods and their rationale is presented.

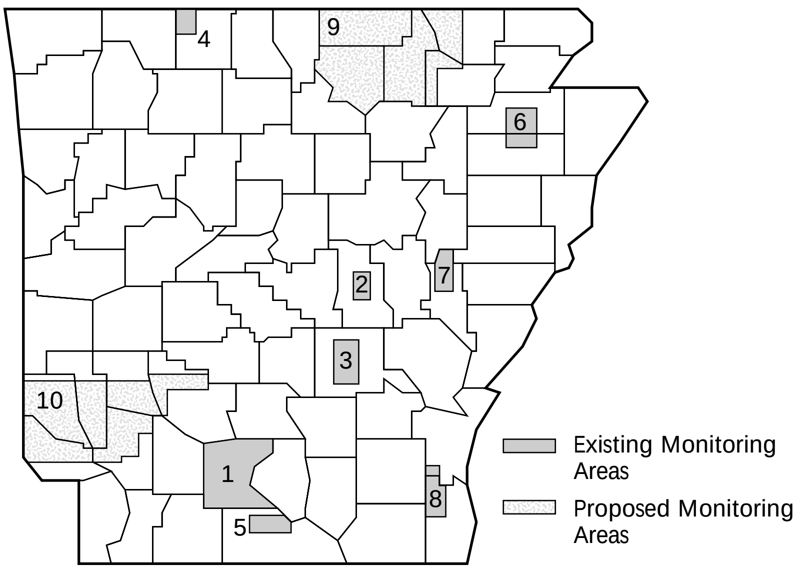

Figure 1. Arkansas Ambient Ground Water Monitoring Program

Existing monitoring areas include Ouachita (1), Lonoke (2), Pine Bluff (3), Omaha (4), El Dorado (5), Jonesboro (6), Brinkley (7), and Chicot (8). Expansion areas will include Hardy (9) and Athens Plateau (10).

Arkansas – Ambient Ground Water Monitoring Program

The Arkansas Department of Pollution Control and Ecology began its Ambient Ground Water Monitoring Program in 1986 to monitor overall ground water quality in the state. The Program currently consists of eight active monitoring areas and two proposed areas selected to evaluate potential impacts from multiple land uses (Figure 1). The areas are in different counties covering the diverse geologic, hydrologic, and economic regimes within the state. One area is characterized by the largest community using ground water to meet all of its needs. An objective of the monitoring program is to monitor water quality that is affected by public and commercial well use. For the 1998 305(b) cycle, Arkansas reported their most recent round of results for the eight active monitoring areas.

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Indiana – Hydrogeologic Settings

Indiana developed a system that allows for data to be analyzed according to similar surface and subsurface environments. To interpret the ground water sensitivity to contamination, the analysis considers the composition, thickness, and geometry of the aquifers; variability of the confining units; surface and ground water interactions; and recharge/discharge relationships (Figure 2). For the 1998 305(b) cycle, Indiana selected hydrogeologic settings that were vulnerable to contamination and contain large populated areas (i.e., areas of greatest ground water demand). These settings were principally outwash deposits or fans of glacial origin.

