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National Water Quality Inventory 1994 Report to Congress

Ground Water Chapters

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Preface

The *National Water Quality Inventory Report to Congress* is the primary vehicle for informing Congress and the public about general water quality conditions in the United States. It summarizes information related to the quality of our Nation's water resources as reported by States, Territories, and American Indian Tribes in their water quality assessment reports. The Clean Water Act, Section 305(b), requires that the States and other participating jurisdictions submit water quality assessment reports every 2 years. It also requires that the U.S. Environmental Protection Agency (EPA) summarize the reports submitted by the States and other jurisdictions and provide the information to Congress every 2 years. Most of the survey information in the 1994 Section 305(b) reports is based on water quality information collected and evaluated by the States, Territories, and Tribes during 1992 and 1993.

In reviewing the data in this bulletin, it is important to remember that the States and other participating jurisdictions that provided data for the report do not use identical survey methods and criteria to rate water quality. The *National Water Quality Inventory Report to Congress* must balance flexibility with the goal of obtaining comparable and consistent data. In the past 6 to 8 years, EPA has sought to establish guidelines for data collection that would lend consistency to the data collected, analyzed, and provided to EPA for this report. Recent joint actions by EPA, States, and other agencies include implementing the recommendations of the Intergovernmental Task Force for Monitoring Water Quality and refining the *Guidelines for Preparation of the 1996 State Water Quality Assessments (305(b) Reports).* The Task Force report recommends a strategy for nationwide water quality monitoring and technical monitoring improvements to support sound water quality decision-making at all levels of government and in the private sector. The 1996 guidelines for the 305(b) process give the States much needed flexibility in selecting aquifers on which to focus their efforts in assessing ground water quality and establishing baseline data requirements. The refinement of these guidelines is expected to make comparison and interpretation of ground water quality more meaningful in the *1996 National Water Quality Inventory Report to Congress.*

The following bulletin focuses on our Nation's ground water resources. Using information supplied by the States, Territories, and Tribes in their 1994 Section 305(b) reports, the two chapters characterize our Nation's ground water quality, identify widespread ground water quality problems of national significance, and describe various programs implemented to restore and protect our ground water resources. The chapters summarize information submitted by 48 States, 2 Territories, and 5 Tribes, and highlight additional subjects that are important in ground water quality protection.

It is hoped that the reader recognizes the importance of ground water from this reading. It is also important to note that national initiatives alone cannot clean up our waters; water quality protection and restoration must happen at the local and State levels in conjunction with State and Federal activities, funding, and programs. This bulletin alone cannot provide the detailed information needed to manage a water quality program. However, this information can be used, together with the individual State Section 305(b) reports, water management plans, and other local documents, to assist in developing a ground water management program.

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Acknowledgments

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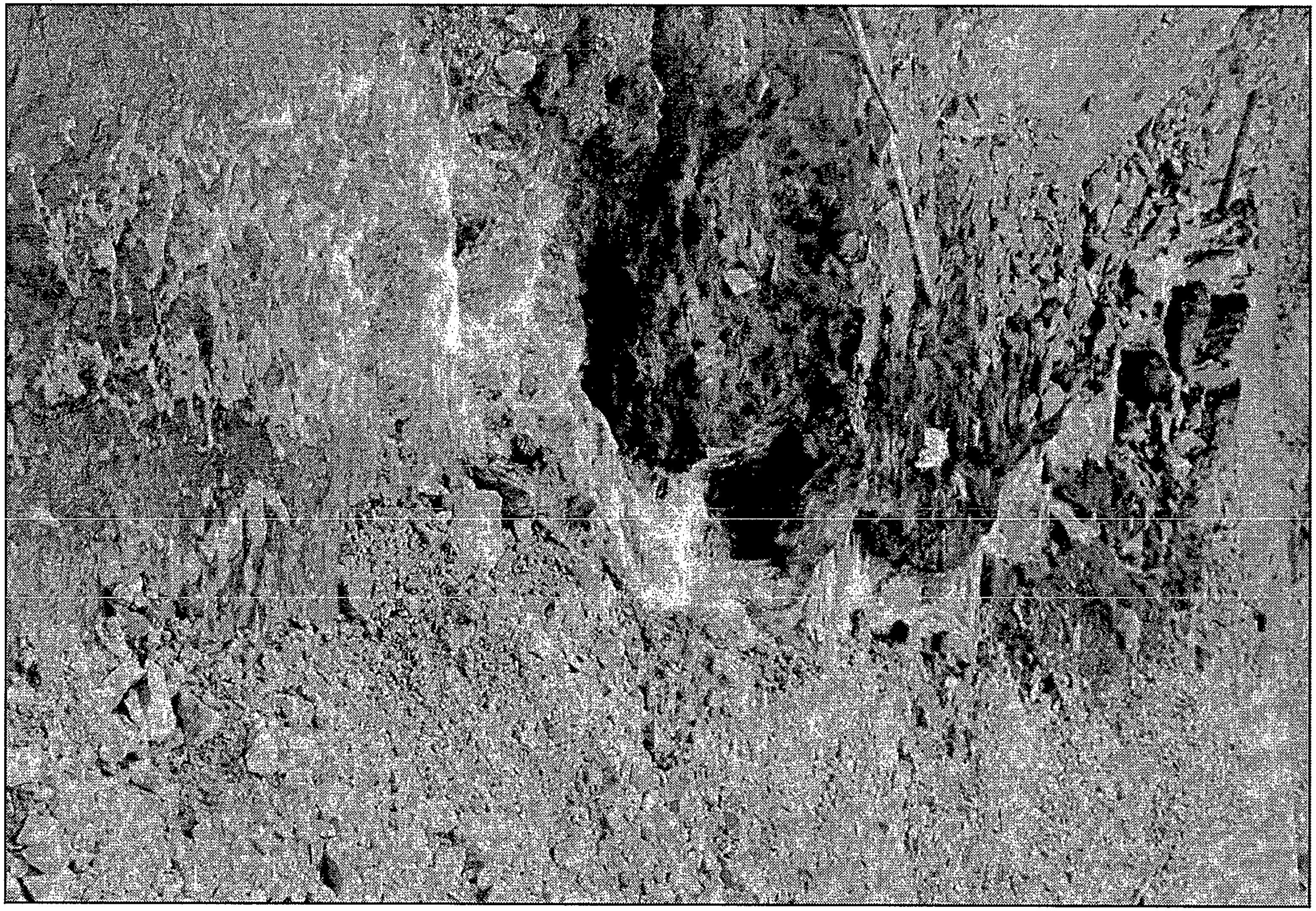


Ground Water Quality

Ground water is a vital national resource that is used for a myriad of purposes. It is used for public and domestic water supply systems, for irrigation and livestock watering, and for 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. In their 1994 305(b) reports, States, Tribes, and Territories identified contaminant sources and the associated contaminants that threaten the integrity of their ground water resources. Controlling these sources of contamination and preventing further contamination of the resource have become the focus of numerous local, State, and Federal programs.

This section contains information provided by 48 States, 2 Territories, and 5 Tribes in their 1994 305(b) reports. The 1994 305(b) reports are based on guidelines, developed by EPA, requesting that each reporting agency characterize the quality of its ground water resources. Because few States and Tribes possess the capability to characterize ground water quality using ambient monitoring data, EPA asked them to provide available information on specific contaminant sources and associated contaminants degrading ground water quality. And, for the first time, EPA asked States and Tribes to provide information on selected parameters that will be used in the future to provide an indication of spatial and temporal trends in ground water quality.

This chapter presents an overview of ground water use in the United States as well as a discussion detailing State-identified sources of contamination and contaminants that are adversely impacting our Nation's ground water quality. State progress in the development of ambient ground water monitoring networks is highlighted. The progress made in developing ground water indicators is also described.

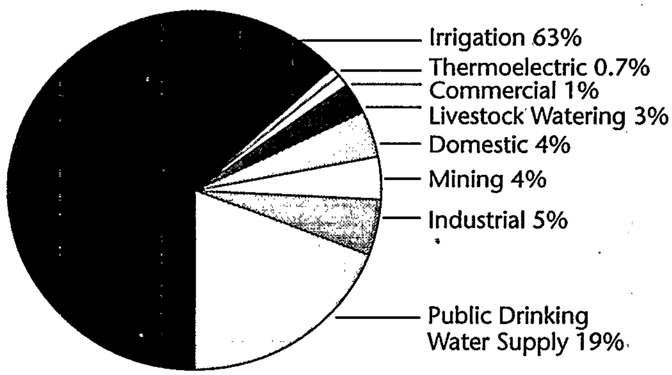
GROUND WATER is a source of drinking water for 51% of the population.

Ground Water Use in the United States

In 1990, ground water supplied 51% of the Nation's population with drinking water—the highest-priority use of water. Overall, ground water supplied approximately 20% (80.6 billion gallons per day [bgd] out of a total 408.4 bgd) of all water uses in the United States. These water uses include public and domestic water supply, irrigation, livestock watering, mining, and commercial, industrial, and thermoelectric cooling applications. Figure 1 illustrates the distribution of ground water use among these categories. As shown, irrigation

Figure 1

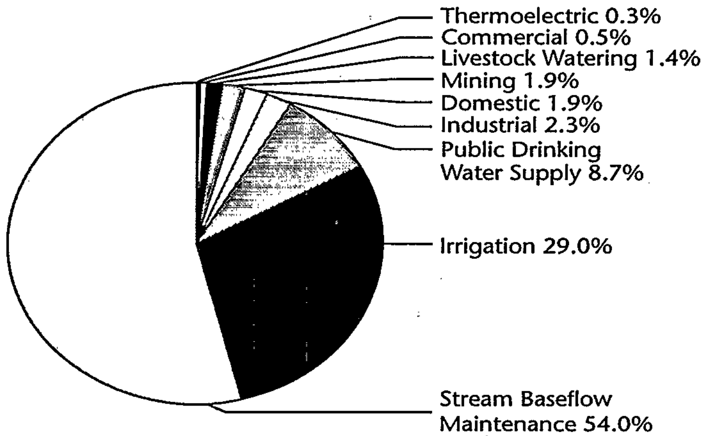
National Ground Water Use as a Percentage of Total Withdrawals



Source: Open-File Report 92-63, U.S. Geological Survey.

Figure 2

Withdrawal and Discharge of Ground Water as a Percentage of Contribution



Source: Open-File Report 92-63, U.S. Geological Survey, and *National Water Summary 1986, Hydrologic Events and Ground-Water Quality*, U.S. Geological Survey, Water-Supply Paper 2325.

(63%) and public water supply (19%) are the largest uses of ground water withdrawals.

One of the largest and most important contributions of ground water is not presented in Figure 1. The volume of ground water that is naturally discharged to streams and other surface waterbodies, thereby maintaining streamflow during periods of low flow or drought conditions, was previously unrecognized and unquantified. This volume, 492 bgd, is measured using special instruments or estimated using stream gaging and hydraulic gradient data. The importance of ground water flow into streams and other surface waters cannot be underestimated. Ground water can transport contaminants to streams and affect surface water quality and quantity, which may impact drinking water supplies drawn from surface waters, fish and wildlife habitats, swimming, boating, fishing, and commercial navigation. Modifications to the quantity or quality of ground water discharged into surface water ecosystems can also have major economic repercussions as a result of adverse impacts on recreation, public health, fisheries, tourism, and general ecosystem integrity.

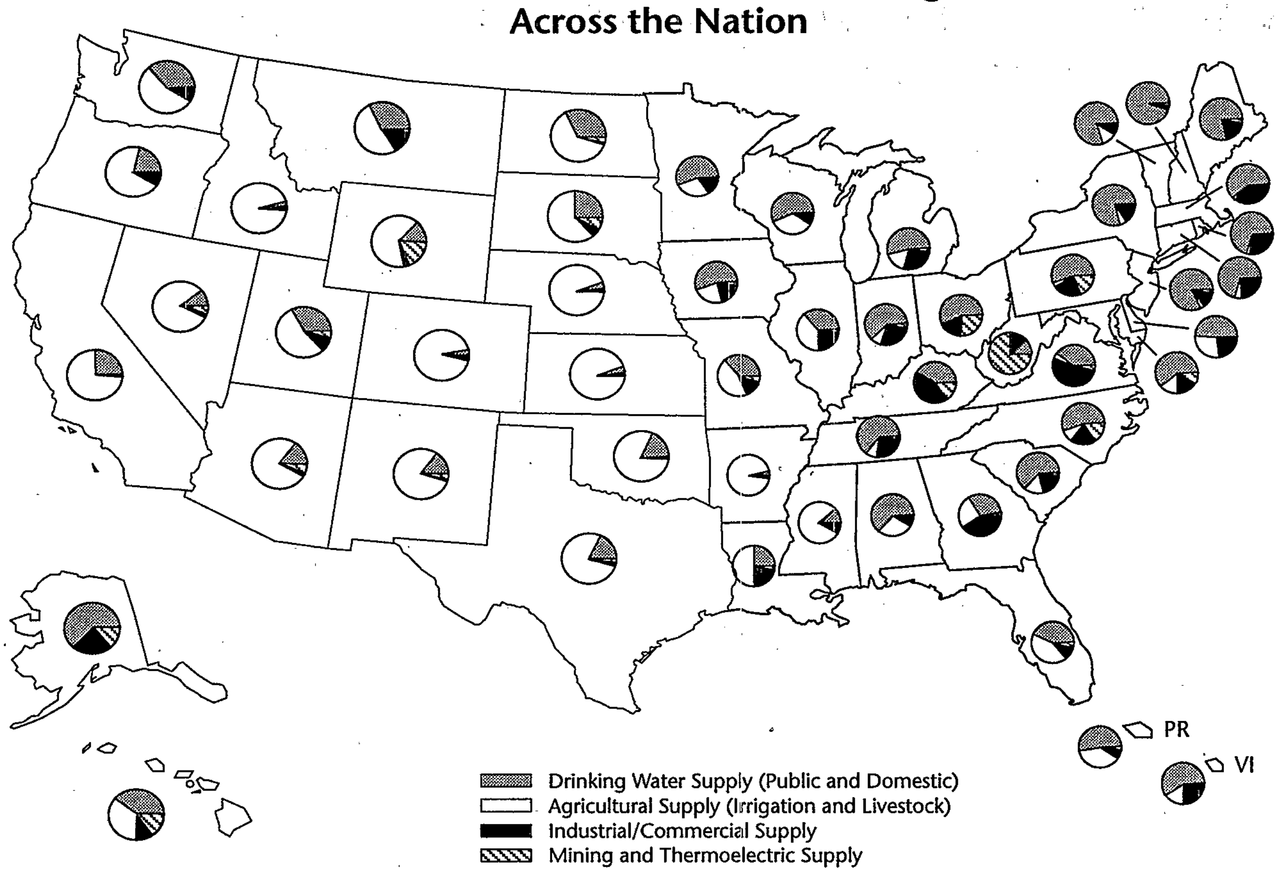
The importance of ground water to stream baseflow maintenance is illustrated in Figure 2, which shows all of the major uses of ground water in relation to stream baseflow maintenance. Stream baseflow maintenance accounts for 54% of ground water discharges. The next highest use of ground water is irrigation, which accounts for 29% of national ground water use. Figure 3 shows that ground water use for drinking water supply, agricultural supply, industrial/

commercial supply, and mining and thermoelectric supplies varies in different regions of the country. For example, ground water is more heavily used for drinking water and industrial/commercial supplies in eastern States and for drinking water and agricultural supplies in western States.

Despite the variation in usage across the Nation, ground water used for drinking water supply is one of the most critical uses. Data reported by the U.S. Geological Survey (USGS) were used to estimate ground water statistics related to public water supply (PWS) and private wells on a State-by-State basis. Specifically, the data were used to determine whether there was an increase or a decrease in the volume of ground water used for PWS from 1970 to 1990; the percent change in volume during the same period; the ratio of the change in ground water use from 1980 to 1990 to the change in surface water use during the same period for PWS; the percent of population dependent upon ground

Figure 3

Distribution of Ground Water Usage Across the Nation



Source: Open-File Report 92-63, U.S. Geological Survey.

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Vulnerability

Virtually all aquifers have some inherent susceptibility to contamination. To determine the susceptibility of aquifers to contamination from shallow (Class V) injection wells, EPA performed a nationwide assessment.* The purpose of the assessment was to determine ground water vulnerability and aquifer sensitivity for each of the 48 conterminous States.

Ground water vulnerability is dependent upon the geology of the physical system. However, population density and distribution are also important as the greatest number of shallow injection wells occur in areas of high population density. Aquifer sensitivity is related to the potential for contamination to occur. Aquifers that have a high degree of vulnerability and occur in areas of high population density are considered to be the most sensitive. The assessment determined that 44% of the shallow unconfined aquifers in the continental United States are highly susceptible to contamination, and that 60% have some degree of susceptibility.

Estimates of inherent susceptibility can be obtained through a variety of assessment methods that consider different characteristics of the aquifer and/or overlying materials. The assessment method selected depends on the goal of the assessment. Because the goal of, and method for, each assessment may be different, multiple assessments may yield different results. Such a seeming discrepancy in results does not detract from the benefits of susceptibility assessments for ground water management purposes, because results are goal-specific.

Several States have performed their own statewide aquifer susceptibility assessments to address a high-priority management concern. For example, Georgia performed a "DRASTIC" assessment of susceptibility and determined that approximately 65% of the State was either moderately or highly susceptible to surface-applied sources of contamination. These results are similar to those obtained by Pettyjohn et al. (1991)* in which it was estimated

* Pettyjohn, W.A., M. Savoca, and Dale Self, 1991, *Regional Assessment of Aquifer Vulnerability and Sensitivity in the Conterminous United States*, Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Ada, Oklahoma, 319 pages.

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that 62% of Georgia is susceptible to shallow subsurface sources of contamination.

Although high-priority concerns differ among States, the results of the nationwide assessment show that a significant part of the Nation is highly susceptible to at least some type of contamination. That such a significant portion of the Nation's ground water is susceptible attests to the need for contaminant prevention.

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Examples of Surface Water Contaminated by Contaminated Ground Water

EPA's Chesapeake Bay Office estimates that 30% to 40% of the nitrates entering the Bay, the major pollutant in the Bay, comes from ground water discharge. Agriculture is the primary source of these nitrates because farming is common in the huge watershed draining into the Bay. Along with nitrates, pesticides also enter the Bay. Pesticides are used to control pests on land and may be destroying beneficial organisms in ground water as well. Thus, the benefit that these organisms provide in cleaning ground water before it enters the Bay is lost. To further exacerbate the problem, the forests that surround the shoreline continue to be cleared as development spreads. Research shows that trees are effective in removing nitrates and other pollutants from ground water before it discharges to surface water, and thus another water cleaning mechanism is lost. In addition, the development that removes the trees adds yet more pollutant load to the watershed. This general model, with minor variations, is common throughout the country.

EPA recently published *A Review of Methods for Assessing Nonpoint Source Contaminated Ground Water Discharge to Surface Water,** which identified seven methods commonly used to estimate the quantity of ground water discharging to surface water. Although these methods are well established, published research that describes loadings from ground water for specific locations is not abundant. Nevertheless, a review of the scientific literature identified more than 100 studies nationwide in which contaminated ground water was discharged into and contaminated surface water. For example,

- In the Missouri Valley watershed, ground water accounts for 84% to 95% of the nitrate loading to surface water.