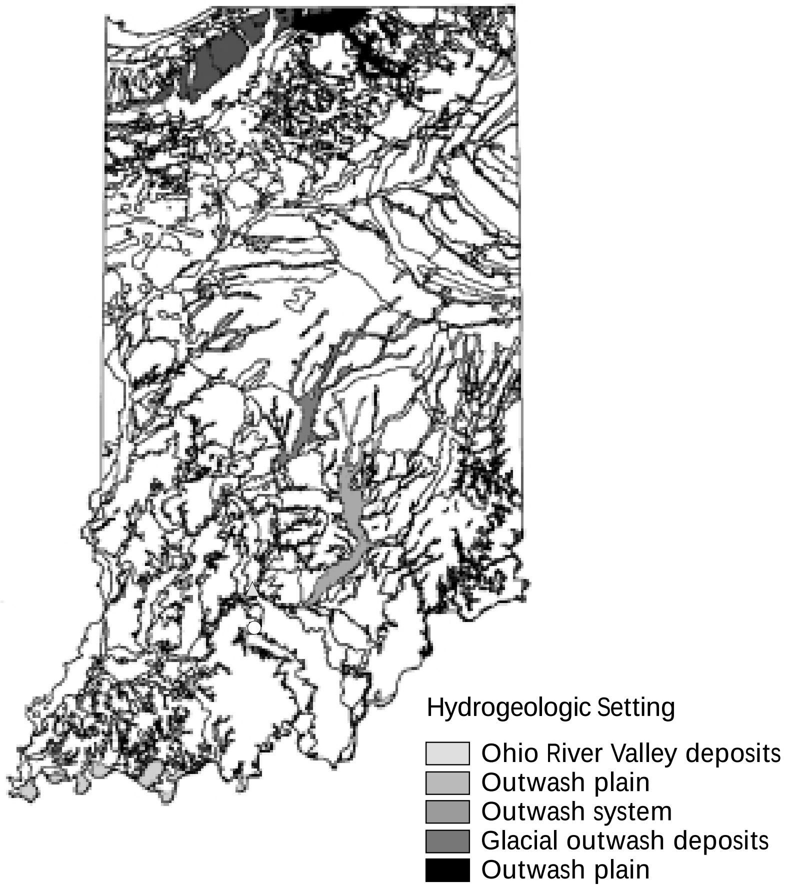

Figure 2. Map of Hydrogeologic Settings

Alabama – Cumberland Plateau Ground Water Province

Alabama divided the state into physiographic provinces and is assessing ground water quality in aquifers in different provinces with each successive 305(b) cycle. Ground water quality in the Tuscumbia Fort Payne Aquifer outcrop area in the Highland Rim Province

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was evaluated in 1996. Alabama provided ground water quality data for the Cumberland Plateau Ground Water Province for 1998 (Figure 3). This area includes all or parts of 13 counties in north Alabama that are underlain by three major aquifer outcrop areas. The aquifers outcropping include the Pottsville Aquifer, the Tuscumbia-Fort Payne Aquifer, and those aquifers of Cambrian-Ordovician age. The shallow aquifers of the Cumberland Plateau Ground Water Province are considered vulnerable to contamination from surface sources through fractures and sinkholes that provide direct recharge to the subsurface. Some of these aquifers are also highly vulnerable to contamination through karst features that provide direct access from the surface into the aquifer.

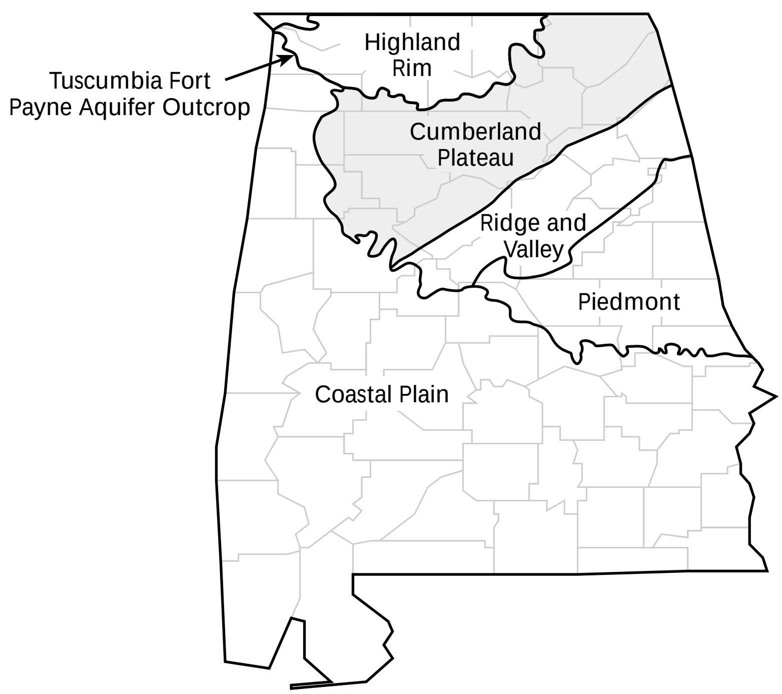


Figure 3. Alabama Physiographic Provinces

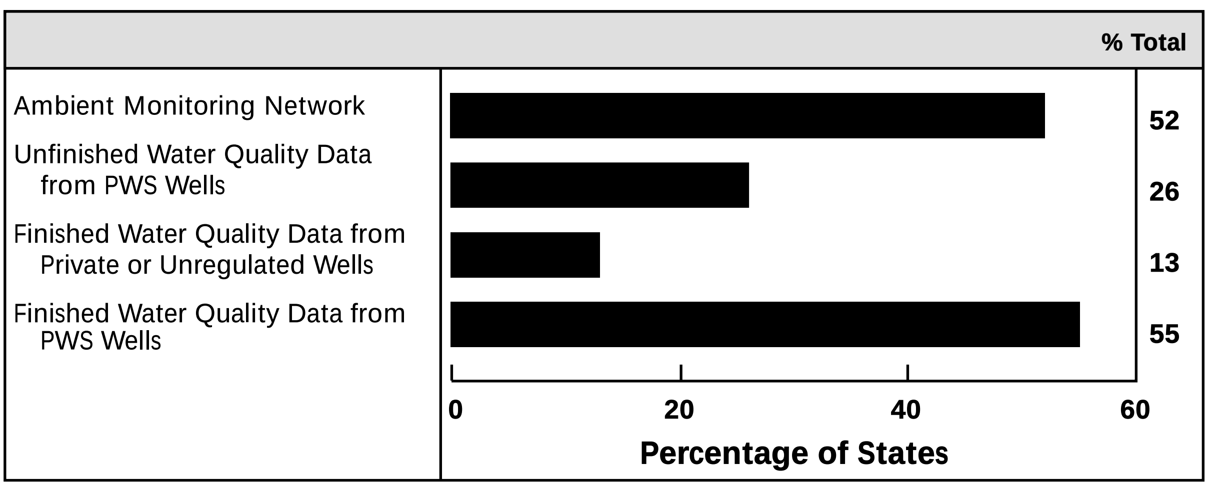
manufactured compounds (i.e., the volatile organic compounds and semivolatile organic compounds) in ground water is a definitive indication of contamination from human sources. Even if only limited data are available for assessing ground water quality, the presence of VOC and SVOCs is of serious concern. The presence of nitrate at concentrations exceeding background levels is another sign of human impacts to ground water quality. In fact, states indicated that they used nitrate as an “indicator” parameter of water quality impacts, and all 31 states reported nitrate data.

States also reported monitoring data for an “others” category. This usually referenced inorganic and/or metallic contaminants. Inorganic constituents generally referred to water quality parameters that were more reflective of natural background conditions than adverse impacts to ground water quality resulting from human activities. Some examples include sodium, calcium, magnesium, potassium, bicarbonate, fluoride, and chloride. In contrast, elevated concentrations of some metals can be a strong indication of water quality impacts resulting from human activities. Metals that reflect human activities include barium, arsenic, mercury, cadmium, zinc, lead, selenium, copper, chromium, silver, and nickel.

Tables 7-2 through 7-6 present state data for nitrate, VOCs, SVOCs, pesticides, and metals. In most cases, the reported data represent average concentration values for the monitoring period. However, some states reported results based on the maximum concentration detected in wells during the monitoring period. It is important to remember that the aquifer monitoring data reported by states represent different sources, often with different monitoring purposes, and care must be taken in making data

Figure 7-10

Sources of Ground Water Monitoring Data



Note: Percentage based on a total of 31 states submitting data. Some states used multiple data sources.

comparisons. Monitoring data most closely approximating actual ground water conditions (e.g., untreated ground water) are given special consideration in these assessments.

States reported aquifer monitoring data for nitrate more frequently than for any other parameter or parameter group. Nitrate is well suited for use as an indicator parameter. Its presence in ground water systems is indicative of human activities and it can be detected at relatively low concentrations through the use of standard, reliable, and relatively inexpensive analytical methodologies.

Table 7-2 presents aquifer monitoring data for nitrate for the 1998 305(b) reporting cycle. With the exception of untreated water quality data from public water supply (PWS) wells, the maximum contaminant level (MCL) of 10 mg/L was exceeded in at least 40% of the hydrogeologic settings for which states reported nitrate data. However, although elevated nitrate levels were documented by states in ground water, the percentage of wells that were impacted by nitrate levels in excess of the MCL was less than 5% for ambient ground water monitoring networks and less than 1% for drinking water sources. The percentage of wells impacted by nitrate was higher in the two special studies reported by states. However, these studies were specifically designed to monitor land use effects with the potential to contribute nitrate to the environment, so their data may be skewed.

Tables 7-3 through 7-5 provide summary information for VOCs, SVOCs, and pesticides. States reported ground water monitoring data for VOCs more frequently than for either SVOCs or pesticides.