- On the St. John's River, Florida, about 20% of chloride loading comes from ground water seeping into canals that drain into the river.

- At the Mahantango Creek watershed in Pennsylvania, a link was observed between the intensity of corn production and concentrations of atrazine in ground water. As corn production and the use of atrazine increased, higher concentrations of atrazine were observed in more wells. Specifically, atrazine was

*U.S. EPA, 1991, Office of Water, EPA 570/9-91-010.

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detected at concentrations less than EPA standards in 74% of all sampled wells.

- In Rehoboth Bay, Indian River Bay, and Little Assawoman Bay, Delaware, over 75% of nitrogen loading comes from ground water discharge.

- In Key Largo Marine Sanctuary, Florida, ground water discharge showed numerous pesticide peaks and heavy metal concentrations 100 to 10,000 times above sea water levels.

- In Cedar River, Iowa, the pesticides atrazine and deethylatrazine were found in the river and 75% was contributed from ground water.

- In the Indian River estuary in Florida, dissolved reactive phosphate was found and 99% came from ground water discharge.

Microbial Paths of Contamination

Various pathogenic microorganisms are also introduced into ground water and surface water as a result of various human activities. These activities include malfunctioning septic systems, back-siphonage of water systems, and maintenance deficiencies. The most relevant diseases spread by these pathogens are those related to consumption of contaminated drinking water, including gastroenteritis, campylobacteriosis, and hepatitis A. The protozoan *Cryptosporidium* has recently been recognized as a significant human pathogen. Floods and other natural disasters can also cause pathogens to enter ground water and surface water used for drinking water supplies.

In the summer of 1994, State agencies in Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin and the Centers for Disease Control and Prevention coordinated a survey of the contamination of well water. Samples were taken from 5,530 private wells evenly spaced across these States. Preliminary results of the survey indicated that coliform bacteria were present in 41% of these wells. The presence of coliform bacteria may indicate contamination by harmful bacteria and viruses. In the sampled wells, Federal drinking water standards established for nitrates and atrazine in public water systems were exceeded in 14% and 0.4% of these wells, respectively. The results are being analyzed for associations between well contamination and well construction practices and health effects.

water for drinking water supplies in 1990; and the percent of ground water used for private drinking water supplies. Ground water statistics are provided in Appendix A, Table A-1. Figure 4 illustrates the percentage of population dependent upon ground water for drinking water in 1990. As shown, New Mexico, Mississippi, and Florida rely on ground water for 90% or more of their drinking water supply. Following is a brief summary of significant trends.

For the period 1970 to 1990,

- Twenty-one States and one Territory increased ground water use for public water systems at a rate greater than overall public water use.

- Alaska, Arizona, California, Florida, Kentucky, Missouri, and Puerto Rico more than doubled their use of ground water for public supply.

- Hawaii, Idaho, Louisiana, Maryland, Minnesota, Montana, Massachusetts, New Mexico, North Carolina, Pennsylvania, Texas, and Wyoming nearly doubled their use of ground water for public supply.

For the period 1980 to 1990,

- For incremental drinking water use, ground water supplied two of every three additional gallons of water supplied by public water systems nationally.

In 1990,

- More than half of the national population was dependent upon ground water for drinking water.

- More than half of the population (51% to 93%) in 30 States relied on ground water for drinking water.

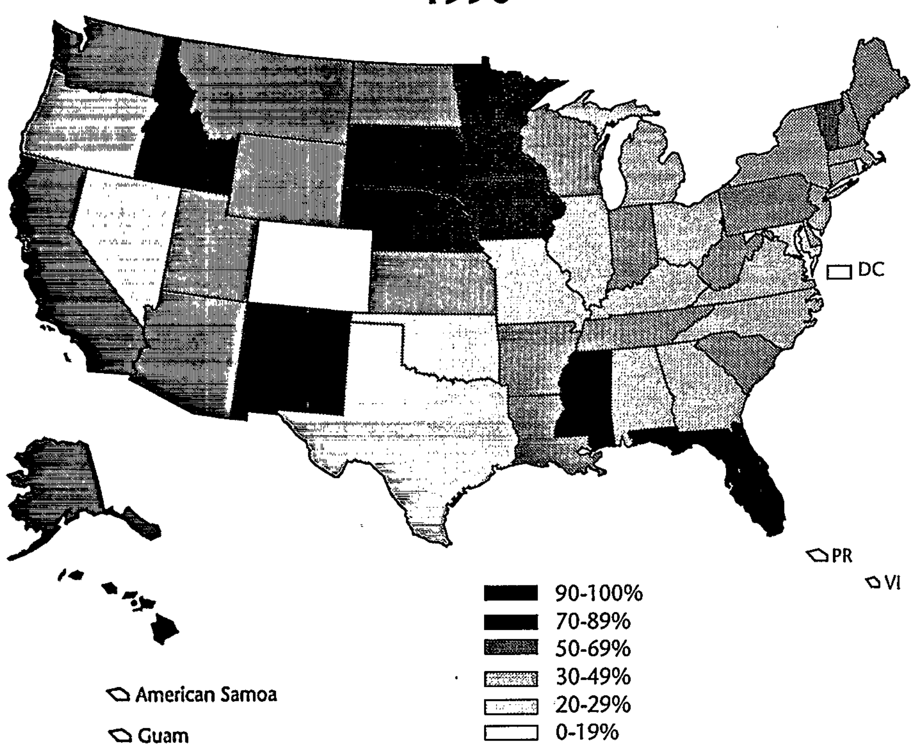
- Approximately 32% of the national population dependent upon ground water obtained their drinking water from private wells.

- Ninety-five percent of the population in rural areas relied on ground water for their water supply.

- In Kentucky, Maine, North Carolina, South Carolina, and West Virginia, 65% to 77% of the population relied on ground water from private wells.

Figure 4

Percent of Population Dependent on Ground Water for Drinking Water 1990



Source: Open-File Report 92-63, U.S. Geological Survey.

■ At least 40% of the population in 23 States and 1 Territory relied on ground water from private wells.

Ground Water Quality

Ground water moves slowly, on the order of less than an inch to tens of feet per day. Consequently, contaminants introduced into the subsurface are less likely to be diluted than those introduced into more rapidly moving surface water. The slow movement of ground water often results in a delay in the detection of ground water contamination. In some cases, contaminants introduced into the subsurface more than 10 years ago are only now being detected and affecting ground water uses.

While the larger ground water resource is of good quality, localized areas of high demand and chemical use can be affected by contamination. This situation exists because locations of more productive ground water yields are often places that allow more infiltration and recharge of aquifers, carrying contaminants more easily to ground water. This vast resource remains exceedingly vulnerable to contamination by toxic compounds, bacteria, viruses, and inorganic contaminants. In one study of five midwestern States, the Ground Water Protection Council* estimated that between 15% and 48% of the land area is underlain by highly vulnerable aquifers.

Contamination of ground water typically occurs in localized areas. These incidents are frequently serious and often pose threats to human health or result in increased costs to consumers. Many locations within every State have shown water quality degradation that constrains the use of ground water resources. As ground water quality is degraded, Americans are becoming increasingly aware that contaminated ground water is both difficult and expensive to clean up.

The following statistics help to illustrate the prevalence of localized ground water contamination incidents:

■ More than 85% of abandoned hazardous waste disposal sites (Superfund sites) have some degree of ground water contamination. Most of these sites impact aquifers that are currently used or could potentially be used for drinking water.

■ Of the contaminated aquifers at Superfund sites, 62% discharge into surface waters. Of these aquifers, 38% are used to supply drinking water. Nineteen percent of these contaminated aquifers discharge to sensitive ecological environments.

■ At 49% of the Superfund sites where cleanup costs are expected to exceed $20 million, dealing with large volumes of contaminated ground water is a key factor contributing to that cost.

■ Currently, 418 land disposal facilities are subject to ground water monitoring requirements under the Resource Conservation and Recovery Act (RCRA). Of these, an estimated 37% are undertaking measures to clean up existing ground water contamination. The EPA estimates

Do You Drink Ground Water?

Ground water is water that is stored in the spaces between rocks underground. It is pumped to the surface for residential, commercial, and agricultural use. Over 80% of public water supply systems in this country depend at least partially on ground water for source water, 95% of the rural population use ground water for drinking water, and water from most private wells is not monitored or treated.

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* Wayne A. Pettyjohn, *Aquifer Vulnerability, Sensitivity, and Ground Water Quality in Selected States*, Ground Water Protection Council, 1994, 94 pages.

that another 10% of the land disposal facilities will detect ground water contaminants in the next 2 years.

- EPA estimates that 1.2 million federally regulated underground storage tanks (USTs) are buried at over 500,000 sites nationwide. An estimated 139,000 USTs have leaked and impacted ground water quality.

- EPA estimates that the total number of leaking USTs could reach 400,000 in the next several years.

The EPA requested that States provide information on the degradation of ground water resources used for public drinking water supply. As a result, 21 States reported on the quality of ground water supplied by a total of 20,294 public water systems that serve approximately 52 million people. Among these States:

- Nineteen reported incidents of public water systems that use ground water exceeding the Maximum Contaminant Level (MCL) for at least one contaminant. These exceedances occurred in 3% of the ground-water-supplied public water systems and affected drinking water quality for 1.4 million Americans.

- Eleven reported incidents in which ground water supplied by public water systems exceeded the MCL for nitrate. Barium, arsenic, and fluoride were cited most frequently among the other 12 inorganic contaminants reported to have exceeded MCLs.

- Fifteen volatile organic compounds (VOCs) and eight pesticides were noted to have exceeded MCLs in ground-water-supplied public water systems. Among the most frequently cited of these compounds were trichloroethylene, tetrachloroethylene, and benzene.* Atrazine, alachlor, and lindane were the most frequently cited pesticides.

Sixteen States also reported on the occurrence of ground water contaminants at levels that are approaching the MCL. The concentrations of these contaminants in ground water do not yet present human health hazards. Nonetheless, they provide a clear indication that future uses of ground water may be impaired. Of the 16 States reporting:

- Fourteen States detected nitrate at a level between 50% and 100% of the MCL in ground water supplied by public water systems. Among the 12 other inorganic contaminants reported to be approaching the MCL, the most frequently cited were cadmium, nickel, selenium, and thallium.

- Fourteen VOCs and 13 pesticides were reported at levels that approached MCLs. The most frequently cited of these compounds were benzene, carbon tetrachloride, and vinyl chloride.+ Lindane, simazine, and aldicarb were the most frequently cited pesticides.

* Trichloroethylene is a carcinogen (i.e., cancer-causing substance) used in textiles, adhesives, and metal degreasers. Tetrachloroethylene is a carcinogen used in dry cleaning and other solvents. Benzene is a widely used carcinogenic component of gasoline, pesticides, paints, and plastics.

+ Carbon tetrachloride is a carcinogenic component of solvents and their degradation products. Vinyl chloride is a carcinogen that may leach from polyvinyl chloride pipe or be formed by the breakdown of other solvents.

Ground Water Contaminant Sources

Ground water quality may be adversely impacted by a variety of potential contaminant sources. EPA presented a list of potential contaminant sources in the 1994 305(b) guidelines and requested each State to identify and rank the specific sources that threaten their ground water resources. Ranking was based on the best professional judgment of the State ground water officials and took into account the number of each type of source in the State, the location of the various sources relative to ground water 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), and the findings of the State's ground water protection strategy and/or related studies.

Figure 5 lists potential ground water contaminant sources ranked according to the number of States that identified each source as a high, medium, low, or unspecified priority. As shown, the greatest number of States reported that leaking underground storage tanks (USTs) are a source of ground water contamination with 41 States rating USTs as a high-priority source of ground water contamination in their 1994 305(b) reports. Montana indicated that there have been 963 confirmed releases from USTs and that half of these releases impacted ground water resources. Leaking USTs have also caused serious ground water pollution problems in Rhode Island with more than 511 leaking USTs identified in the State since 1985. Many of these sites have required active remediation of contaminated ground water. In several cases, restoration of contaminated ground water was deemed infeasible, and alternative measures had to be taken to supply affected areas with drinking water.

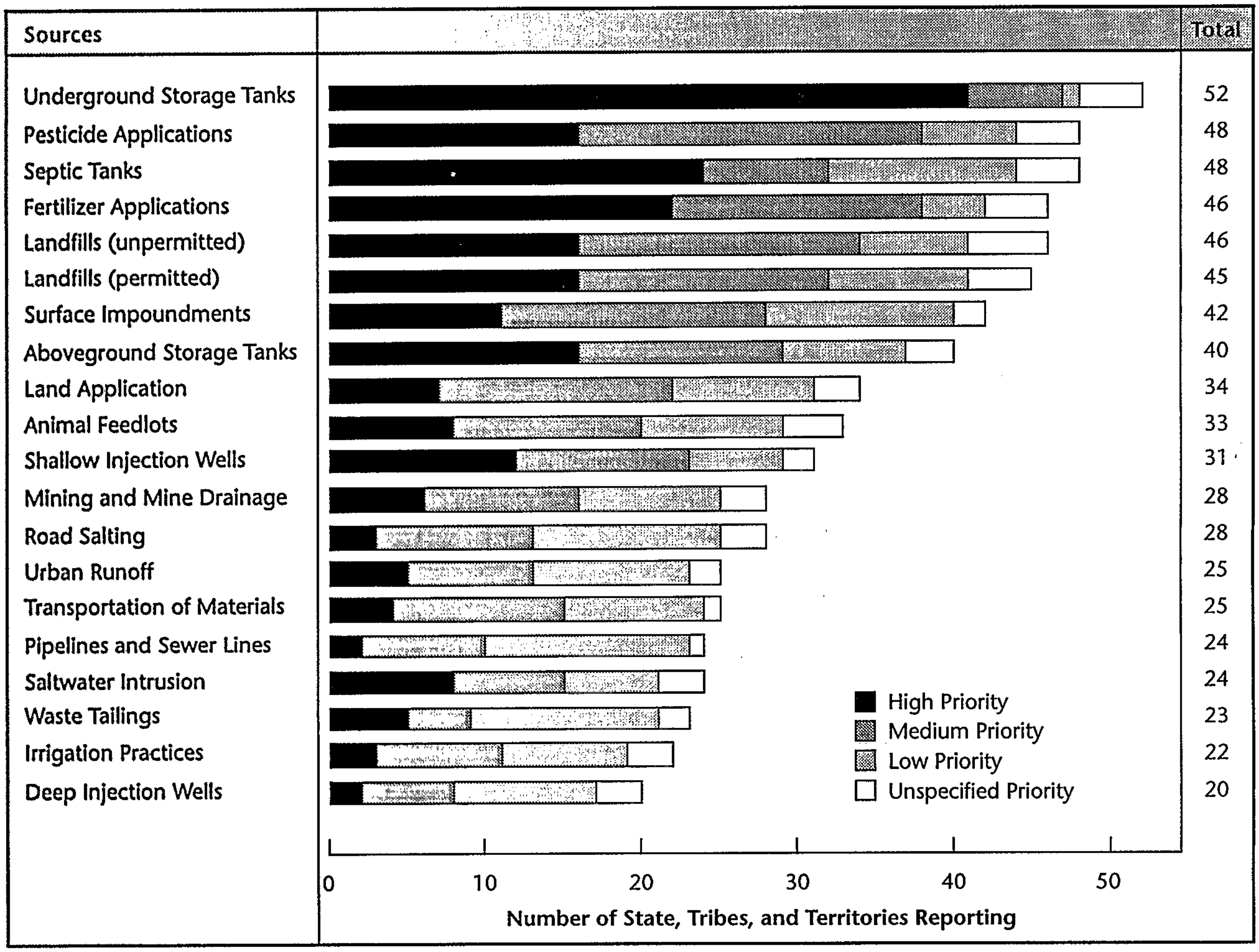
The primary causes of leakage in USTs are faulty installation and corrosion of tanks and pipelines. It is estimated that, on a national basis, 139,000 tanks have leaked and impacted ground water quality, and reports of leaking USTs continue to increase. Rhode Island indicated that new reports of leaking UST sites requiring investigation for potential ground water contamination numbered 50 to 70 per year during 1992-1993. Montana indicates that new reports of leaking USTs come in at a rate of 20 to 30 per month. This rise in the number of reports of leaking USTs most likely reflects increased awareness, stricter requirements on site assessments upon closure of tanks, and monetary aid to assist responsible parties to clean up the contaminated sites. In addition, increased reporting of UST leaks may reflect an increase in leaks as older tanks corrode.

In general, most USTs are found in the more heavily developed urban and suburban areas of a State. They are primarily used to hold petroleum products such as gasoline. Ninety-five percent of the USTs in Texas contain petroleum products. Rhode Island reports that, of 255 active sites, approximately 75% involve motor fuels (gasoline and diesel fuel). The majority of these leaks at the active sites in Rhode Island occurred at gasoline service stations. North Carolina reported that leaking USTs accounted for 87% of the ground water contamination incidents occurring from October 1991 through September 1993. Of these incidents, 86% were related to the release of gasoline. Maine reports that petroleum leakage has contaminated over 200 private wells between 1990 and 1992.

Septic tanks and shallow injection wells were listed as the third and eleventh most common sources of ground water contamination, respectively. Shallow injection wells (classified as Class V wells in the Underground Injection Control Program) inject fluids into or above

Figure 5

Contaminant Sources Prioritized by States



Source: 1994 Section 305(b) reports submitted by States, Tribes, and Territories.

underground sources of drinking water. They include dry wells, septic systems, geothermal reinjection wells, industrial and utility disposal wells, and aquifer recharge wells. New Jersey reports that in a four-county study, including Passaic, Somerset, Camden, and Ocean Counties, subsurface discharges of wastewater from industrial septic systems, dry wells, and service station drains are a major source of drinking water contamination. One-hundred and twenty-four private wells and five municipal wells were contaminated—half by subsurface discharges.

Contamination of drinking water from shallow injection wells may take years to be detected in nearby wells. A chemical company in the Bethpage/Hicksville area of New York disposed of industrial wastewater containing a carcinogenic compound—vinyl chloride—into sumps. Two million gallons of wastes were discharged each year for 19 years. This led to extreme contamination of the Magothy aquifer. Fourteen wells, including five municipal supply wells, were contaminated with industrial organic wastes. An estimated 100,000 people were affected by the contaminated wells.

One obstacle in remediating ground water contaminated by shallow injection wells is determining the responsible parties. Three wells were closed in Burlington, Maine, due to trichloroethylene (TCE) and tetrachloroethylene (PCE) contamination. The closure of the wells affected 50% of the town's primary well field and approximately 20,000 people. Two nearby manufacturing plants are unconfirmed but suspected sources of contamination. Both facilities have dry wells and septic systems that contain TCE and PCE. The town continues to supply water to residents using a wellfield that previously served as a backup water supply.

In severe cases, even when responsible parties are required to remediate the contaminated area, costs are high—often too high for the responsible party or parties to afford. From the 1950s through 1981, a thermostat manufacturer in South Cairo, New York, poured wastes containing TCE and PCE sludges down drains connected to an abandoned septic system. As a result, high levels of TCE and PCE were detected in five privately owned wells in the vicinity. A 1983 Consent Order required the manufacturer to clean up the site, supply bottled water, and install, monitor, and maintain carbon filter systems for the five affected homes. In 1985, the manufacturer filed for bankruptcy, and EPA has assumed responsibility for maintaining the carbon filter systems and monitoring. EPA has also installed two new carbon filtration units and an air stripping system and drilled a new well in an effort to provide clean water. Future remedial action will include the provision of an alternate water supply through a pipeline at estimated capital costs of $2,270,000 and annual operation and management costs of $100,000.

A March 22, 1991, report prepared for EPA entitled *Drinking Water Contamination by Shallow Injection Wells* estimated that shallow injection wells contaminated the drinking water of approximately

1.3 million people at a cost ranging from $30,000 to $3.8 million.

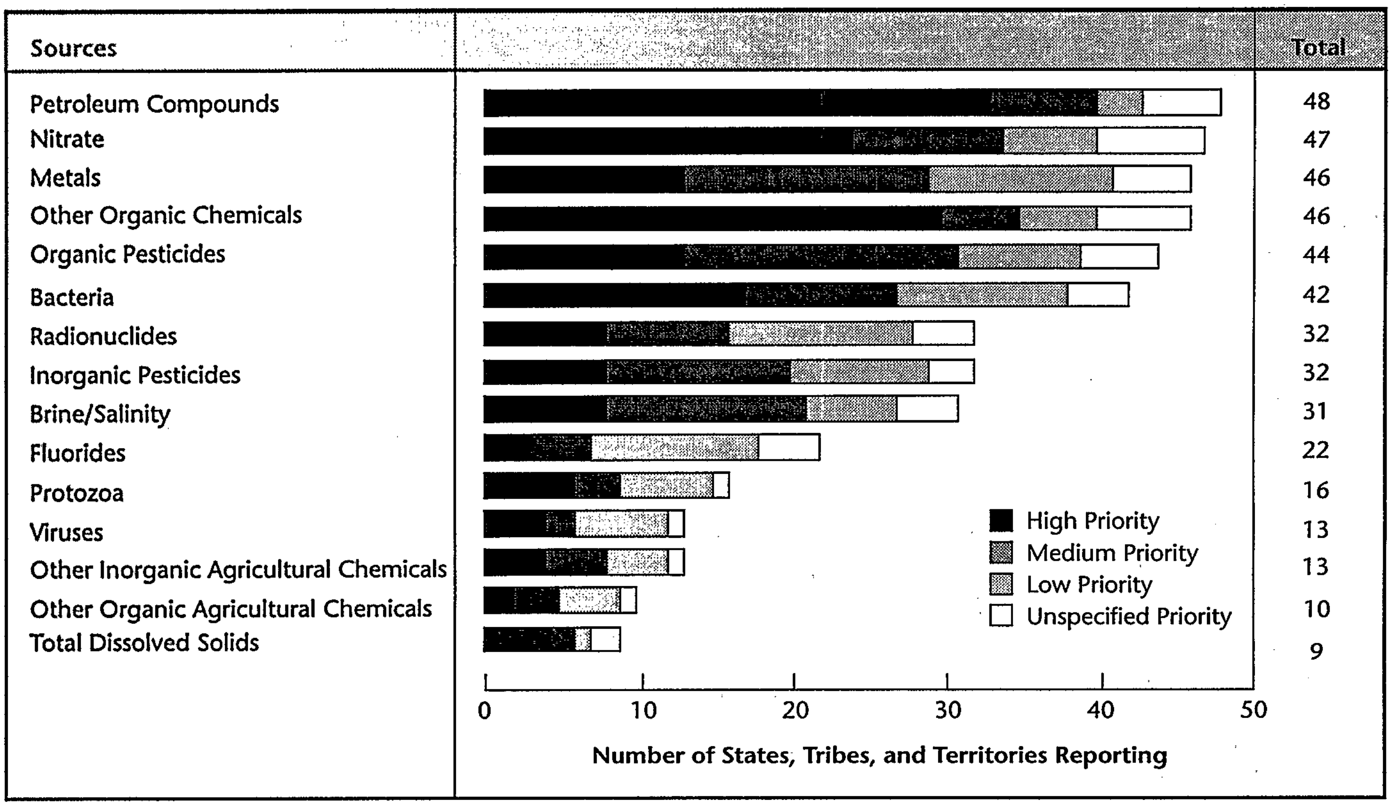
Ground Water Contaminants

EPA also requested that States identify and rank the contaminants impacting their ground water resources. This information was also based upon the best professional judgment of the State ground water experts. Factors that were considered include the areal extent of contamination, the location of contamination relative to ground water supplies used for drinking water purposes, the size of the population at risk from drinking water threatened by the contaminant, the risk posed to human health and/or the environment from this contaminant, hydrogeologic sensitivity, and findings of the State's ground water protection strategy or other reports.

As shown in Figure 6, the greatest number of States cited petroleum compounds as a high-priority contaminant in their ground water. Petroleum compounds are generally

Figure 6

Ground Water Contaminants Prioritized by States



Source: 1994 Section 305(b) reports submitted by States, Tribes, and Territories.

associated with underground and aboveground storage tanks, and their frequent detection in ground water is consistent with the high priority assigned by the States to storage tanks as a contaminant source.

Petroleum is a complex mixture of more than 200 different compounds. Studies have found that four compounds (benzene, toluene, ethyl benzene, and xylenes) make up 95% of the compounds detected in ground water impacted by petroleum releases. It is generally these compounds that are most frequently detected in contaminated ground water. Using this information, Montana was able to relate five incidents of benzene contamination in public water supplies to leaking USTs.

Nitrate was the second most common ground water contaminant cited in State 305(b) reports. Twenty-four States indicated that nitrate was a major concern. Ten of these States indicated that nitrate was the prime contaminant of concern. High concentrations of nitrate in drinking water can cause serious human health problems, especially in babies. Exposure to high concentrations of nitrate (>10 mg/L) in drinking water causes methemoglobinemia, or blue baby syndrome, an inability to fix oxygen in the blood.

Nitrate is soluble in water, and, as a consequence, it is easily transported from the soil surface to ground water. Nitrate is applied extensively on agricultural fields, residential lawns, and golf courses to promote crop and lawn growth. Sources of nitrate include fertilizer, domestic wastewater and sludge, and septic tanks. Natural concentrations of nitrate in ground water vary, but a concentration of 3 mg/L is often considered to be typical outside of areas of naturally high nitrate levels. Concentrations measured above this level are typically considered to be the result of human activity. Elevated concentrations of nitrate in ground water are frequently considered to be an important indication of the degradation of ground water resources. The EPA drinking water standard for nitrate is 10 mg/L.

Following are highlights of several State programs focusing on nitrates.

Maine

The Maine Soil and Water Conservation Districts collected soil from the plow layer of 249 corn fields as part of a Manure Management Project. Soil nitrate was found to be twice the level needed to produce a normal corn crop, suggesting a threat that the excess nitrate could leach to ground water. In response, the Maine Cooperative Extension Service developed guidelines for manure utilization that include (1) the analysis of nitrate levels in soils and plants prior to fertilization, and (2) fertilization according to realistic crop uptake rates.

South Dakota

The Oakwood Lakes-Poinsett Rural Clean Water Program examined the impacts of agricultural chemical practices on ground water quality. A total of 114 monitoring wells were installed at seven study sites that represented both farmed and unfarmed areas. The study results showed that nitrate concentrations in ground water ranged from less than 0.1 mg/L to more

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Frequently Detected Pesticide Residues in Ground Water

Ground water monitoring for agricultural chemicals during the past decade has shown that this vital resource is susceptible to contamination. The tabulated information on the following pages shows the results of recent monitoring for pesticides in the ground water of some States. These studies indicate that among the most frequently detected pesticides are those with active ingredients from the triazine (atrazine, cyanazine, simazine, and prometon) and amide (alachlor, metolachlor, and propachlor) herbicide families. While a number of pesticides have been detected in ground water, however, very few are found at levels that exceed health-based standards for drinking water.

Atrazine is the common name of an herbicide that is frequently used to control weeds in corn, sorghum, and other agricultural crops. Atrazine has a high potential to be transported to ground water, and is the seventh most frequently detected active ingredient tracked in the U.S. Environmental Protection Agency's Pesticides in Ground Water Database.* Atrazine residues were found in 1,512 (5.6%) of the 26,909 well samples that were collected for studies conducted across the United States from 1971 to 1991. Only 172 of the wells (0.6%) yielded samples in which atrazine levels exceeded the MCL.

Alachlor is the common name of an herbicide that is commonly applied to weeds in corn, cotton, soybeans, and peanuts. Alachlor has a moderate potential to be transported to ground water and is the ninth most frequently detected pesticide residue listed in the Pesticides in Ground Water Database. Of the 26,856 wells tested for alachlor residues in the past two decades, 543 (2%) contained detectable levels of this herbicide. Alachlor residues that exceeded the MCL for this compound were found in 101 wells (0.4%).

Simazine is the common name of an herbicide used primarily to control weeds in corn, vineyards, citrus orchards, and other agricultural crops. Simazine has a moderate potential to be transported to ground water. The Pesticides in Ground Water Database lists simazine as the tenth most frequently detected pesticide residual found in ground water over the past two decades. Simazine residues were found in 486 (2.2%) of the 22,374 well samples that were reported from 1971 to 1991. Only 89 of the wells (0.4%) yielded samples in which simazine levels exceeded the MCL.

*U.S. Environmental Protection Agency, 1992, *EPA Pesticides in Ground Water Database: A Compilation of Monitoring Studies from 1971-1991*, EPA 734-12-92-001, 182 pages.

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Factors Affecting Pesticide Occurrence in Ground Water

In a study of the corn and soybean producing region of the midcontinental United States, researchers sought to understand the occurrence and distribution of selected agricultural chemicals and their degradation products in shallow aquifers.* The study region included parts of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. Nearly 60% of the pesticides and nitrogen fertilizers used in the United States is applied to crops in these 12 States. A total of 303 wells were sampled during both the preplanting and postplanting seasons. Herbicides and metabolites were detected in 24% of the samples. None of the pesticides were detected at levels that exceeded the MCL.

Many of the studies summarized in the attached table sought to discern relationships between the occurrence of pesticides in shallow ground water and specific aquifer or land use conditions that rendered the cropland particularly susceptible to ground water contamination. In a recent study of agricultural chemicals in the ground water of Nebraska,+ the authors concluded that the following factors may be related to pesticide occurrence in ground water:

- Nearly 70% of the atrazine detections occurred in highly vulnerable areas where nonpoint nitrate contamination has also been documented.

- The dispersed pattern of alachlor detections may suggest contamination that originated from misuse, overuse, back siphoning, or spills at mixing/loading areas, rather than through normal agricultural application.

- Some detections of propachlor in ground water may be related to use of the pesticide to control weeds around the wellhead of unsealed irrigation wells.

*Burkart, M.R., and D.W. Kolpin, 1993, Hydrologic and land-use factors associated with herbicides and nitrate in near-surface aquifers, *Journal of Environmental Quality*, Vol. 22, No. 4, pp. 646-656.

+Exner, M.E., and R.F. Spalding, 1990, *Occurrence of Pesticides and Nitrate in Nebraska's Ground Water*, Water Center, Institute of Agriculture and Natural Resources, University of Nebraska, Report WC1, 34 pp.

Recent Monitoring Results for Pesticides in Ground Water

State	Study Purpose[1]	No. Wells in Study	Pesticides (Percent of wells with pesticides detected below the MCL)											
			2,4-D	Alachlor	Atrazine	Bentazone	Chlordane	Chlorpyrifos	Cyanazine	DBCP	Dicamba	Dieldrin	Diuron	Endrin
California	Evaluate ground water quality for 15 major ground water basins in Southern California[2]	3,500 municipal water supply wells	•		•	•	•			•				•
	Summary of sampling for pesticides in California ground water from July 1, 1992, to June 30,1993[3]	Varies by analyte (from 393 to 1,271 wells)			3	2							3	
	Summary of sampling for pesticides in California ground water from July 1, 1993, to June 30, 1994[4]	Varies by analyte (from 261 to 1,328 wells)			1	1							4	
Colorado	Monitor South Platte Alluvial Aquifer for presence of commercial fertilizers and pesticides in ground water[5]	96		2	26									
Maryland	Document statewide water quality conditions and establish basis for long-term water quality monitoring[6]	Varies by analyte (from 7 to 38 wells)	3	5	24				5		14	4		
Nebraska	Characterize the areal distribution of agrichemicals in ground water and correlate occurrence with parameters that enhance leaching[7]	Varies by analyte (from 35 to 2,260 wells)	3	1	13				1			6		
South Dakota	Assess presence of pesticides and nitrogen-based fertilizers in ground water in 1993[8]	44	6	14	6				1		8			
	Evaluate effectiveness of BMPs on reducing pesticides and nitrate in the Big Sioux aquifer, Oakwood Lakes-Poinsett project area (10-year study)[9]	73	30	33	3				4		27			

• = Detected at levels below the MCL. Number of wells unspecified.
[1] The reader is referred to the footnoted studies for additional information concerning sampling strategies, detection limits, and more detailed data.
[2] Anderson, Lisa, 1994, *Groundwater Quality, A Regional Survey of Groundwater Quality in the Metropolitan Water District Service Area*, Metropolitan Water District of Southern California, Report Number 991.
[3] California Environmental Protection Agency, 1993, *Sampling for Pesticide Residues in California Well Water, 1993 Update, Well Inventory Data Base*, Department of Pesticide Regulation.
[4] California Environmental Protection Agency, 1994, *Sampling for Pesticide Residues in California Well Water, 1994 Update, Well Inventory Data Base*, Department of Pesticide Regulation.
[5] Colorado Department of Health, *Report to the Commissioner of Agriculture, Colorado Department of Agriculture, Ground Water Monitoring Activities, South Platte Alluvial Aquifer, 1992-1993.*
[6] Bolton, David W., *A State-Wide Ground-Water Quality Network for Maryland: Network Design, Description of Sampling Sites, and Initial Ground-Water-Quality Data*, Department of Natural Resources, Maryland Geological Survey, Prepared in cooperation with the United States Department of Interior Geological Survey, the United States Environmental Protection Agency, and the Maryland Department of the Environment.
[7] Exner, Mary E., and Roy F. Spalding, 1990, *Occurrence of Pesticides and Nitrate in Nebraska's Ground Water*, Water Center, Institute of Agriculture and Natural Resources, University of Nebraska.
[8] Department of Environment and Natural Resources, 1994, *1993 Pesticide and Nitrogen Sampling Program*, prepared for the 1994 South Dakota Legislature, prepared by the Division of Environmental Regulation, Ground-Water Quality Program.
[9] Rural Clean Water Program, 1991, *South Dakota Oakwood Lakes-Poinsett, Project 20, Ten Year Report*, in cooperation with the U.S. Department of Agriculture, the South Dakota Department of Environment and Natural Resources, and the Brookings, Kingsbury, and Hamlin Counties.

NOTE: Blank boxes indicate that data were not available.

	Pesticides (Percent of wells with pesticides detected below the MCL)																Pesticides (Percent of wells with pesticides detected above the MCL)							
	Fonofos	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Metolachlor	Metribuzin	Picloram	Prometon	Propachlor	Silvex	Simazine	Terbufos	Toxaphene	Trifluralin		2,4-D	Alachlor	Atrazine	Bentazone	Chlordane	DBCP	Heptachlor	Heptachlor epoxide
		•	•	•	•						•	•		•						<1	<1	1	<1	<1
									<1			3												
									<1			2												
																		1						
				4		5			3			5					0	0	3					
	<1					1			1	12		8	<1		<1									
						13		2		1														
	10			3		16	8	4							10									

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A National Look at Nitrates*

In addition to work being conducted by States, the U.S. Geological Survey evaluated nitrate concentrations on a national basis. The U.S. Geological Survey conducted an analysis of approximately 12,000 water samples collected from wells and springs in 18 of the 20 Study Units of the National Water Quality Assessment and five supplemental study areas.

The analysis indicated that about 50% of the wells were characterized by elevated levels of nitrate (levels that exceeded 3 mg/L, which is typically held as the threshold indicating human impacts). Nitrate concentrations exceeded the EPA maximum contaminant level (MCL) of 10 mg/L in approximately 21% of the samples. Samples collected from agricultural areas had significantly higher nitrate concentrations than other land use settings (for example, forest), with 16% of the samples exceeding the MCL. The nitrate concentrations were generally highest in the Northeastern, Northern Plains, and Pacific States. This reflects the fact that much of the agricultural land in these regions of the country is underlain by permeable, more well-drained materials, such as unconsolidated sand and gravel, or fractured carbonate bedrock. It was shown that nitrate concentrations were highest in areas of sandy soil.

The analysis indicated that nitrate concentrations exceeding the MCL were most frequently detected in irrigation and stock wells (16%) as opposed to private wells (9%) and public water supply wells (1%). However, EPA still urges well owners who know or suspect that their wells are affected by nitrates to have the water tested. Because of the many factors that may influence the contamination of drinking water wells, EPA recommends an approach that focuses on pollution prevention. Among the steps that should be considered to protect the Nation's ground water resources are appropriate applications of pesticides and fertilizers, site-specific assessments to accurately target and protect vulnerable ground water supplies, identification and protection of ground water recharge areas and wellhead areas, more careful use of flood irrigation, and continued efforts to identify problem areas.

* From *Nutrients in Groundwater and Surface Water of the United States – An Analysis of Data Through 1992*, Water-Resources Investigations Report 95-4031, by D.K. Mueller, P.A. Hamilton, D.R. Helsel, K.J. Hitt, and B.C Ruddy, U.S. Geological Survey, Denver, Colorado, 1995.

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Occurrence of Nitrate Concentrations Associated with Hydrogeologic and Land Use Factors

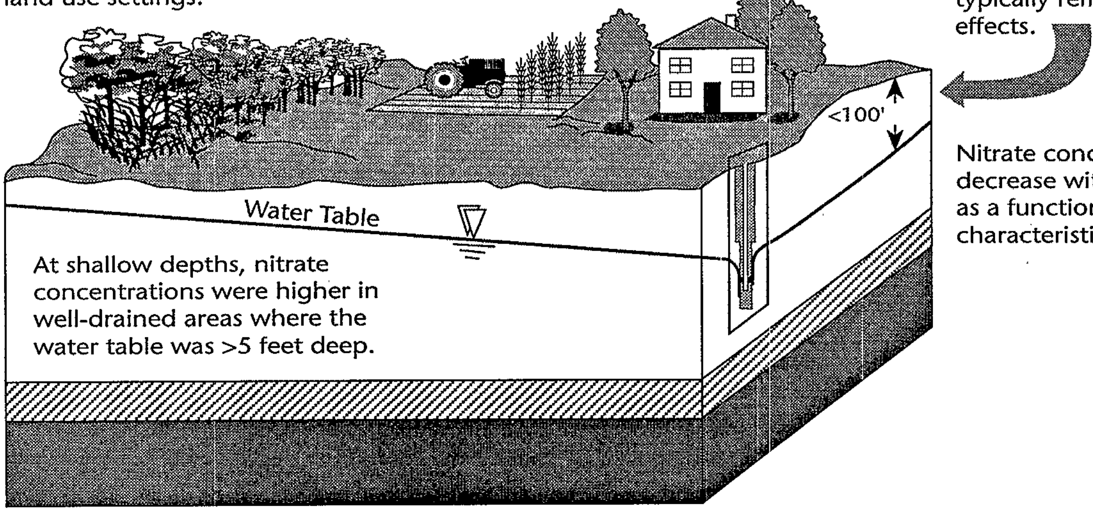
22% of wells in agricultural areas exceeded the MCL for nitrate.