Table 7-2. Monitoring Results for Nitrates

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceedances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceedances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	16	10	95	38 (40%)	7,555	307	55 out of 114	8
Unfinished Water Quality Data from PWS Wells	8	0	20	0	538	0	0 out of 173	0
Unfinished Water Quality Data from Private or Unregulated Wells	4	3	4	3 (75%)	12,180	62	48 out of 3,165	21
Finished Water Quality Data from PWS wells	17	10	57	26 (46%)	32,936	379	284 out of 3,057	14
Special Studies	2	2	6	4 (67%)	424	68	33 out of 96	17

MCL = Maximum contaminant level.
PWS = Public water supply.

Approximately half of the reporting states indicated that VOCs had exceeded MCLs in ground water. Approximately 25% of the hydrogeologic settings were characterized by MCL exceedances of VOCs in ambient ground water. However, only 6% of the wells used to assess ambient ground water quality were characterized by MCL exceedances of VOCs. The greatest percentage of MCL exceedances (9%) was observed in private and unregulated wells.

Four states reported data for pesticides in ambient ground water. Of these four states, two states reported the presence of pesticides at concentrations exceeding MCLs. Levels of pesticides exceeding MCLs impacted 17% of the hydrogeologic settings and 2% of the wells monitoring ambient ground water conditions. Semivolatile organic compounds were rarely measured in ground water at concentrations exceeding MCLs.

Forty percent of the hydrogeologic settings for which states reported ambient ground water monitoring data were affected by metal concentrations that exceeded MCL values. The percentage of hydrogeologic settings affected by elevated metal concentrations was even higher for untreated and finished water collected from PWS wells. Again, although the number of settings is relatively high, the percentage of wells that are characterized by MCL exceedances is relatively low with approximately only 1% of the wells monitoring ambient ground water conditions being impacted. In contrast, 12% of the wells supplying untreated water quality data from PWS were impacted.

Table 7-3. Monitoring Results for Volatile Organic Compounds

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceedances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceedances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	9	4	55	13 (24%)	3,644	214 (6%)	143 out of 441	16
Unfinished Water Quality Data from PWS Wells	6	3	18	3 (17%)	404	9	6 out of 11	3
Unfinished Water Quality Data from Private or Unregulated Wells	1	1	2	1 (50%)	23	2 (9%)	2 out of 19	2
Finished Water Quality Data from PWS wells	17	9	60	13 (22%)	17,021	83	47 out of 1,484	6
Special Studies	1	0	1	0	0	0	0	0

MCL = Maximum contaminant level.
PWS = Public water supply.

Examples of State Assessments

Although very positive strides were made in assessing ground water quality in 1998, ground water data collection under Section 305(b) is still too immature to provide national assessments. Despite the lack of national coverage, states have demonstrated strong assessment capabilities. Following are descriptions of two states' assessments that may be useful to other states in designing and implementing monitoring programs.

Idaho

Idaho is one of the top five states in the nation with respect to the volume of ground water used to meet the needs of its population. Idahoans use an average of 9 billion gallons of ground water daily. Sixty percent of this water is used for crop irrigation and stock animals, 36% is used by industry, and 3% to 4% is used for drinking water. Even though the volume of ground water used as drinking water is relatively small in comparison to the total ground water used, more than 90% of the total population in Idaho relies on ground water for drinking water supply.

To characterize and protect this valuable resource, Idaho developed a monitoring approach that includes a statewide ambient ground water quality monitoring network integrated with regional and local monitoring. The statewide monitoring network is used to

- Characterize ground water quality conditions
- Identify trends in ground water quality

Table 7-4. Monitoring Results for Semivolatile Organic Compounds

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceed-ances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceed-ances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	6	1	18	1	357	1	1 out of 81	1
Unfinished Water Quality Data from PWS Wells	7	1	16	1	338	1	1 out of 26	1
Unfinished Water Quality Data from Private or Unregulated Wells	1	0	1	0	2	0	0 out of 2	0
Finished Water Quality Data from PWS wells	15	2	36	2	12,518	8	7 out of 193	4
Special Studies	—	—	—	—	—	—	—	—

MCL = Maximum contaminant level.
PWS = Public water supply.
— = Not applicable.

■ Identify existing and emerging ground water quality concerns in Idaho's major aquifers.

The monitoring network consists of a statistically designed set of more than 1,500 sites (wells and springs) used for domestic, irrigation, public water supply, and stock purposes. These sites are sampled on a rotational basis so that most locations are sampled at least once every 4-year period, with some wells being sampled yearly. Ground water samples are analyzed for many of the analytes monitored under the Safe Drinking Water Act. All samples are analyzed for volatile organic compounds, nutrients, fecal coliform, trace elements, radionuclides, pesticides, and major ions.