9% of private wells and 1% of public supply wells exceeded the MCL for nitrate.

16% of irrigation and stock wells exceeded the MCL for nitrate.

Forest land had significantly lower concentrations of nitrate in ground water than other land use settings.

Shallow wells (<100 feet) typically reflect land use effects.



Nitrate concentrations generally decrease with depth (>100 feet), as a function of soil and aquifer characteristics.

At shallow depths, nitrate concentrations were higher in well-drained areas where the water table was >5 feet deep.

Median nitrate concentrations were highest in areas with sandy soils.

Concentrations were greatest in unconsolidated sand and gravel and in fractured carbonate bedrock aquifers.

than 70 mg/L. Fifteen percent of the 3,092 samples exceeded the EPA MCL of 10 mg/L. The highest nitrate concentrations were found in the top 20 feet of the aquifer, and nitrate concentrations were significantly higher at the farmed sites.

Arizona

Nitrate is one of the most common pollutants in Arizona's ground water. Large portions of aquifers within the Salt River Valley, including areas within Glendale, Mesa, Chandler, and Phoenix, contain ground water with nitrate concentrations high enough to render the water unfit for consumption. In addition, high nitrate levels occur in Marana, St. David, Quartzsite, Bullhead City, and other areas. Septic tank discharges are particularly prevalent sources of nitrate in rural areas and have often contaminated drinking water wells.

As a consequence, the following investigations are under way:

- Studies will be conducted in the Bullhead City/Riviera, Fort Valley, and Casa Grande areas to investigate the impacts of septic tanks and other nitrate contributions.

- Maps that reflect nitrate concentrations in Arizona's ground water are being produced to target prevention activities.

Georgia

The Georgia Environmental Protection Division (EPD) sampled over 5,000 shallow domestic drinking water wells for nitrate/nitrite. Results indicate that only 1% of the 5,000 wells is characterized by nitrate concentrations that exceed the MCL of 10 mg/L for nitrate in drinking water. Water from 97% of the wells is characterized by nitrate concentrations of less than 5 mg/L. Although it does not appear that nitrate is a widespread problem in Georgia, the EPD observed a very slight increase in average nitrate concentrations in the recharge areas of some Coastal Plain aquifers. These increases may indicate a future increase in nitrate in the down-dip confined portions of the aquifers. EPD will continue to monitor changes in the aquifers.

Iowa

Agriculture, Iowa's largest industry, is currently the primary source of ground water contamination in the State. One of the most significant impacts is related to the application of commercial fertilizers. An estimated 30% to 50% of the nitrogen applied as fertilizer to Iowa farm acres is volatilized and lost to the atmosphere or is lost through infiltration through the soil. Currently, approximately 18% of the State's rural population is served by water with nitrate concentrations in excess of the MCL (10 mg/L as nitrogen). However, only 10 out of 1,130 ground-water-based community public water supplies have levels of nitrate exceeding the MCL. High levels of nitrate affect a relatively low percentage of the population of Iowans served (0.3%).

Ground Water Monitoring

Section 106(e) of the Clean Water Act requests that each State monitor the quality of its ground water resources and report the status to Congress biennially. The most comprehensive approach to determining overall ground water quality is to use an ambient ground water monitoring network. However, the expense associated with installation and maintenance of such a network is often high and, depending upon State priorities, it may be prohibitive. Despite this, many States are taking the initiative to develop programs designed to evaluate the quality and vulnerability of their ground water resources, to identify potential threats to ground water quality, and to determine ways to protect their ground water resources from degradation. Thirty-three States indicated that they have implemented statewide ground water monitoring programs that focus on one or more contaminants. This is an increase of four States from what was reported in 1992. Additionally, six States indicated that they are in the process of developing similar programs. Following is a brief description of several State monitoring programs.

Pennsylvania – Fixed Station and Ambient Monitoring Programs

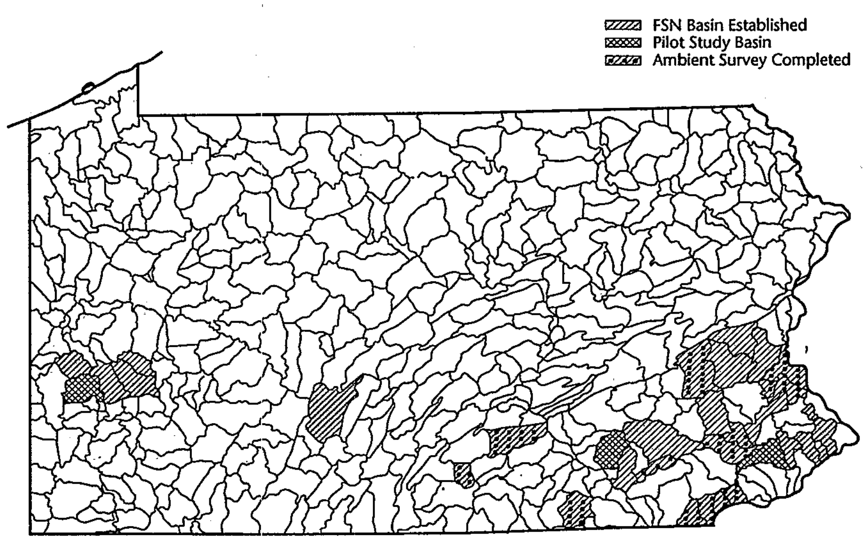
To improve the effectiveness of its ground water resource protection efforts, the Pennsylvania Bureau of Water Quality Management developed two ground water quality monitoring programs—the Fixed Station Monitoring Network and the Ambient Ground Water Quality Survey Programs. These joint programs enable Pennsylvania to (1) detect emerging ground water problems, (2) evaluate the impacts of unmonitored sources of pollution, and (3) assess the overall effectiveness of their regulatory program.

Pennsylvania's Fixed Station Monitoring Program was developed following division of the State into 478 ground water basins (Figure 7). These basins were then prioritized based on ground water use, land use (potential unmonitored sources of pollution), and environmental sensitivity. The 50 highest ranking basins were selected for inclusion in the Fixed Station Monitoring Network Program.

To date, 537 ground water monitoring stations have been established in 20 basins covering 2,318 square miles. The average ground water basin is 125 square miles in size and includes 25 monitoring locations, which are selected to represent the ambient ground water quality of a 4-square-mile area. Each ground water sample is analyzed for 27 parameters.

Figure 7

Ground Water Basin Map of Pennsylvania



Source: 1994 Water Quality Assessment, 305(b) Report, Commonwealth of Pennsylvania.

Pennsylvania's Ambient Ground Water Quality Survey Program was initiated in 1988 to obtain ground water quality data in those basins not covered by the Fixed Station Program. Because these basins are considered to be less vulnerable, ground water samples are scheduled to be collected only two times.

Florida – Comprehensive Monitoring Networks

Florida's Water Quality Assurance Act required the establishment of a ground water monitoring network designed to (1) establish the baseline water quality of the major aquifer systems in the State, (2) detect and predict changes in ground water quality resulting from the effects of various land use activities and potential sources of contamination, and (3) disseminate to local governments and the public water quality data generated by the network. The Florida Network has three components: the Background Network, the Private Well Survey, and the Very Intense Study Area Network.

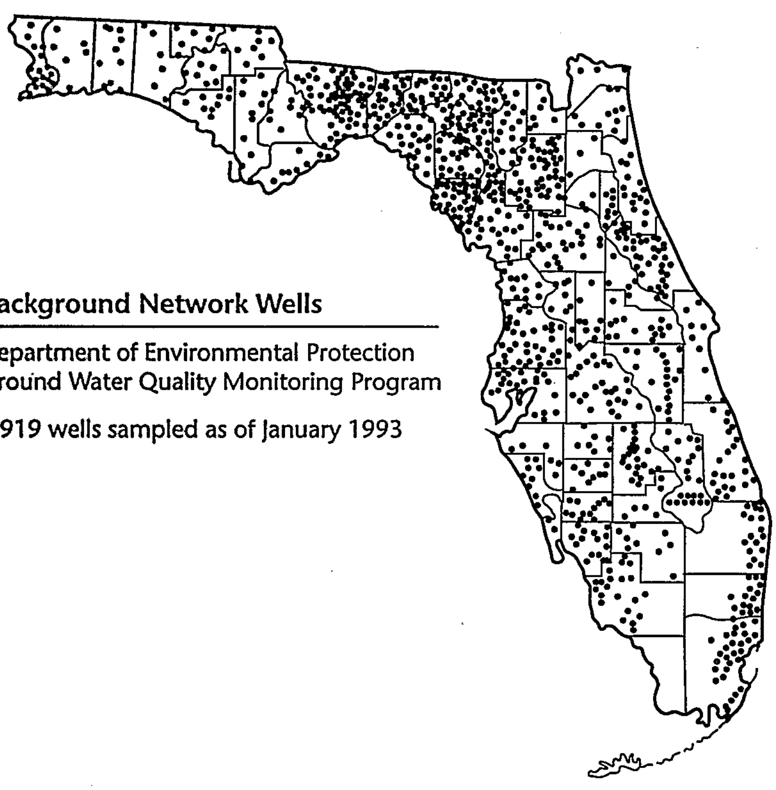
The Background Network was designed to help define background water quality using a statewide grid of wells that collectively tap all major aquifers, including the surficial, intermediate, Floridan, and Claiborne aquifers (Figure 8). One-third of the wells are sampled annually with a complete rotation of wells every 3 years. Approved data are available to the public on the Florida Ground Water Quality Monitoring Network Electronic Bulletin Board and in three State publications.

The Private Well Survey provides an evaluation of water quality in private drinking water wells serving families in 67 Florida counties. The survey calls for 50 private water wells to be sampled in each individual county. To date, sampling in 23 counties has been completed.

Twenty-three areas believed to be highly susceptible to ground water contamination based on predominant land use and hydrogeology are being studied as part of the Very Intense Study Area Network. A total of 461 wells make up this network, which is designed to monitor the effects of multiple

Figure 8

Location of Ground Water Quality Monitoring Program Background Network Wells in Florida



Background Network Wells

Department of Environmental Protection
Ground Water Quality Monitoring Program

1,919 wells sampled as of January 1993

Source: 1994 Florida Water Quality Assessment, 305(b) Report, Florida Department of Environmental Protection.

sources of contamination on water quality within a segment of an aquifer. The land uses represented are urban, suburban, industrial, agricultural, and mixed. Cumulative monitoring data will be compared to similar parameters in the Background Network representing the same aquifer segment to determine the effects of land use and site hydrogeology upon ground water quality.

Kansas – Assessing Temporal and Spatial Trends

Kansas established a Ground Water Quality Monitoring Network in 1976 to procure long-term, statewide ground water quality data for use in the identification of temporal and spatial trends related to (1) alterations in land use, (2) application of land treatment methods and other nonpoint source best management practices, (3) changes in ground water availability or withdrawal rates, and (4) variations in climatological conditions within the State. In addition, the network is intended to assist in the identification of ground water contamination problems.

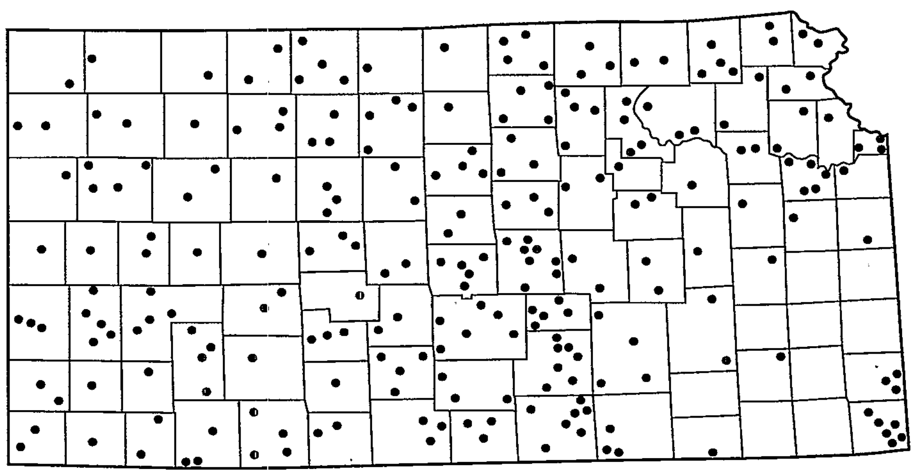
The network currently consists of 242 wells (Figure 9), including public water supply wells (71%), irrigation wells (14%), private domestic wells (10%), multiple use wells (3%), livestock watering wells (1%), and industrial supply wells (1%). During the period 1990-1993, 599 samples were analyzed for common inorganic chemicals and heavy metals; 285 samples were analyzed for pesticides; 110 samples were analyzed for volatile organic chemicals; and 105 samples were analyzed for radionuclides. In evaluating the data, 103 instances were found in which the chemical quality of the raw ground water samples exceeded State drinking water standards. Of these, 71 were related to the presence of nitrate.

Wisconsin – Pesticide Monitoring Program

Wisconsin developed a pesticide monitoring program in response to the detection of aldicarb in 1980 in ground water near Stevens Point. Initially the monitoring program focused on aldicarb; however, it was expanded in 1983 to include additional pesticides (e.g., atrazine), and several studies were initiated to determine the potential impact of pesticide use on ground water quality. Following are the results of four studies:

Figure 9

Kansas Ground Water Quality Monitoring Network



Source: 1994 Kansas Water Quality Assessment, 305(b) Report, Kansas Department of Health and Environment.

- In 1985, the Wisconsin Department of Agriculture, Trade, and Consumer Protection installed monitoring wells at a number of farm fields in susceptible geologic environments. To date, atrazine was detected at 25 of the 35 study sites and alachlor was detected at 7 of the 23 study sites.

- During the period between August 1988 and February 1989, well water from 534 Grade A dairy farms was randomly collected by the Wisconsin Department of Agriculture, Trade, and Consumer Protection and analyzed for 44 pesticides. One or more pesticides were detected in 71 wells.

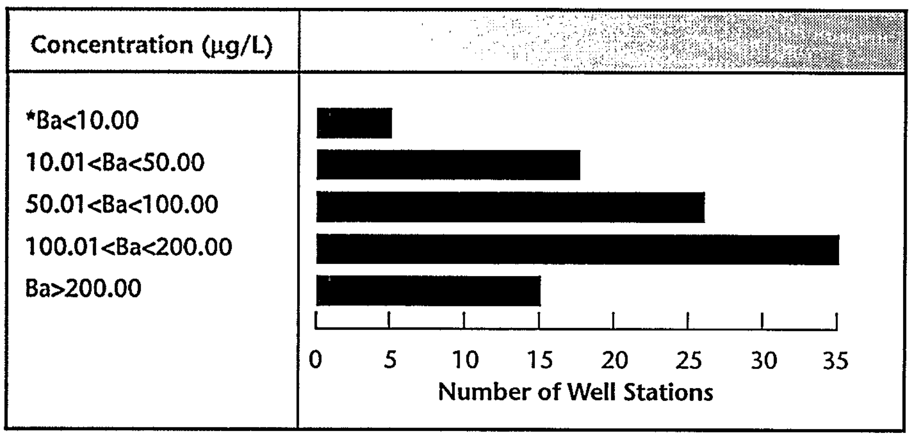
- Sixty-nine of the 71 Grade A dairy farm wells were resampled by the Wisconsin Department of Natural Resources along with 212 wells located in the areas of concern to determine the possible extent of the pesticide occurrences. One or more pesticides were detected in 57 of the 69 resampled wells and 63 of the other 212 wells.

- To better understand pesticides and nitrates in ground water, the Wisconsin Department of Agriculture, Trade, and Consumer Protection sampled nearly 2,200 rural wells for atrazine and triazine herbicides. Sixteen percent, or 351 of 2,187 wells, contained detectable concentrations of triazine-class compounds.

In response to concerns about pesticides in ground water, Wisconsin adopted an administrative rule to regulate atrazine use starting with the 1991 growing season. This rule has been revised in each subsequent year to account for additional atrazine data. Application rates are limited statewide based on soil texture and former use. The use of atrazine is prohibited in certain areas of the State. Throughout the rest of the State, a rate of application is required that is more stringent than Federal recommended limits.

Figure 10

Ambient Ground Water Data from Ohio: Average Barium Concentration in Well Stations



*Detection Limit = 10 µg/L.

Source: 1994 Ohio Water Resource Inventory, State of Ohio Environmental Protection Agency.

Arkansas – Ambient Ground Water Monitoring

The Arkansas Department of Pollution Control and Ecology has established an ambient monitoring program at various locations statewide that enables the State to gather background ground water quality data from various aquifers in the State. Arkansas monitors water quality in 100 wells and 10 springs once every 3 years. The wells and springs are monitored for specific constituents likely to be found in the respective areas. Monitoring wells located at industrial or landfill sites regulated by RCRA or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) are monitored at least annually, but only for indicator parameters required by the regulations.

Ohio – Tracking Ground Water Quality Using GIS

The Ohio Environmental Protection Agency Division of Drinking and Ground Waters is responsible for characterizing Ohio's ground water quality. The Division has collected an extensive amount of ground water quality data through three monitoring programs: the Ambient Network, the Pollution Source Network, and the Nonpoint Source Network. The Ambient Network currently includes approximately 200 well stations at nearly 150 sites. Of the total sites, roughly 110 (70%) are public water systems and roughly 40 (30%) are industrial/commercial water suppliers. Raw water samples are collected semiannually and are analyzed for a series of inorganic constituents. Organic constituents are analyzed at least annually.

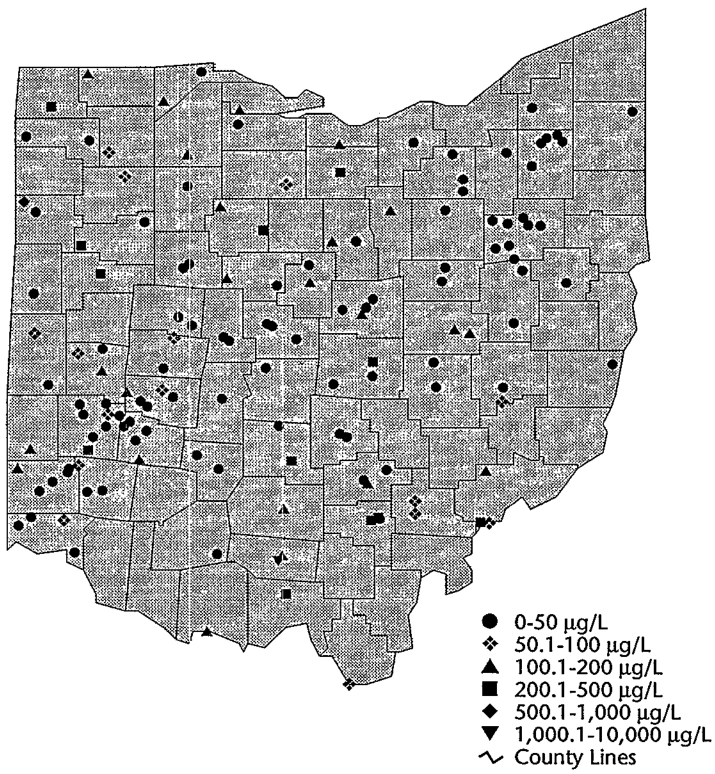
Until recently, the ambient ground water data were kept solely in hard-copy files. However, during the past 2 years, the data were entered into a comprehensive database system, and locational information pertaining to each well station was entered into a geographic information system (GIS). In using the GIS program, the Ohio EPA has gained the ability to provide both graphical and numerical summaries of their monitoring data. Several preliminary plots are presented in Figures 10 and 11.

Indicators of Ground Water Quality

Developing the ability to characterize trends in ground water quality over space and time was one of the key recommendations of EPA's 1986 Ground-Water Strategy. However, data collection and organization varies among the States, and a single data source for

Figure 11

Ambient Ground Water Data from Ohio: Geographic Barium Plot – Preliminary Averages



Source: 1994 Ohio Water Resource Inventory, State of Ohio Environmental Protection Agency.

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Ground Water Quality Indicators

EPA's 1986 Ground-Water Strategy recommended that States develop the ability to characterize trends in ground water quality over time. To support this goal, EPA's Ground Water Protection Division has been involved in the Intergovernmental Task Force for Monitoring Water Quality (ITFM), which has developed a set of environmental indicators that EPA and the States may use to target monitoring efforts and set priorities in ground water protection activities.

Selection of ground water indicators by the ITFM was based on their relevance to important water quality issues, such as human health protection, monitoring objectives, and the existence of appropriate analytical methodologies. The following criteria were considered in the selection of indicator parameters for ground water monitoring:

- Is the indicator parameter potentially toxic to human health and the environment, livestock, and/or beneficial plants?

- Does the presence of the parameter (e.g., hardness, iron, taste, odor, color) impair the suitability of the water for general use?

- Is the parameter of concern in surface water and is it easily transported from ground water to surface water?

- Is the parameter an important "support variable" for interpreting the results of physical and chemical measurements (e.g., temperature, specific conductance, major ion balance, depth to the water table)?

- Is analysis of the parameter affordable using well-established analytical methods at appropriate minimum detection and reporting levels necessary to achieve the objectives of the study?

Due to regional differences in the relative importance of water quality issues and the potential for significant differences in the objectives of monitoring programs, no one set of indicators is suitable or appropriate for all monitoring programs. However, the following table provides examples of ground water monitoring parameters that could be considered for monitoring in areas of differing land use and contaminant sources. The table focuses on classes of contaminants, including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), petroleum hydrocarbon compounds, pesticides, and pathogens. The table does not include physical indicators such as color, odor, pH, specific conductance, temperature, or total dissolved solids because these six indicator compounds are suggested for each of the categories in the table.

The abbreviated table below provides a starting point for evaluating the relationship between land use patterns and likely contaminant loading to ground water. Monitoring agencies may tailor this list by reviewing existing data to determine what parameters are likely to be present in a given area. If documented occurrences of a particular parameter exist, that parameter should be included in the monitoring program.

If not, the likelihood that that parameter will be present in the ground water system must be determined. For example, whether potential sources of the contaminant exist in the area, whether the physical and chemical properties of the indicator parameter are likely to enhance mobility in the environment, and whether the aquifer system is susceptible to contamination must be considered.

Potential Indicator Parameters Based on Land Use

Land Use	Municipal		Domestic	Commercial	Agricultural
Parameters	**Land-fill**	**Sewer/ Pipeline**	**Storage Tanks**	**Property**	**Animal Feedlots**
VOCs	●		●		
PCE	●				
TCE	●				
1,1-DCE	●				
Vinyl Chloride	●				
SVOCs	●		●		
PCP	●				
PAHs	●				
Dioxins	●				
PCBs	●				
Petroleum Hydrocarbons	●		●	●	
BTEX	●	●	●	●	
Pesticides				●	●
Pathogens		●			●
Nitrate		●			●

characterizing ground water quality does not exist for purposes of this report. To amend this problem, the Office of Ground Water and Drinking Water developed a set of indicators to track progress and set priorities in ground water protection efforts. The **initial** (1992) set of ground water indicators included

- MCL violations in public drinking water systems supplied by ground water, and the population at risk from these violations

- Extent of ground water contamination resulting from hazardous waste sites, and the population at risk from exposure to this contamination

- Detections and levels of VOCs in ground water

- Detections and levels of nitrates in ground water

- Extent of leachable agricultural pesticide use.

In its guidelines for preparation of the 1992 State 305(b) reports, EPA encouraged States to use one or more of the above indicators to characterize ground water quality. As development of ground water indicators progressed, more explicit guidance was provided to the States for preparation of their 1994 State 305(b) reports.

The 1994 guidelines focused on four indicators specifically selected to provide a relative indication of the condition of ground water resources. The selected indicators were based on existing data and/or data that could readily be collected by the States over time. Where data were available, the States were encouraged to report the following:

- Number of MCL exceedances for ground-water-based or partially ground-water-supplied community water systems

- Number of ground-water-based or partially ground-water-supplied community water systems with reported MCL exceedances

- Number of ground-water-based or partially ground-water-supplied community water systems with detections between 50% and 100% of the MCLs

- Number of ground-water-based or partially ground-water-supplied community water systems that have local Wellhead Protection Programs in place.

Although this was the first time EPA had requested information specific to ground-water-based or partially ground-water-supplied public water systems, 21 States were able to provide quantitative data characterizing at least one of the above indicator parameters. States most frequently reported the total number of samples analyzed for metals, VOCs, pesticides, and nitrates, along with the number of exceedances in each category.

The above set of indicator parameters is being refined so that, over time, it can be used to detect and predict changes in ground water quality resulting from human effects and to assess the overall effectiveness of State ground water monitoring programs.

Ground Water: What We Still Need to Know

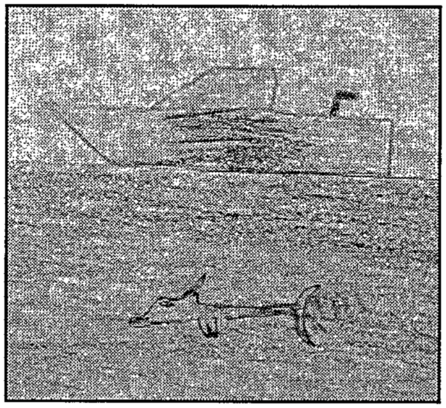
We are continuing to learn a great deal about the nature and quality of our Nation's ground water. Still, there is much we do not yet know about how to most effectively protect and preserve this vast and often vulnerable resource.

While the importance of ground water as a source of water in private wells is recognized, the quality of the water drawn from those wells is largely unknown. There are indications that private wells are vulnerable to contamination from microorganisms, nitrates, and pesticides. The occurrence of viruses in ground water and their impacts on private drinking water wells are poorly understood. Furthermore, the risks associated with redirecting surface water runoff into surface impoundments and infiltration ponds are frequently overlooked.

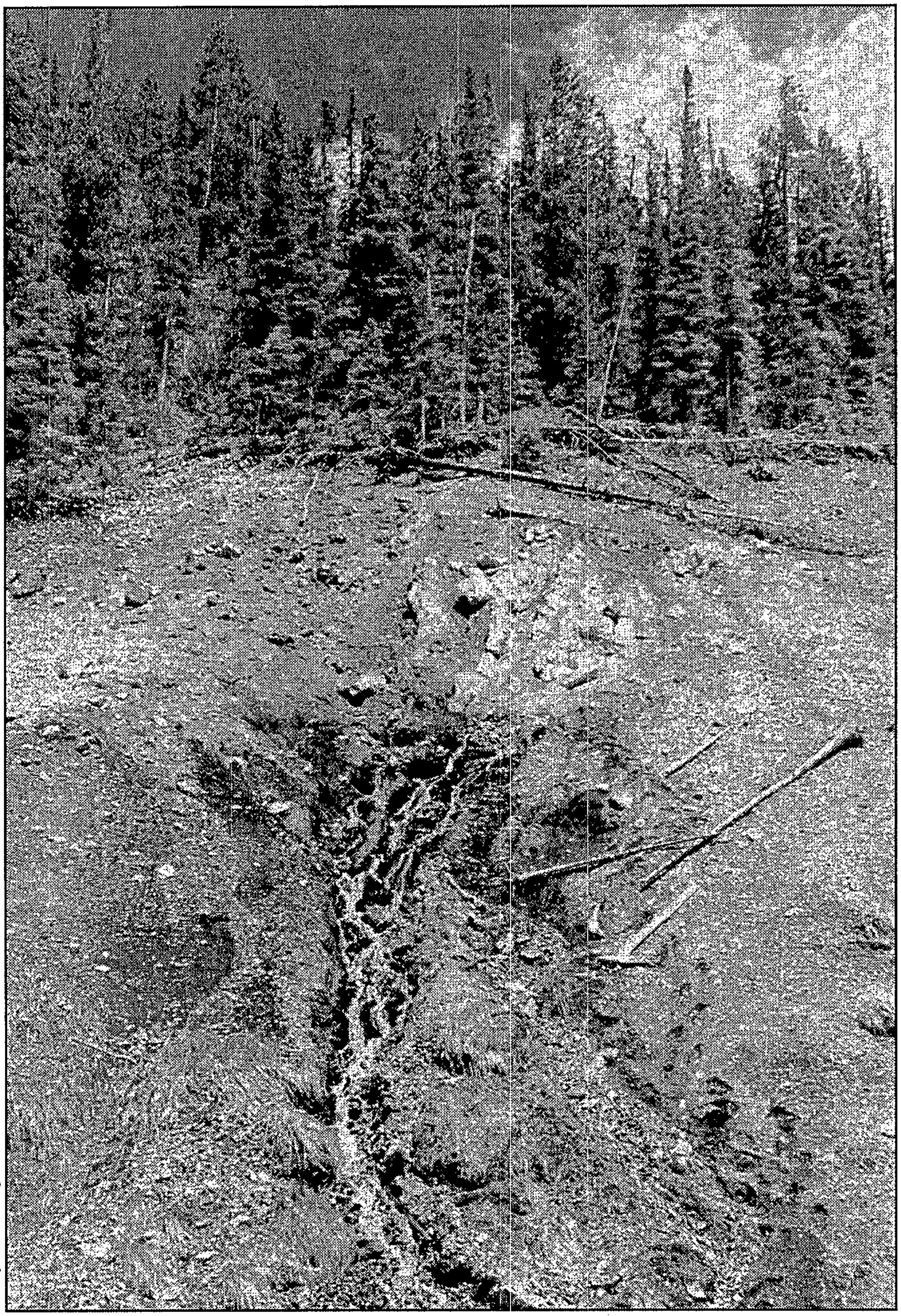
Whereas ground water protection measures are accepted as a "good idea," the performance of these measures in improving the quality of vulnerable ground water has not been tested. What are the differential impacts of nonpoint source best management practices on ground water and surface water? How effective are wellhead protection approaches in areas with fractured bedrock, sinkholes, or areas near surface water features? What are the indicators that should be used to track ground water quality and assess change over time?

We are only beginning to understand the capacity of the land to assimilate contaminants without adversely affecting the use of the ground water. Scientists have only begun to explore the effectiveness of natural ecosystems in processing and degrading contaminants. Many people are able to drink untreated ground water because natural processes improve water quality. Natural ground water systems may remove contaminants that conventional treatment does not address, such as pesticides, heavy metals, and a variety of toxic chemicals present at low concentrations. Ground water organisms are continually found and identified, yet their function in contaminant degradation and their impacts on ground water quality are only beginning to be understood. The interactions between ground water and surface water are known to be significant at the local level, but we do not often recognize the larger-scale implications on the quality of both resources.

Our continued quest for high quality and representative information about the status of our ground water resources will help to answer these questions. Through a greater understanding of how human activities have influenced the quality of our waters, we can better ensure the long-term availability of high-quality water for future generations.



Alisha Batten, age 8, Bruner Elementary, North Las Vegas, NV



Jeff Reynolds, Raleigh, NC

Ground Water Protection Programs

Fifty-one percent of the Nation's population depended upon ground water as a source of drinking water in 1990 (U.S. Geological Survey Circular 1081, 1993). In addition to providing much of our Nation with drinking water, ground water is used for agricultural, industrial, commercial, and mining purposes.

The importance of our Nation's ground water resources is evident. Unfortunately, ground water is vulnerable to human contamination, and, in the 1994 305(b) reports, States identified 66 contaminant sources that threaten the integrity of ground water resources. Because it is expensive and technologically complex to remediate ground water resources that have been adversely impacted by human activities, ground water protection has become the focus of numerous State and Federal programs.

This section presents an overview of ground water protection programs and activities that have been described by the States in their 1994 305(b) reports and the laws and programs instituted by the Federal Government to provide a framework for ground water protection for the States.

State Programs

In their 1994 State 305(b) reports, States provided narratives detailing legislation, statutes, rules, and/or regulations dedicated to ground water protection that are in place, pending, or under development. The narratives also highlighted major studies undertaken by the States in the interest of ground water protection, issues related to ground water quality that are currently of concern or may be in the future, and progress in developing and implementing ground water protection programs. The purpose of these narratives was to provide an indication of the comprehensive nature of ground water protection activities among the States.

Clearly, States are committed to a number of activities to address existing ground water contamination problems and to prevent future impairments of the resource. These activities include enacting legislation aimed at the development of comprehensive ground water protection programs and promulgating protection regulations; adopting and implementing ground water protection strategies; adopting ground water classification and mapping programs; and establishing

Wellhead Protection (WHP) Programs. Figure 12 presents the percentage of States, Territories, and Tribes reporting on each of these activities. As shown, States are making excellent progress in developing and implementing programs related to ground water protection.

Ground Water Protection Legislation

Forty-six of the 58 responding States, Territories, and Tribes report some form of current or pending legislation geared specifically to ground water protection. Generally, legislation focuses on the need for program development, increased data collection, and public education activities. In many States and Tribes, legislation also mandates strict technical controls such as discharge permits, underground storage tank registrations, and protection standards. Additionally, some States and Tribes have enacted legislation establishing a policy to restore and maintain ground water quality and remediate pollution that has occurred.

Minnesota passed the Ground Water Protection Act (GWPA) of 1989 and continues to fund projects such as ground water monitoring and data management, increased control of pesticides and fertilizers, agricultural chemical cleanups, and local water plans. The law also states that ground water quality should be maintained so that it is continually free of human-induced pollutants.

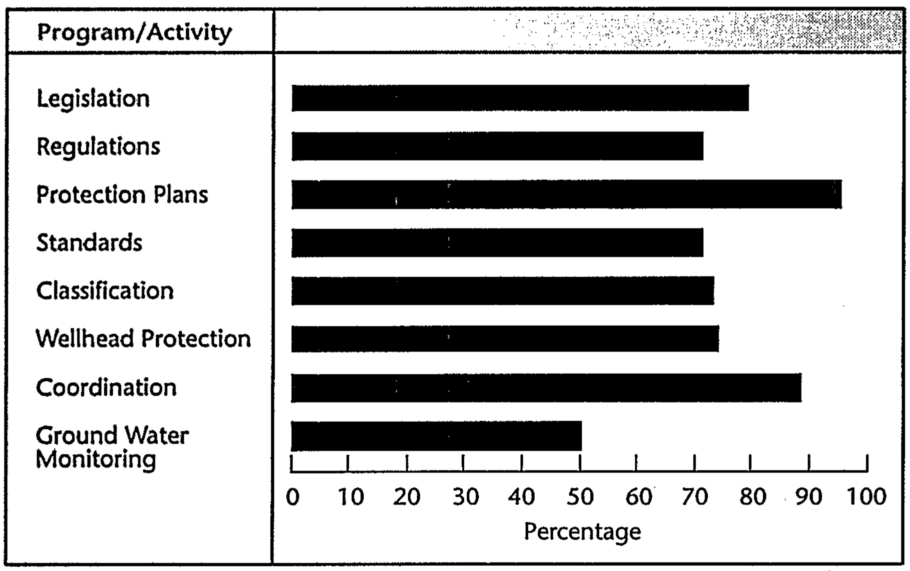
The Michigan Legislature enacted the Environmental Response Act to identify, prioritize, and fund the cleanup of environmentally contaminated sites in cases where responsible parties do not provide relief. The Michigan Department of Natural Resources coordinates the State program with the Federal Superfund program. The two programs are complementary in their goals and objectives.

The primary legislation for Illinois ground water protection, the Illinois Groundwater Protection Act (IGPA), was enacted in 1987. The Act establishes the policy of the State to "restore, protect and enhance the ground waters of the State, as a natural and public resource."

Discovery of extensive contamination in the State's ground water prompted Arizona to develop strong and comprehensive ground water legislation. The 1980 Ground Water Management Act promotes a

Figure 12

Percentage of Reporting States Having Implemented Programs or Activities



Source: Section 305(b) reports submitted by States, Tribes, and Territories.

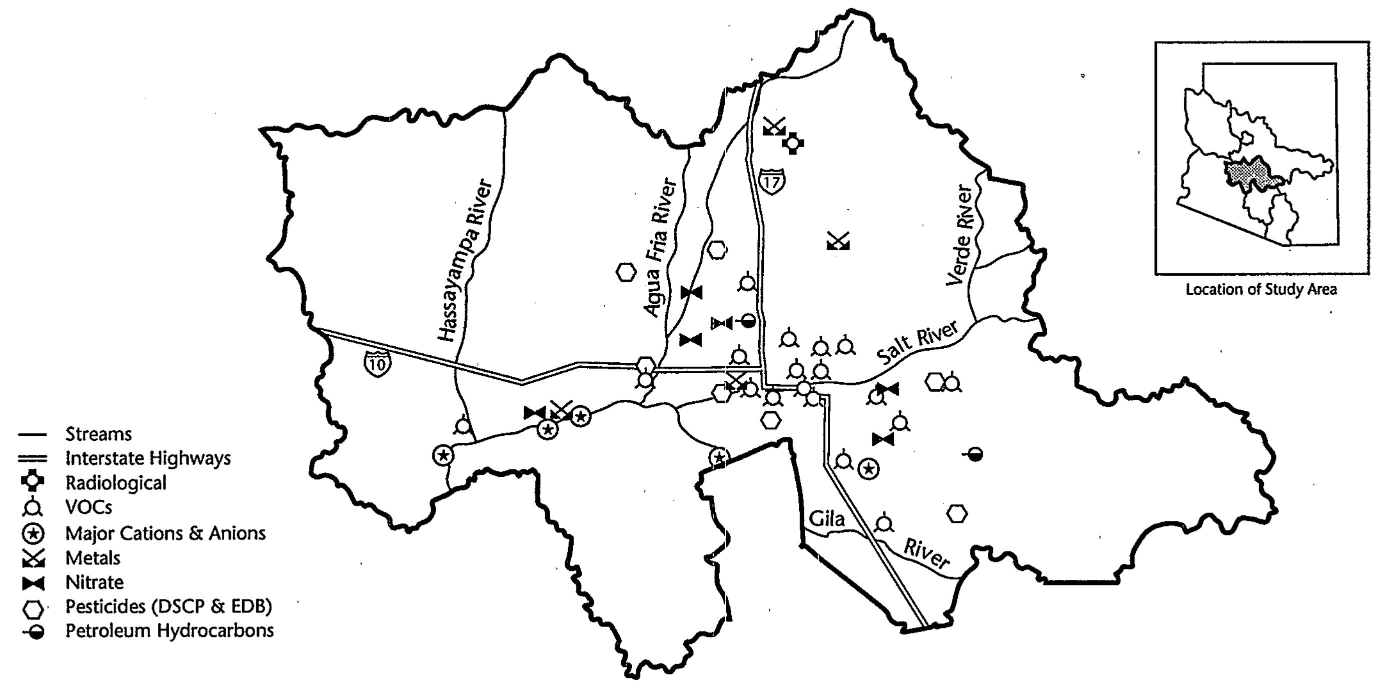
strategy of preserving, enhancing, and protecting current water quality; remediating, minimizing, and preventing past, present, and future discharges to aquifers; and prohibiting discharges of toxic pollutants to aquifers. This Act defines several geographic areas in which ground water supplies are threatened. The State has designated these areas as Active Management Areas (AMAs). Figure 13 illustrates one AMA. Areas in which there is a possible or known threat to ground water resources are marked with the appropriate symbol. Management plans in these areas address the threats of both overdrafts and contaminants.