Regional and local monitoring can be used to (1) identify and delineate ground water contamination problems that are smaller in scale and may not be immediately evident on the larger scale of the statewide monitoring effort, (2) determine the areal extent of ground water contamination to ensure that beneficial uses are protected, (3) determine the effectiveness of remediation activities and best management practices, and (4) provide information, direction, and prioritization to state ground water quality programs. Thus far, regional or local monitoring projects have been used to further characterize many of the aquifers in Idaho, especially those where ground water quality has been identified as a concern.

Idaho has a very diverse geology and there are numerous aquifers and aquifer types throughout the state. Seventy major flow systems, with each flow system comprising one or more major aquifers, have been identified and combined into 22 hydrogeologic areas. Each area represents

Table 7-5. Monitoring Results for Pesticides

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceedances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceedances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	4	2	18	3 (17%)	758	16 (2%)	8 out of 25	5
Unfinished Water Quality Data from PWS Wells	1	1	7	1	46	2	2 out of 3	2
Unfinished Water Quality Data from Private or Unregulated Wells	1	0	1	0	27	0	0 out of 27	0
Finished Water Quality Data from PWS wells	1	1	1	1	8	1	1 out of 8	1
Special Studies	2	1	4	2	328	2	1 out of 96	1

MCL = Maximum contaminant level.
PWS = Public water supply.

geologically similar areas and generally encompasses one or several of the 70 major ground water flow systems. Figure 7-11 shows the hydrogeologic area boundaries and the major flow systems within Idaho.

For ground water quality management purposes, including implementation of regional and local monitoring, areas or flow systems are usually further broken down to a single aquifer or portion of an aquifer that focuses on a specific priority area. These priority area boundaries are usually based on considerations such as land use, hydrogeology, ground water quality, political boundaries, wellhead (source water) protection areas, and watershed boundaries. Figure 7-12 illustrates some of these priority areas where there are elevated levels of nitrate. This information is being used to provide direction to various ground water quality protection programs in Idaho.

Data collected from all monitoring efforts thus far indicate that most of Idaho's ground water is both potable and safe for current beneficial uses. However, no area tested is free of contaminant concerns. At least 7% of the sites had a constituent with a concentration exceeding the Safe Drinking Water Act maximum contaminant level. Initial trend analyses indicate that, overall, nitrate concentrations increased from the first round (1991 through 1995) of sampling to the second round (1995 through 1998). Although results show that only 3% of sample sites across Idaho exceed the nitrate MCL of 10 milligrams per liter, within the nitrate priority areas (Figure 7-12), this value increases to about 17%.

Table 7-6. Monitoring Results for Metals

Monitoring Type	Number of States Reporting	Number of States Reporting MCL Exceedances	Total Number of Units for Which Data Were Reported	Number of Units Having MCL Exceedances	Total Number of Wells for Which Data Were Reported	Number of Wells Impacted by MCL Exceedances	Highest Number of Wells that Exceeded MCL within a Single Unit	Average Number of Wells that Exceeded MCL within a Single Unit
Ambient Monitoring Network	7	5	40	16 (40%)	19,636	111 (<1%)	24 out of 28	5
Unfinished Water Quality Data from PWS Wells	4	2	4	2	199	23 (12%)	20 out of 71	8
Unfinished Water Quality Data from Private or Unregulated Wells	1	0	1	0	5	0	0 out of 5	0
Finished Water Quality Data from PWS wells	3	2	4	2	3,380	63	46 out of 1,107	16
Special Studies	1	0	2	0	63	0	0	0

MCL = Maximum contaminant level.
PWS = Public water supply.

Pennsylvania

Nearly half of the population in Pennsylvania relies on ground water for drinking water purposes, and, in some areas, ground water serves as the sole source of water. To protect its ground water resources, Pennsylvania developed a ground water monitoring system that accomplishes the following goals:

- Measures ambient ground water quality
- Provides an indication of long-term ground water quality trends resulting from land use practices
- Assesses the success or failure of land management practices.