In Hawaii, problems with the quality and reliability of surface water supplies have led to concern over the protection of the State's ground water. The 1987 State Water Code protects ground water by authorizing the prohibition, control, and regulation of activities in areas vulnerable to ground water contamination. The State has adopted a policy of antidegradation and uses the authority established by this legislation to require proof that proposed activities will not degrade ground water before issuing a permit.

The Rhode Island legislature passed the Ground-Water Protection Act in 1985, establishing a

Figure 13

Ground Water Contamination in the Phoenix Active Management Area



Source: *Arizona Water Quality Assessment 1994*, Arizona Department of Environmental Quality.

comprehensive ground water protection policy. Reenacted in 1991, it emphasized restoring, enhancing, and maintaining the chemical, physical, and biological integrity of Rhode Island's ground water. The legislature passed this law based on the belief that ground water is a critical renewable resource that must be protected to ensure the availability of drinking water.

Ground Water Regulations

Of the 58 responding States, Territories, and Tribes, 41 report that they have established regulations specifically geared toward protection of ground water quality. In general, State and Tribal ground water protection regulations stipulate controls for the management of specific sources of contamination and standards for ground water quality protection. These standards may be used to apply limits on the allowable discharges from contaminant sources and/or to set contaminant concentration targets or threshold levels for ground water cleanup.

Nevada has adopted statutory authority and promulgated associated regulations to implement a mining strategy that is widely considered to be a model for western States in terms of both controls placed upon the mining industry and the explicit considerations of impacts on ground water quality. Regulations include several requirements for the purpose of protecting ground water by minimizing or preventing discharges from mining facilities.

The Florida Department of Environmental Regulation (DER) has established both general and specific permitting provisions for permitting discharges to ground water. The regulations require that all discharges to ground water meet certain water quality conditions, such as Florida's water quality standards.

South Carolina's ground water regulations establish a ground water classification system to protect public health and maintain and enhance ground water quality. They include general rules and specific water quality criteria to protect classified and existing water uses. The regulations also set forth narrative standards for classification and specific numeric water quality standards for ground water that is classified as a source of drinking water.

Ground Water Protection Plans

Fifty-five of the 58 responding States, Territories, and Tribes have adopted, or are in the process of developing, ground water protection plans. The general content of these plans includes: selection of goals and objectives for ground water problems identified in the jurisdiction; development of a ground water classification system; program coordination mechanisms for local, State, and Federal ground water protection activities; public education and/or involvement; development of an interagency ground water data collection system; legislative recommendations pertaining to the regulation of contaminating sources; development of a ground water monitoring system; establishment of a WHP Program; improvement of existing ground water protection programs; and development of statewide standards for ground water quality. These plans provide the basis for their Comprehensive State Ground Water Protection Programs (CSGWPPs).

Texas outlines goals, needs, and recommendations in six important areas in its Ground Water Protection Plan: interagency coordination, hazardous and nonhazardous materials management, public water supply, rural water supply, research, and legislation. Within these areas, each of the following plan elements are discussed: status of existing programs, gaps or inadequacies in these programs, areas of currently unaddressed ground water issues, recommendations for changes or improvements in existing programs, and institution of new programs where needed.

The Indiana Plan is an agenda for State action to prevent, detect, and correct contamination and depletion of ground water resources. The implementation plan identifies key steps, schedules, responsibilities, resources, outputs, and contingencies to accomplish the objectives of the plan. This plan is to be adaptable to new Federal requirements, responsive to emerging issues and proprieties, and subject to revision based on experience.

As of January 1994, 8 of the 23 Nebraska Natural Resource Districts had developed local Ground Water Protection plans, including

- Stated goal to maintain ground water levels and quality at predevelopment levels forever

- Development of Ground Water Control areas with mandated permitting, spacing, and reporting requirements

- Development of Special Protection areas with required education, monitoring, and regulatory programs to reduce nonpoint source contamination

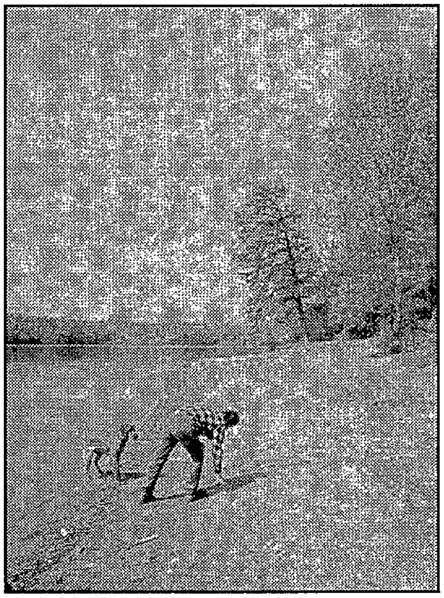
- Development of Ground Water Management Plans

- Development of Ground Water Quality Management Areas to manage nitrogen fertilizer application and irrigation practices.

Ground Water Protection Standards

Although many States and Tribes use Federal drinking water standards to direct their ground water protection activities, a number have tailored the standards to meet their specific conditions. State and Tribal ground water protection standards may be either narrative or numeric. Numeric standards set health-based MCLs for specific compounds in ground water. Narrative standards are adopted for contaminants for which numeric standards have not been adopted. Forty-one States, Territories, and Tribes reported the development or implementation of ground water protection standards.

All ground water in South Carolina is classified as Class GB, which is ground water that meets the definition of an underground source of drinking water (USDW). All USDW supplies must have contaminant levels that are below MCLs set forth in the South Carolina *Primary Drinking Water Regulations*. Compounds for which standards or proposed MCLs do not exist are evaluated individually.



John Theilgard, Bynum, NC

Arizona's *Aquifer Water Quality Standards* are the cornerstone of the State's ground water protection program. All aquifers were initially classified and protected for drinking water use, and none has been reclassified. Numeric Aquifer Water Quality Standards were developed and adopted by Arizona as enforceable standards for the maximum permissible level of a parameter in a public water system. The Arizona Department of Environmental Quality has also adopted narrative aquifer water quality standards that allow regulation of pollutant discharges for which no numeric standards have been adopted.

Standards for ground water quality in Nebraska are intended to be the foundation for ground water point source programs in the State. Narrative standards deal primarily with beneficial uses of ground water. Beneficial uses of ground water, hydrologically connected ground waters, and surface waters are all protected. Numeric standards in the form of MCLs for various parameters are also provided. Some parameters listed are assigned "reserved status." This means that ground water standards have not been adopted for these parameters but will be in the future.

Ground Water Classification/Mapping Programs

Forty-two States, Territories, and Tribes have developed or are developing ground water classification systems to aid in the protection and management of their aquifers. Classification systems can be used as a basis for the maintenance and restoration of ground water quality, the development of ground water quality standards, and land use and pollution source management and regulation. Most ground water classification systems are based on the understanding that some human activities have the potential to degrade ground water. The systems are designed to restrict such activities to areas overlying aquifers containing lower quality waters while protecting the most vulnerable and ecologically important ground water systems. Most States and Tribes that have classification systems apply them to the permitting of discharges or potential discharges to ground water and the remediation of contaminated ground water. Some States may also use their systems to guide the development of new water supplies or to site certain types of industries.

The first tiers of a State's classification system are typically designed to identify and protect water that is currently used or has the potential to be used as a source of drinking water. The potential for drinking water use is generally based on water quality indicators, such as salinity and total dissolved solids, and potential yield. Some States and Tribes also place ecologically sensitive aquifers in the highest tiers of their classification systems.

Aquifers that do not meet these requirements or that are unsuitable for use because of poor ambient water quality or because of past contamination are generally classified for other types of uses, such as industrial processes or, in some cases, waste disposal.

The New Jersey Department of Environmental Protection and Energy has classified the State's ground water on a regional basis according to its hydrogeologic characteristics and designated uses. The State has applied a nondegradation policy to the most sensitive ecological area but allows minimal degradation in some other areas, recognizing that some human activities will adversely affect ground water.

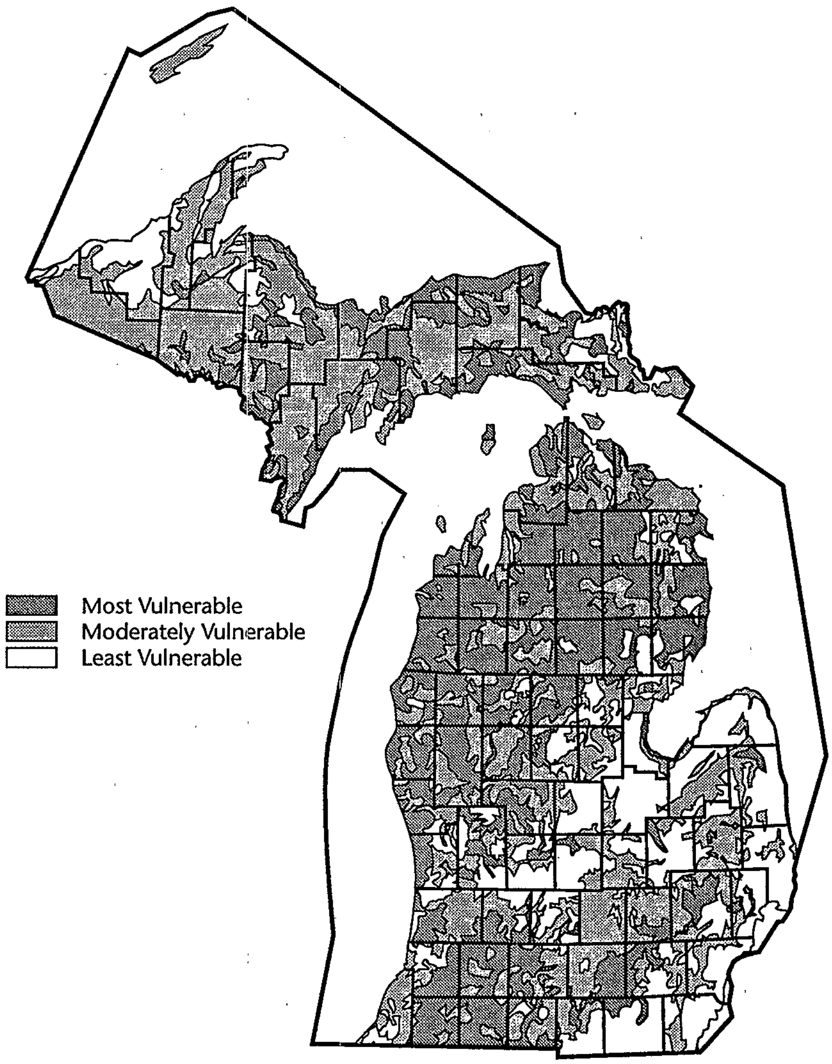
In 1992, Michigan State University Center for Remote Sensing mapped aquifer vulnerability to surface contamination for use in siting facilities or activities with a potential for ground water contamination. The most vulnerable areas constitute 31% of the State's land area and are composed of highly permeable soils over highly sensitive glacial drift, principally composed of sand and gravel (Figure 14). The moderately and least vulnerable areas make up 44% and 25% of the State, respectively.

As part of the development of a ground water classification system, the recharge areas for major aquifers in Rhode Island as well as approximately 450 sources of known and potential sources of ground water contamination have been mapped. The Rhode Island Department of Environmental Management (DEM) has made extensive use of the Rhode Island Geographic Information System (GIS) in this mapping. Maps can be produced with the GIS at different scales, in various formats, and with different layers of information. DEM encourages the use of these maps in local ground water protection efforts.

The lack of a classification system does not indicate a lower priority for ground water protection.

Figure 14

Aquifer Vulnerability to Surface Contamination in Michigan



Source: *Water Quality and Pollution Control*, Michigan 305(b) Report: Volume 13, Michigan Department of Natural Resources.

The majority of States, Territories, and Tribes that do not have explicit classification systems apply the same level of protection to all aquifers, with either a statewide antidegradation policy or the preservation of all ground water for drinking water use. For example, Minnesota does not employ a classification system. However, the State supports a nondegradation policy, promoting preventive measures to protect all ground water from degradation by human activities.

Wellhead Protection Programs

The 1986 Amendments to the Safe Drinking Water Act (SDWA) established the WHP Program. Under SDWA Section 1428, each State must prepare a WHP Plan and submit it to EPA for approval. By the end of April 1995, a total of 39 States had EPA-approved WHP Programs in place.

Six cases of benzene contamination were detected in public water supplies in Louisiana in 1992. Louisiana's WHP Program aided the communities in locating the sources of contamination and in the siting of new wells. Case studies of these communities prompted a coordinated effort between the WHP Program and the Louisiana Department of Environmental Quality Underground Storage Tank Division to see that all unregistered USTs are registered and all abandoned USTs within a 1,000-foot radius of public water supply wells are closed. This restrictive radius will increase with time.

Coordination of Protection Programs Among State Agencies

Historically, ground water protection programs have been overseen by many different agencies within the States, Territories, and Tribes, making coordination difficult for those programs. Coordinating the activities of these agencies to ensure an efficient ground water protection program has become a top priority in many jurisdictions. Fifty-one States, Territories, and Tribes report having developed a plan to coordinate ground water protection programs among their agencies.

The Illinois Ground Water Protection Act (IGPA) created the Interagency Coordinating Committee on Groundwater (ICCG) to direct efforts of State agencies and expedite implementation of ground water protection efforts. Ten State agencies actively participate in the ICCG. In order to direct overall comprehensive ground water protection efforts, the ICCG established the Governor-Appointed Groundwater Advisory Council (GAC), which is comprised of various interest groups, including business, industry, agriculture, regional planning, environmental, municipalities, water well drillers, and public water supplies.

Ground water protection in Colorado is a shared responsibility of many agencies at all levels of government. Colorado authorized four "implementing" agencies as partners in ground water protection: Mined Land Reclamation Board, The Oil and Gas Commission, the State Engineer (Division of Water Resources), and the Hazardous

Materials and Waste Management Division of the Health Department. Each of the implementing agencies has developed regulations to protect ground water within the area of authority with which each agency is charged, and they annually report their progress to the Water Quality Control Division, the agency with final authority for protecting the resource.

Ground Water Monitoring Programs

Two types of ground water monitoring programs are used by States to collect data on ground water quality: ambient monitoring and compliance monitoring. Ambient monitoring programs measure background or existing water quality and are used to track long-term trends in contaminant concentrations. Compliance monitoring programs are required by Federal or State regulations (e.g., ground water monitoring at site cleanups under CERCLA, detection monitoring under RCRA, or community water supply monitoring under SDWA). Compliance monitoring activities measure for specific constituents to ensure that their concentrations in ground water are below regulated levels. In addition to ambient and compliance monitoring, States may also rely on monitoring data collected by Federal agencies, such as the USGS National Water Quality Assessment program, to assess basin ground water quality.

Chemical or constituent-based indicators are generally used as part of a monitoring program to define trends in ground water quality. The constituent-based indicators used in each State are typically selected based on local or regional water quality, contaminant use characteristics, or previously observed contamination patterns. By identifying changes in the concentrations of these constituents in ground water, land uses affecting vulnerable aquifers can be identified and corrected.

Administrative indicators are another form of indicator parameter that may be used by States. Administrative indicators assess the status of potential sources of contamination, such as the number of hazardous waste sites, the amount of leachable pesticides applied to land, the amount of toxic chemicals released annually, the number of abandoned water wells, or other changes in regional land use practices. These administrative indicators allow States to target their ground water protection and monitoring activities.

Table 1 summarizes the types of indicators and monitoring programs that States and Territories currently use to measure ground water quality. Appendix A, Table A-2, presents this information in greater detail. Data were obtained from review of 305(b) reports, monitoring program documentation, and contact with State officials. For conflicting sources, the most recent information is presented and the source is cited.

Virtually all of these States engage in some type of ground water quality monitoring program. Specifically, 23 States report active ambient monitoring programs. In addition, Colorado and Nevada have proposed ambient monitoring programs. Sixteen of these States

Table 1. Summary of Current State Ground Water Monitoring Programs

State	Constituent-Based Indicators	Administrative Indicators	Monitoring
Alabama	Not applicable	Not applicable	Compliance; Ambient
Alaska	Not applicable	Administrative[a]	Compliance
Arizona	(pesticides, VOCs, ions, metals, hydrocarbons, radionuclides, bacteria)	Not applicable	Ambient; Federal
Arkansas		Administrative[a]	Compliance; Ambient; Federal
California	Not applicable	(pesticide residues)	Compliance; background monitoring for pesticides
Colorado	Not applicable	Not applicable	Compliance; Ambient proposed
Connecticut	Not applicable	Not applicable	Compliance; past monitoring for pesticides
Delaware	Not applicable	Not applicable	Compliance; periodic ambient studies; Federal
Florida[b]	Not applicable	(pesticides, VOCs, metals, nitrates, trihalomethanes)	Compliance; Ambient; Federal
Georgia	(pH, nitrate, specific conductivity, inorganics)	(land use)	Ambient
Hawaii	(organics, chlorides)	Not applicable	Not applicable; Federal
Idaho	(radionuclides, pesticides, ions, bacteria, VOCs)	Administrative[a]	Ambient
Illinois	Not applicable	Not applicable	Ambient
Indiana	(bacteria)	Not applicable	Not applicable; periodic ambient studies
Iowa	Not applicable	Not applicable	Compliance; Federal
Kansas	Not applicable	Not applicable	Ambient
Kentucky	Not applicable	Administrative[a]	Compliance
Louisiana	Not applicable	Administrative[a]	Compliance; Federal
Maine	Not applicable	Not applicable	Not applicable
Maryland	(pH, alkalinity, ion-specific conductance)	Not applicable	Ambient; Federal
Massachusetts	(specific conductance, TOC, COD, ionic balance)	Not applicable	Compliance
Michigan	Not applicable	Administrative[a]	Compliance
Minnesota	Not applicable	Administrative[a]	Ambient; Federal; Compliance
Mississippi	Not applicable	Not applicable	Compliance; Federal

Table 1. Summary of Current State Ground Water Monitoring Programs (continued)			
State	Constituent-Based Indicators	Administrative Indicators	Monitoring
Missouri	(nitrate)	Not applicable	Not applicable; Federal
Montana	Not applicable	Not applicable	Compliance
Nebraska	(pesticides, nitrate)	Not applicable	Compliance; periodic ambient studies; Federal
Nevada	Not applicable	Not applicable	Not applicable; proposed Ambient
New Hampshire	Not applicable	Not applicable	Not applicable
New Jersey	Not applicable	Administrative[a]	Compliance
New Mexico	Not applicable	Not applicable	Compliance
New York	(alpha particle activity)	(public supply vulnerability)	Compliance; Federal
North Carolina	Not applicable	Not applicable	Compliance
North Dakota	Not applicable	Not applicable	Ambient
Ohio	Not applicable	Not applicable	Ambient
Oklahoma	Not applicable	(maximum allowable limit [MAL] violations)	Compliance; Ambient
Oregon	Not applicable	Not applicable	Compliance
Pennsylvania	Not applicable	Not applicable	Ambient
Rhode Island	Not applicable	Not applicable	Compliance; Federal
South Carolina	Constituent	Not applicable	Compliance; Ambient
South Dakota	(bacteria)	Administrative[a]	Compliance; Federal
Tennessee	Not applicable	Not applicable	Not applicable; Federal
Texas[b]	Not applicable	Not applicable	Compliance; Ambient
Utah	Not applicable	Not applicable	Compliance
Vermont	(many)	Administrative[a]	Compliance
Virginia	Not applicable	Administrative[a]	Ambient
Washington	(specific conductivity, gross alpha, nitrate, pesticides)	Administrative[a]	Compliance; periodic ambient studies for agricultural chemicals; Federal; proposed Ambient
West Virginia	(many)	Not applicable	Ambient; Federal
Wisconsin	Not applicable	Administrative[a]	Compliance; Ambient
Wyoming	Not applicable	Not applicable	Compliance

[a] Indicators suggested by EPA in the guidance document for the 305(b) report.
[b] State relies on programs below State level for ground water data.

NOTE: Although all States have federally mandated compliance monitoring programs, this table reports those States that use their compliance monitoring data to evaluate ground water quality.

report using specific constituent-based indicators to track trends in ground water quality statewide. Florida has focused the set of parameters monitored under their ambient program based on their understanding of local water quality patterns and contaminant sources. In regions of high agricultural land use, Florida focuses on nitrate and chloride levels in ground water. Similarly, Florida analyzes for certain trace metals (e.g., arsenic, barium, cadmium, chromium, copper, mercury, nickel, silver, and zinc) in regions of industrial land use. South Carolina has established a network of 114 public and private water supply wells that draw water from a single aquifer and are known not to be impacted by contaminants in order to assess ambient ground water quality statewide. South Carolina tests for 39 individual parameters once every 5 years on a rotating basis. Several States are also pursuing the use of indicators to screen for certain sets of water quality parameters in their monitoring programs. For example, Idaho is developing the use of immunoassays to assess the presence of pesticides in ground water. Idaho uses the immunoassay methods to analyze specifically for 2,4-D, alachlor, carbamate, carbofuran, cyanazine, metalachlor, and triazines.

In addition to ambient monitoring, 31 States report that they also use data from compliance monitoring activities to assess trends in ground water quality, and 18 use Federal monitoring data.

A total of 18 States use administrative indicators to track potential sources of contamination. Of these 18 States, 13 use indicators that were suggested by EPA in its guidance document for the 305(b) Water Quality Report to Congress. These indicators include MCL violations, point sources of pollution (e.g., underground storage tanks, military bases, RCRA, CERCLA, and other hazardous waste sites), nitrate contamination, and pesticide use.

Federal Programs

The Federal Government has instituted laws and programs to provide a framework to States, Territories, and Tribes for protection of our Nation's ground water resources. These include Federal statutes that mandate certain ground water protection activities and EPA programs that deal specifically with the control of contaminant source activities conducted under the authority of Federal statutes. Federal statutes include the Safe Drinking Water Act, the Clean Water Act, the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation, and Liability Act, the Toxic Substances Control Act, the Federal Insecticide, Fungicide, and Rotenticide Act, and the Pollution Prevention Act.

Under these Acts, the EPA is responsible for 20 programs related to ground water protection. Most of these are regulatory programs that restrict or prevent specific activities from introducing contaminants onto the land, into the subsurface, or into ground water resources. The rest are nonregulatory and provide national guidance and technical assistance to jurisdictions to identify and protect their vulnerable ground water resources and integrate existing ground water protection programs. Both types of programs are key components of EPA's successful ground water protection strategy when building partnerships with other EPA programs, Federal agencies, State and local governments, industry, environmental groups, and the regulated community. Several concepts fundamental to this approach to ground water protection are based on EPA's guiding principles: ecosystem protection, environmental justice, pollution prevention, strong science and data, partnerships, and compliance. They are:

- Review regulations for opportunities to get better environmental results at less cost; improve new rules through increased coordination.

- Actively promote pollution prevention as a standard business practice and a central ethic of environmental protection.

- Make it easier to provide, use, and publicly disseminate relevant pollution and environmental information.

- Assist companies that seek to obey but exceed legal requirements and consistently enforce the law against those that do not.

- Change permitting so that it works more efficiently, encourages innovation, and creates more opportunities for public participation.

- Give industry the incentives and flexibility to develop innovative technologies that meet and exceed environmental standards while cutting costs.

Highlights of a number of Federal ground water protection programs are presented according to the following protection categories: resource protection, pollutant source control, and pollution prevention.

Resource Protection

The protection of the Nation's ground water resources is addressed under the Clean Water Act and the Safe Drinking Water Act. The Clean Water Act (CWA) encourages ground water protection, recognizing that ground water provides a significant proportion of the base flow to streams and lakes. Ground water protection afforded by the SDWA is focused on waters that supply public water systems, and through implementation of the Wellhead Protection and Underground Injection Control Programs.

Clean Water Act

In the CWA (Public Law 92-500) of 1972 and in the CWA Amendments of 1977 (Public Law 95-217), Congress provided for the regulation of discharges into all navigable waters of the United States. Ground water protection is addressed in Section 102, providing for the development of Federal, State, and local comprehensive programs for reduction, elimination, and prevention of ground water contamination.

As part of the CWA, a process is established that allows for the generation of information concerning the quality of our Nation's ground water resources and the reporting of this information to EPA and the U.S. Congress. The requirements for this process are found in Sections 106(e) and 305(b) of the CWA. Section 305(b) mandates that States develop a program to monitor the quality of their waters and report the status in this biennial National Water Quality Inventory Report to Congress. This process, referred to as the 305(b) process, is the principal means by which the EPA, Congress, and the public evaluate water quality, the progress made in maintaining and restoring water quality, and the extent to which problems remain.

Unfortunately, information reported on the quality of our Nation's ground water resources has not always provided a complete and accurate picture of overall ground water quality. This is due, in part, to the expense involved in collecting ground water monitoring data, the complex spatial variations of aquifer systems across the Nation, and the differing levels of sophistication among State programs. Recognizing this problem, EPA worked with States to develop guidelines for the comprehensive evaluation and reporting of ground water quality.

Appreciating that data collection and organization vary among the States and that a single data source for evaluating ground water quality does not exist, EPA suggested several different sources of data that may be used by States to evaluate their ground water quality. EPA then encouraged States to use available data that they believe reflects the quality of the resource. EPA also focused on allowing States to report information for aquifers or hydrogeologic settings that are a State priority due to high ground water demand or vulnerability. Using these guidelines, States will be able to provide a more meaningful interpretation of ground water quality.

Comprehensive State Ground Water Protection Program

Under the authority of the CWA Section 102, many States are developing Comprehensive State Ground Water Protection Programs tailored to their goals and priorities for the ground water resource. CSGWPPs will guide the future implementation of all State and Federal ground water programs and provide a framework for States to coordinate and set priorities for all ground-water-related activities. Each CSGWPP consists of six strategic components: a goal, a priority-setting mechanism, roles and responsibilities, management measures, information collection and management, and public participation.

The EPA is committed to working with States in developing and carrying out the CSGWPP approach. A State with an EPA-endorsed CSGWPP works in partnership with the EPA to further improve State ground water protection activities, develop a vision of integrated, resource-focused ground water protection, and identify ways that the Federal Government can support State ground water protection efforts.

Figure 15 shows the progress in implementing the CSGWPP approach. As of 1994, the EPA had approved four State CSGWPPs, and EPA endorsement is anticipated for an additional six States in 1995. Another 29 States are expected to submit CSGWPPs for EPA approval by the end of fiscal year 1996.

Safe Drinking Water Act

The SDWA was passed by Congress in 1974 and amended in 1986. Under this Act, EPA sets national limits on contaminant levels in drinking water to ensure that the water is safe for human consumption. The principal ground water protection afforded by the SDWA comes through the enforcement of these limits through State and Federal supervision of public water systems. The SDWA also contains programs to implement the Wellhead Protection Program, the Sole Source Aquifer (SSA) Program, and the Underground Injection Control (UIC) Program, described below.

Approximately 93% of all PWSs (177,589 systems serving nearly 114 million people) obtain their water from a ground water source. These include systems that supply year-round water to households (46,880 Community Water Systems); systems that provide water to places such as schools, factories, and hospitals (23,221 Nontransient Noncommunity Water Systems); and systems that supply water to transitory customers such as campgrounds, motels, and gas stations (107,488 Transient Noncommunity Water Systems). Private, domestic wells are not regulated under the SDWA.

Drinking Water Standards

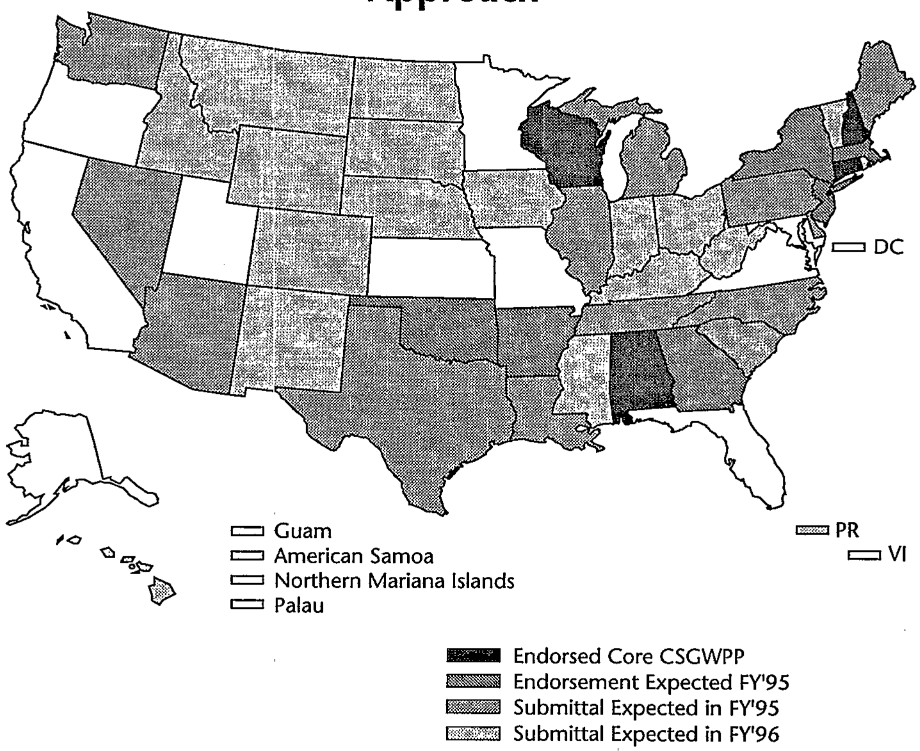
EPA, under the SDWA, seeks to ensure that public water supplies are free of contaminants that may cause health risks and to protect ground water resources by preventing the endangerment of underground sources of drinking water. EPA has pursued a twofold approach: (1) protecting drinking water at the tap, and (2) preventing contamination of ground water sources of drinking water supplies.

The 1986 Amendments to the SDWA provided for an expanded Federal role in protecting drinking water, mandating changes in nationwide safeguards, and new responsibilities to enforce them in the event of State inaction.

EPA has also focused on the prevention of contamination of

Figure 15

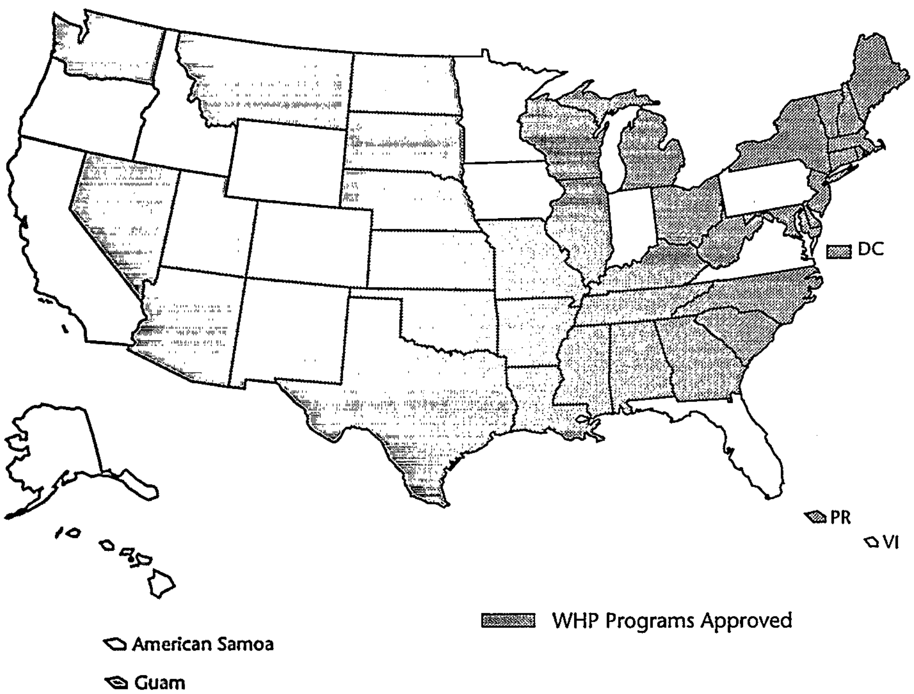
Progress in Implementing the Comprehensive State Ground Water Protection Program Approach



vulnerable ground water resources by assisting States in the development and implementation of comprehensive ground water protection plans. These plans address both the full range of actual and potential sources of ground water contamination and provide for local wellhead protection programs in the areas around public water wells. In addition, EPA has targeted specific activities to protect drinking water sources from the harmful effects of injection of wastes and other fluids. Utilizing authorities provided by the UIC, EPA is increasing emphasis on the vast number of diverse shallow (Class V) injection wells by developing technical industry guidance. EPA is also reviewing the permitting requirements for Class I hazardous waste wells and the imposition of more restrictive standards for all Class II oil and gas injection wells.

Figure 16

Status of Wellhead Protection Programs Across the U.S. and Territories



Wellhead Protection Program

The 1986 Amendments to the SDWA established the WHP Program. Under SDWA Section 1428, each State must prepare a WHP Plan and submit it to EPA for approval. The objective of this program is to protect public health through local action to prevent ground water contamination from reaching public wells by (1) identifying the areas around public water supply wells that contribute ground water to the well, and (2) managing potential sources of contamination in these areas to reduce threats to the resource.

By the end of April 1995, a total of 39 States and Territories had EPA-approved WHP Programs in place. Figure 16 illustrates the States and Territories having regulatory authority to implement WHP programs. EPA is working with the remaining States, Tribes, and Territories to help them develop WHP Programs. EPA's Office of Ground Water and Drinking Water is supporting the development and implementation of WHP at the **local level** through many efforts. For example, EPA-funded support is provided through the National Rural Water Association (NRWA) Ground Water/ Wellhead Protection programs. These programs are currently being implemented voluntarily in 31 States. These States work to integrate their local programs with the WHP Program to meet State requirements. Figure 17 presents the States with active and pending NRWA Wellhead Protection programs.

EPA is also funding Wellhead Protection workshops for local decisionmakers. Eighty-eight of these workshops were held in 26 States. These workshops were attended by approximately 4,400 people.

In 1991, EPA funded a 2-year cooperative agreement with NRWA to promote ground water protection. This agreement was extended for an additional 2 years. At the conclusion of the first 4 years, over 2,000 communities in 26 States were actively involved in protecting their water supplies by implementing wellhead protection programs. These 2,000 communities represent 3,985,000 people in the rural areas of the United States who will have better-protected water supplies.

EPA also funded a 3-year cooperative agreement with the League of Woman Voters (LWV) to develop and test models of community outreach in 18 communities. Based on the experience in those communities, a guidebook entitled *Protect Your Groundwater: Educating for Action* was developed. The popularity of this guidebook led to a national videoconference of the same name. Broadcast in April 1994 to over 150 sites, the videoconference directly reached approximately 3,000 persons. Videotapes were made of the conference and distributed to LWV chapters across the country. The success of this videoconference has led to further cooperation with LWV to bring WHP to even more communities.

According to State 305(b) reports, WHP Programs have taken varying forms in the different States. Among the stages of WHP Program development reported by States are

- Grants to communities to explore and tailor WHP approaches to their needs

- Mapping of sensitive ground water protection areas

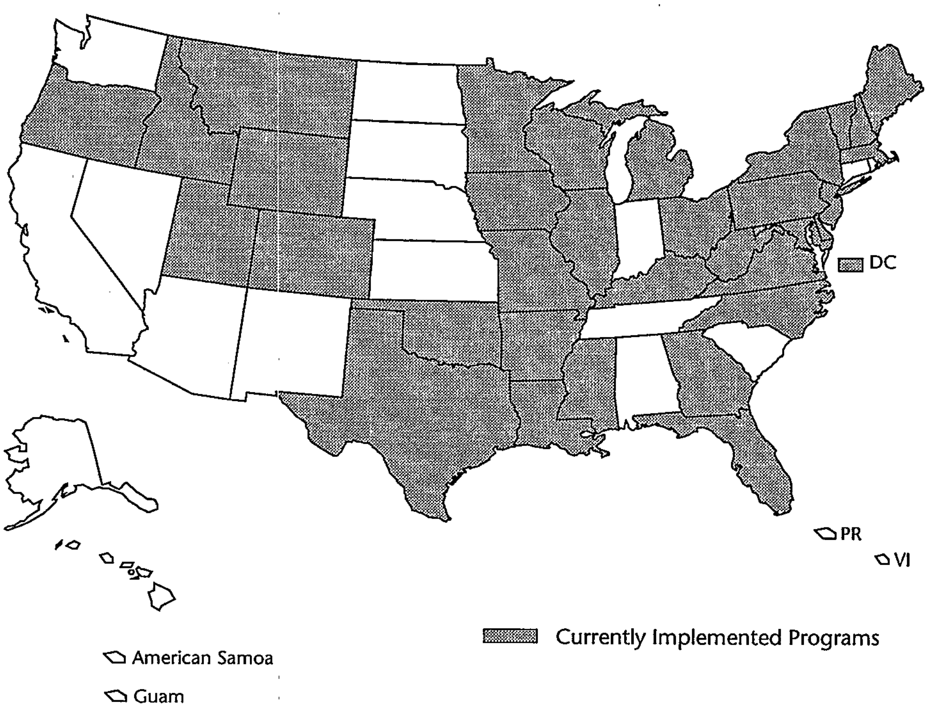
- Establishment of mandatory WHP programs to protect public water supply wells

- Establishment of public education and outreach programs

- Establishment of specific protection criteria for wells tapping confined aquifers and more stringent protection criteria for wells tapping unconfined aquifers.