Pennsylvania's ground water monitoring program was developed following division of the state into 478 ground water basins (Figure 7-13). Although the basins are not true hydrologic units, each basin considers similarities in hydrologic

Figure 7-11

Idaho's Hydrogeologic Subareas and Major Aquifer Flow Systems

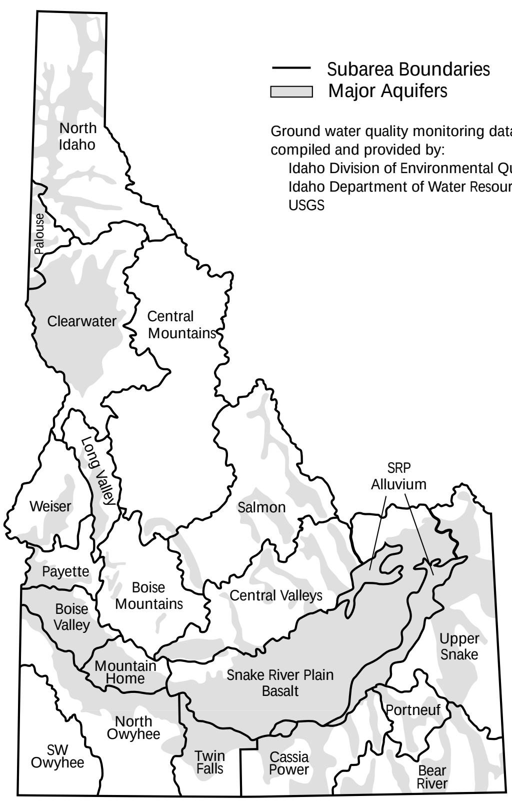
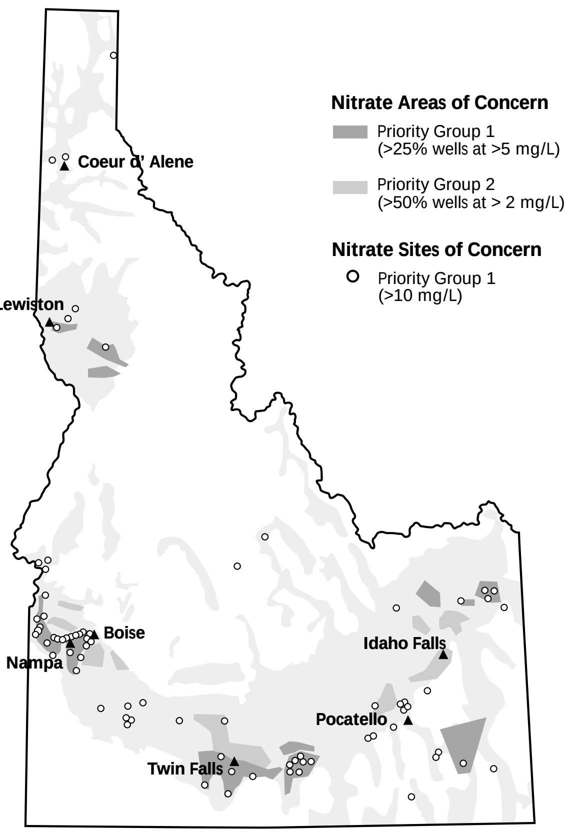


Figure 7-12

Ground Water Areas and Sites Impacted by Nitrate



and physical features. The basins were prioritized for monitoring purposes in 1985 according to three main factors:

- Ground water use
- Potential unmonitored sources of ground water pollution
- Environmental sensitivity.

The 50 highest-ranking basins were selected for monitoring.

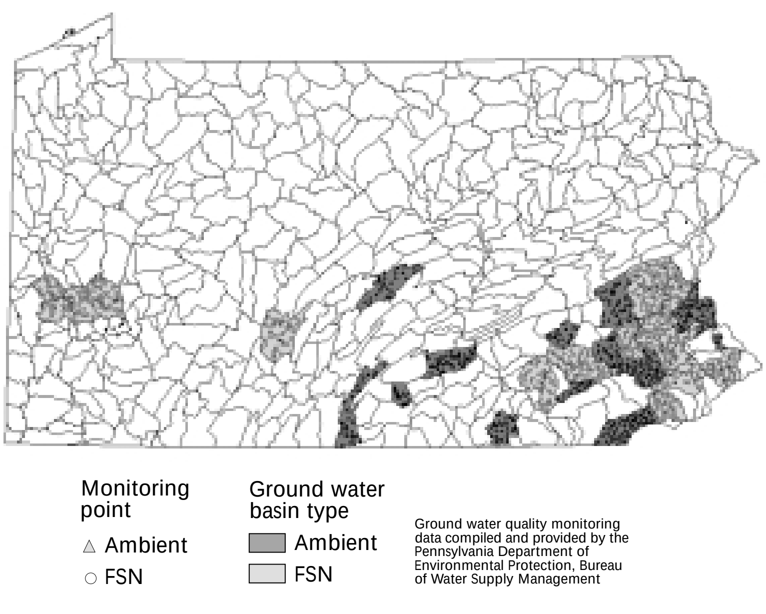
Two types of ground water monitoring are used (Figure 7-13). Ambient monitoring is used to collect basin-wide data for basins where little ground water quality data exist. Typically, two rounds of samples are collected in one hydrologic year. Ambient monitoring supplements other data collection efforts and provides a general picture of ground water quality in the watershed. Fixed station network monitoring is used when long-term data are required. Fixed station monitoring involves collecting two rounds of ground water samples per hydrologic year for a minimum of 5 years. Basins selected for this type of monitoring are typically high-priority basins where regional changes are occurring such as rapid urbanization or other modifications in land use or where specific water quality problems exist.

Results indicate that ground water quality in Pennsylvania is typically good. This is despite sampling in high-priority basins, which likely biases the data and presents a more negative picture of the overall ground water quality.

In spite of the overall good quality of ground water, exceedances of drinking water standards were detected. Some exceedances result from naturally elevated concentrations of substances such as iron, total dissolved solids, manganese, or low pH. However, trend analyses of nitrate, sodium, chloride, and total hardness suggest that ground water quality in Pennsylvania is undergoing some change that likely results from human activities. Sodium and chloride were two of the analytes exhibiting upward trends at more than 10% of the 478 monitoring points (Figure 7-14). Analytes with downward trends at more than 10% of the 478 monitoring points included pH, nitrate, magnesium, and sulfate.

Figure 7-13

Location of High-Priority Ambient and Fixed Station Network (FSN) Ground Water Basins and Monitoring Points



Ground water quality monitoring data compiled and provided by the Pennsylvania Department of Environmental Protection, Bureau of Water Supply Management

Exact causes of the ground water quality trends are difficult to determine. Different areas of the state are obviously under different stresses and only general inferences can be made from the data. Natural shifts in ground water quality may result from changes in precipitation trends or cycles. Downward trends in nitrate and sulfate at many monitoring points may reflect a reduction in sources of nitrate from agricultural areas (fertilizers), septic systems, and atmospheric deposition. Increasing trends in total dissolved solids (TDS), chloride, calcium, potassium, total hardness, and sodium at many monitoring points may result from increased nonpoint source pollution such as road salting and sprawling paved developments and suburbs.

Conclusions and Findings

Based on results reported by states as part of the 1998 305(b) cycle, the following are concluded:

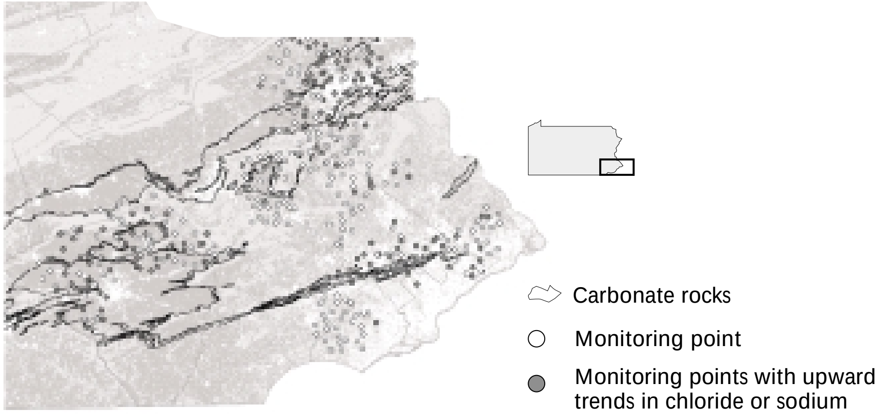
■ Ground water is an important component of our nation's fresh water resources. The use of ground water is of fundamental importance to human life and is also of significant importance to our nation's economic vitality.

■ Assessing the quality of our nation's ground water resources is no easy task. An accurate and representative assessment of ambient ground water quality requires a well-planned and well-executed monitoring plan. Although the 305(b) program is definitely moving in the direction of more and better ground water quality assessments, there is still much more that needs to be done. Coverage, both in terms of the area within a state and the number of states reporting ground water quality monitoring data, needs to be enlarged. States also need to focus on collecting ground water data that are most representative of the resource itself. Specifically, states need to rely less on finished water quality data and more on ambient ground water quality data.

■ Good quality data is essential to forming a basis for determining ground water quality. Required source water assessments under Section 1453 of the Safe Drinking Water Act should prove to be helpful in augmenting the amount

Figure 7-14

Monitoring Points with Upward Trends in Sodium or Chloride



Ground water quality monitoring data compiled and provided by the Pennsylvania Department of Environmental Protection, Bureau of Water Supply Management of data available and to generate good quality data that can be used to evaluate ground water quality over time.

- The 1996 and 1998 305(b) reporting cycles represent the first time that states reported quantitative ground water quality data. One of the greatest successes was the increase in uniformity of data reported by states for 1998. There was an increase in reporting uniformity over the course of just one 305(b) cycle as states became increasingly familiar with the reporting guidelines and developed methods for obtaining and reporting the requested data.

- Although ground water quality assessments are being performed and reported under the 305(b) program, vast differences in ground water management are apparent. Several states have implemented monitoring programs designed to characterize ground water quality and identify and address potential threats to ground water. Other states have only just begun to implement ground water protection strategies.

- One of the most important factors in deciding state priorities concerning the assessment of ground water quality is economic constraints. Characterizing and monitoring ground water quality is expensive. Few states have the economic resources to assess ground water quality across an entire state. Therefore, states are applying different approaches to ground water protection. These approaches are based on each state's individual challenges and economic constraints. Approaches range from implementing statewide ambient ground water monitoring networks to monitoring selected aquifers on a rotating basis. States determine the approach based on the use of the resource, vulnerability to contamination, and state management decisions.

- National coverage increased from 1996 to 1998. In the 1996 305(b) reporting cycle, states reported ground water monitoring data for a total of 162 hydrogeologic settings. In 1998, states reported data for 146 hydrogeologic settings. Data for 65 of the 146 settings described in 1998 represented the most recent monitoring results for units previously described in 1996. Thus, data were reported for 81 new hydrogeologic settings in 1998.

- The conceptual framework for designing and implementing a ground water monitoring network is similar across the nation. The Intergovernmental Task Force on Monitoring Water Quality (ITFM) concluded that the definition and characterization of environmental monitoring settings is a crucial first step in the collection of meaningful ground water quality data. States across the nation are taking this first step and defining and characterizing hydrogeologic monitoring units. Each of the states described in detail their approach and the rationale for that approach.

- EPA and the states need to devise more efficient ways to integrate ground water data collected through the Section 305(b) water quality inventory reports and ground water data collected from state source water assessments under Section 1453 of the SDWA.

Other monitoring data from wellhead protection delineations, source inventories, and other data collection efforts also must be integrated to increase and improve the information that is used to make determinations on the quality of ground water across the nation in the reporting requirement under Section 305(b) of the CWA.

■ Although much progress has been made in the 305(b) program to assess ground water quality, large gaps in coverage exist. The data submitted by states under the 305(b) program preclude a comprehensive representation of ground water quality in the nation at this time but, more importantly, may result in a skewed characterization of ground water quality that is more positive than actual conditions. If this is the case, problems in ground water quality may not be recognized until quality has been degraded to the point that the resource can no longer support the desired uses.

■ Based upon ground water quality data reported by states during the 1996 and 1998 305(b) cycles, ground water quality in the nation is good and continues to support the various uses of this resource.

■ Ground water contamination incidents are being reported in aquifers across the nation. Leaking underground storage tanks have consistently been reported as an important source of ground water contamination for all 305(b) cycles for which data were reported. In general, the threat from leaking underground storage tanks is due to the sheer number of tanks buried above water tables across the nation. Other important sources of ground water contamination include septic systems, landfills, hazardous waste sites, surface impoundments, industrial facilities, and agricultural land practices.

■ Petroleum chemicals, volatile organic compounds, semivolatile organic compounds, pesticides, nitrate, and metals have been measured at elevated levels in ground water across the nation. The most frequently cited contaminants of concern were volatile organic compounds and petroleum chemicals. These classes of chemicals have consistently been reported as ground water contaminants. States have also reported increasing detections of chemicals not previously measured in ground water (for example, MTBE and metals). The recent detection of these chemicals may represent emerging trends in ground water contamination.

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