Figure 17

States with National Rural Water Association Wellhead Protection Programs



Sole Source Aquifer Program

The Sole Source Aquifer protection program was established under Section 1424(e) of the SDWA of 1974. The program allows communities, individuals, and organizations to petition EPA to designate aquifers as the "sole or principal" source of drinking water for an area. Since the first SSA designation in 1975—the Edwards Aquifer in the area around San Antonio, Texas—64 designations have been made nationwide. Seven petitions were evaluated for possible designation at the end of 1994.

If the sole-source designation is approved for an aquifer, EPA is then authorized to review all Federal financially assisted projects to determine if, as a result of the project, the potential exists for adverse impacts to public health due to aquifer contamination. If the Federal financially assisted project is approved by EPA, the project may be implemented as planned with commitment of Federal financial assistance; however, if the potential exists for aquifer contamination, modifications to the project may be necessary prior to commitment of Federal financial assistance. Federal funds may be used to make these modifications to ensure that projects will not contaminate the aquifer.

Federal financially assisted projects undertaken in SSA areas may include a variety of activities involving several agencies. For instance, approximately 50% of the reported activities were initiated by Housing and Urban Development (HUD) through Community Development Block Grants. These include the construction of nursing homes, repair and construction of firehouses to avoid hydrocarbon runoff from equipment from entering the ground water, and installation of septic systems using proper non-polluting drainage construction. The Department of Agriculture Farmers Home Administration has invested in construction and preplanned siting programs for residential areas and ancillary facilities on a large scale.

The Department of Transportation assists in funding construction of roads, highways, mass transit, and certain railroad and airport facilities. This type of construction requires that the proper disposal of surface water runoff be dispersed rather than concentrated on the ground surface and avoid the flooding of local aquifers by runoff from salting stations, hydrocarbons from highway spills and general traffic use, including airports and hangar areas.

Designation helps project sponsors by providing a set of guidelines for aquifer quality review and ground water protection techniques. It also allows individuals, agencies, and States and Tribes the opportunity to develop strategies beyond the SSA program to protect drinking water aquifers, such as adopting Wellhead Protection Programs.

Figure 18 illustrates the number of projects reviewed, approved, and modifed for fiscal years 1990 through 1994. Only five projects were not approved during this same period: four projects in 1991 and one in 1992. There were no other unapproved projects after 1992. This curtailment is an indication that SSA project sponsors have adjusted to the ongoing SSA ground water protection program objectives.

Review of Figure 18 indicates the following:

- A total of 1,039 projects were reviewed over the 5-year period. Of these, 838 were approved and 74 were modified.

- Review of project modifications indicates that ground water protection was achieved through changes in drainage and spill containment, clear identification of SSA boundaries, more focused pre- and postconstruction activity monitoring, and review of initial project designs.

- For fiscal years 1992, 1993, and 1994, project modifications decreased by approximately 64% over previous years. This decrease reflects the maturing of the SSA program as a community ground water protection tool. Project sponsors and designers acknowledge that proper aquifer protection is required up front in the design phase and that incorporation of proper aquifer protection will expedite designations.

Pollutant Source Control

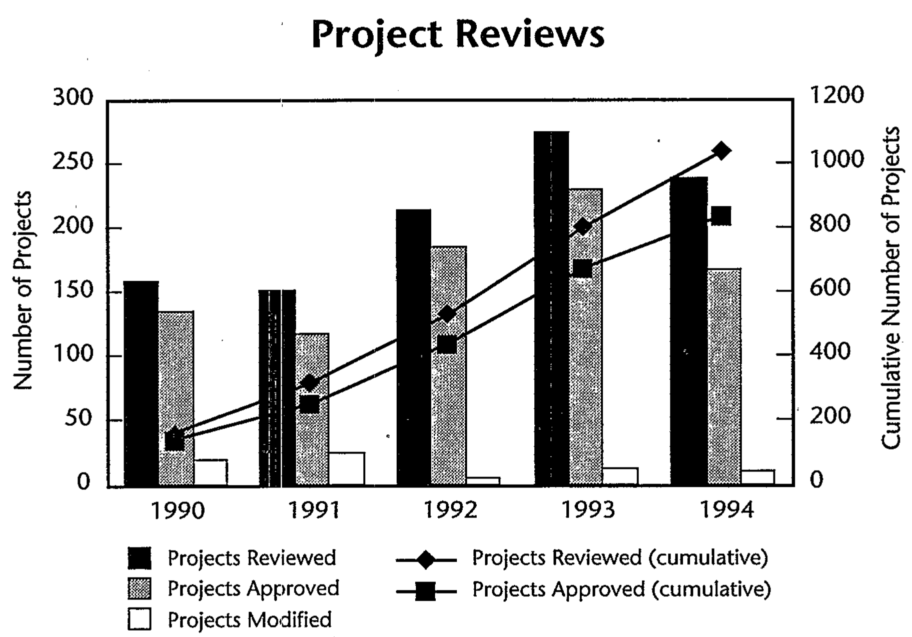
Four principal programs control pollutant sources under four different laws: underground storage tanks and solid and hazardous waste treatment, storage, and disposal are regulated under RCRA; underground injection of waste fluids is regulated under SDWA; abandoned waste is regulated under CERCLA; and nonpoint sources are controlled under CWA.

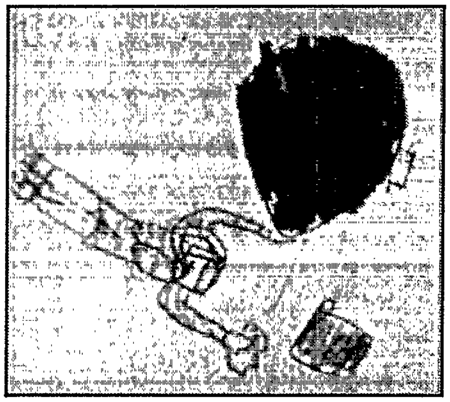
Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (Public Law 94-580) was passed by Congress in October 1976, amending the 1965 Solid Waste Disposal Act to address the problem of safe disposal of the huge volumes of solid and hazardous waste generated nationwide each year. This Act authorizes a regulatory program to identify and manage wastes that pose a substantial hazard to human health or the environment. RCRA is a part of EPA's comprehensive program to protect ground water resources. Protection is achieved through the development of regulations and methods for handling, storing, and disposing of hazardous material and through the regulation of underground storage tanks.

Poorly managed or poorly located municipal landfills rank high

Figure 18





Kings Park Elementary, 3rd Grade, Springfield, VA

among State ground water contamination concerns. Of the quarter million solid waste disposal facilities in the United States, about 6,000 are municipal solid waste facilities. Approximately 25% of these municipal facilities have ground water monitoring capabilities.

As of September 1994, there were 418 land disposal facilities subject to ground water monitoring requirements under RCRA. Approximately 221 of these facilities are conducting detection monitoring, 42 are conducting compliance monitoring, and 155 are undertaking corrective action.

Solid and Hazardous Waste

RCRA has evolved from a relatively limited program dealing with nonhazardous solid waste to a far-reaching program that also encompasses the handling, storage, and disposal of hazardous waste. Hazardous waste generators, transporters, and owner/operators of treatment, storage and disposal facilities (TSDFs) constitute the RCRA-regulated community. On November 8, 1984, Congress passed the Hazardous and Solid Waste Amendments (HSWA) to RCRA, thereby greatly expanding the nature and complexity of activities covered under RCRA.

The goals of RCRA, as set forth by Congress, are

- To protect human health and the environment
- To reduce waste and conserve energy and natural resources
- To reduce or eliminate the generation of hazardous waste as expeditiously as possible.

RCRA also requires the promulgation of standards related to underground storage tank systems for both chemicals and petroleum products.

In 1990 and 1991, RCRA programs continued to emphasize the preparation of risk assessment documents and development and evaluation of tests and procedures for conducting risk assessments. Health and Environmental Effects Documents, Reference Doses, and technical evaluations are provided to support the RCRA waste listing, permitting, and land disposal restriction programs. The 1990 program emphasized the development of health and environmental effects documents for the listing/delisting programs and reference doses for the land disposal restriction program. In addition, techniques for determining soil gas concentrations and constituents and for determining ground water contamination potential were evaluated under field and laboratory conditions. Guidelines for monitoring ground water around RCRA Subtitle D landfill facilities are being developed.

Underground Storage Tank Program

One of the primary goals of this program is to protect the Nation's ground water resources from releases by underground storage tanks containing petroleum or certain hazardous substances. The EPA works with State and local governments to implement Federal requirements for proper management of USTs. The EPA estimates that about 1.2 million federally regulated USTs are buried at over 500,000 sites nationwide. Nearly all USTs contain petroleum; about 30,000 USTs hold hazardous substances covered by the Federal regulations.

In 1988, EPA issued regulations setting minimum standards for new tanks (those installed after December 22, 1988) and existing tanks (those installed before December 22, 1988). By December 1998, existing USTs must be upgraded to meet minimum standards or be replaced with new tanks or be closed properly. Since 1988, more than 900,000 old USTs have been closed, thus eliminating a significant number of potential sources of ground water contamination. Of the remaining 1.2 million USTs, about 400,000 have already been upgraded or replaced.

New and existing USTs complying with EPA's standards can prevent leaks caused by spills, overfills, corrosion, and faulty installation. USTs complying with the leak detection requirements can identify releases quickly, before contamination spreads. Corrective action requirements secure responsible and timely cleanup of contaminated sites.

As of January 1995, more than 278,000 UST releases had been confirmed. The EPA estimates that about half of these releases have reached ground water. Over 110,000 contaminated sites have been cleaned up, and cleanups are under way at 100,000 more sites. EPA estimates that the total number of confirmed releases could reach 400,000 in the next several years, primarily due to releases discovered during the closure or replacement of old USTs. After this peak, EPA expects fewer releases as USTs comply with leak prevention requirements.

Congress created the Leaking Underground Storage Tank (LUST) Trust Fund in 1986 to provide money for overseeing corrective action taken by a responsible party and to provide money for cleanups at UST sites where the owner or operator is unknown, unwilling, or unable to respond or that require emergency action. Since 1986, $469 million has been dispersed to State UST programs for State officials to use for administration, oversight, and cleanup work.

UST owners and operators must also meet financial responsibility requirements that ensure they will have the resources to pay for costs associated with cleaning up releases and compensating third parties. The amount of coverage required ranges from $500,000 to $1 million, according to the type and size of the UST business. Many States have provided financial assurance funds to help their UST owners meet the financial responsibility requirements. These State funds raise over $1 billion annually for use on UST cleanups.

The Agency recognizes that, because of the large size and great diversity of the regulated community, State and local governments are in the best position to oversee USTs. EPA encourages States to seek State program approval so they may operate in lieu of the Federal program. To date, 20 States have received State Program Approval. All States have UST regulations and programs in place. The Agency also has developed a data management system that many States use to track the status of UST facilities, including their impact on ground water resources. EPA also has negotiated UST grants with all States and provided technical assistance and guidance for implementation and enforcement of UST regulations.

Safe Drinking Water Act

Pollutant source control is addressed under the SDWA through the UIC program.

Underground Injection Control Program

EPA's UIC program was developed to regulate underground injection wells and thereby ensure that underground sources of drinking water are protected. Injection wells are classified as follows:

- Class I: Wells used to inject hazardous substances or industrial and municipal waste beneath the lowermost formation containing a source of drinking water. There are 159 hazardous waste wells at 61 facilities and 350 nonhazardous waste wells at 197 facilities controlled by stringent design, construction, and operating requirements. The hazardous waste management facilities inject 9 billion gallons of fluids each year. This volume represents 89% of all hazardous waste that is land disposed.

- Class II: Wells used to inject fluids in the process of oil or natural gas production. More than 160,000 disposal and enhanced recovery wells inject brines into geologic formations. These wells inject approximately 3 billion gallons of produced brine and enhanced recovery fluids every day.

Together Class I and II injection wells dispose of a larger volume of hazardous waste into deep bedrock formation than all the other RCRA hazardous waste disposal facilities by a factor of eight.

- Class III: Wells used to inject fluids for the purpose of in situ mineral extraction.

- Class IV: Wells used to dispose of hazardous or radioactive waste into or above an underground drinking water source. These wells are banned.

- Class V: Class V injection wells are generally shallow wastewater disposal wells, stormwater, and agriculture drainage systems or other devices that can release nutrient and toxic fluids into the ground and eventually into water table aquifers. EPA estimates that more than 1 million Class V wells currently exist in the United States. A majority of Class V wells may pose little or no risk to human health. Others, however, may inject fluids containing bacteria, viruses, nitrate-nitrogen, and toxic chemicals that can contaminate the habitat and food supply of fish and wildlife species, the base flow for surface waterbodies, and the public drinking water supply. These wells include more than

Wells as Conduits of Contamination

Although anecdotal cases abound of wells serving as conduits that allow contaminants to enter an aquifer, few occurrences are documented. However, the publication *Drinking Water: Safeguards Are Not Preventing Contamination From Injected Oil and Gas Wastes* (GAO, 1989) provides a table of 23 documented cases of contamination of an underground source of drinking water via Class II oil and gas injection wells. Fourteen of these cases resulted from wells that were improperly plugged or constructed and/or had leaky casings. Nine other cases were the result of deliberate injection into an aquifer before its designation as an underground source of drinking water. What is particularly noteworthy in these cases is the enormous cost of cleanup. In one of the cases, the State (Kansas) authorized $300 million to begin cleanup because the contamination threatened a major municipal well field. In 18 of the other cases, no cleanup is intended because it is either impractical or too costly.

100,000 shallow injection wells such as those used to dispose of waste from automotive service bays.

Currently, all shallow injection wells that do not endanger underground sources of drinking water are allowed; however, because of the diversity in the risks posed by Class V wells and the size and nature of the regulated community, EPA encourages a nontraditional regulatory approach to addressing these wells. A large proportion of the Class V wells are owned by small businesses. To effectively address the unique challenges posed by the Class V universe, EPA is implementing a comprehensive strategy for the management of Class V injection wells. The strategy involves a carefully tailored combination of guidance, education, and outreach and enhancing the use of existing regulatory authorities through some minor changes to the UIC regulations. The goal of the strategy will be to speed up the closure of potentially endangering Class V wells using current authorities and to promote the use of best management practices to ensure that other Class V wells do not endanger USDWs.

Grants allotted under Sections 1443(b) and 1451 of the SDWA may be used to support UIC activities to protect ground water resources. State and Federal UIC programs include permitting and review of permits to ensure that wells meet requirements for well construction, operation, monitoring, plugging, and abandonment, and financial responsibility to ensure that underground sources of drinking water are not endangered. Section 1422 provides EPA with authority to grant primary enforcement authority (primacy) to States to administer a UIC program in their States. Section 1425 allows an alternative test for EPA to use to approve a State's UIC program for Class II brine disposal wells.

EPA and States currently administer 57 UIC programs to maintain regulatory coverage of the almost one-half million underground injection wells. The majority of these programs are State-administered, as depicted in Figure 19. State agencies with primary enforcement authority respond to UIC violations. If a response cannot be made in a timely manner, EPA takes enforcement action.

In 1992 and 1993, EPA continued to review "no migration" petitions for hazardous waste injection wells to ensure conformance with RCRA and UIC provisions. EPA has targeted specific enforcement, outreach, and regulatory activities to protect drinking water sources from the harmful effects of injections of wastes and other fluids through the vast number of diverse Class V injection wells. The Class V rule has significant implications for the disposal of industrial wastes. EPA also plans to propose "area of review" requirements for all Class II wells.

EPA Regional offices administering UIC programs in nonprimacy States continue to review permit applications for injection wells and continue oversight of State primacy programs to ensure that UIC permits issued meet program requirements. Regional offices also continue to review petitions from operators of hazardous waste injection wells seeking exemptions from the injection well ban.

Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 created several programs operated by EPA, States, Territories, and Tribes that act to protect and restore contaminated ground water. Restoration of contaminated ground water is one of the primary goals of the Superfund program. As stated in the National Contingency Plan, EPA expects to return usable ground waters to their beneficial uses, wherever possible, within a time frame that is reasonable given the particular circumstances of the site. Following are statistics related to Superfund restorations:

- In the absence of Superfund, 11.9 million people could be exposed to carcinogenic risk greater than 1 in a million, and 9.9 million people could be exposed to noncarcinogenic effects above health-based standards at National Priority List (NPL) sites.

- At 94% of NPL sites where ground waters were classified (426 of 453), the ground water is currently used or potentially usable as a source of drinking water. This suggests that only 6% of NPL sites involving ground water contamination are classified as nonusable aquifers (e.g., saline or nonpotable).

- Of the 622 NPL sites reporting ground water contamination near the site, the ground water is currently used for private water supplies at 42% of the sites and for public supplies at 27% of the sites.

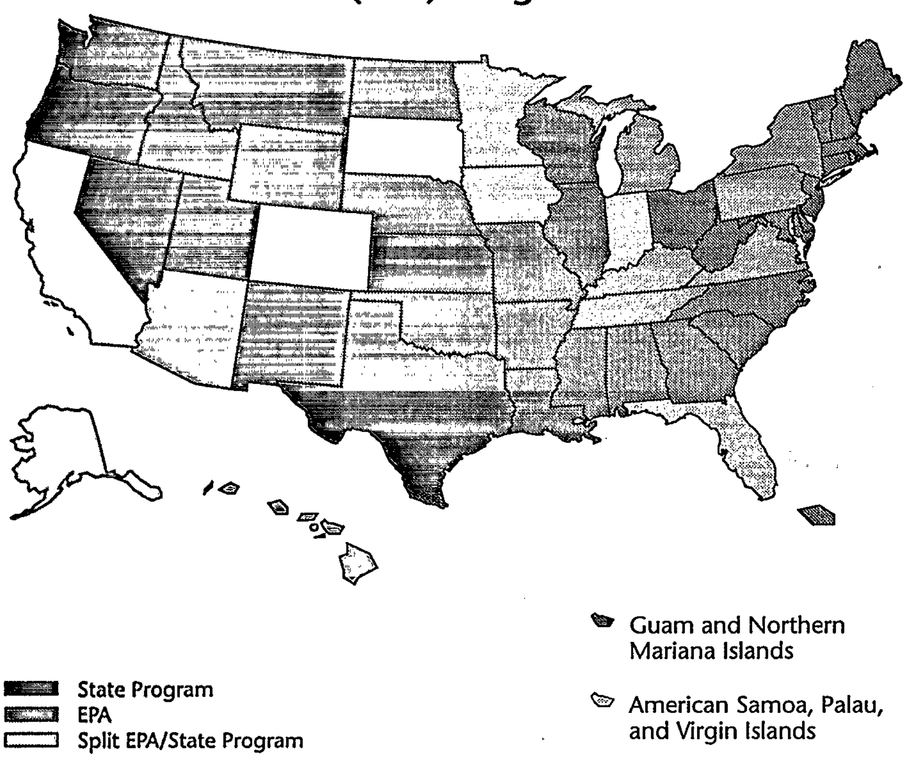
- At the 67% of NPL sites where ground water is currently used for drinking water purposes, the ground water is potentially threatened by a migrating contaminant plume.

- Organic compounds are the predominant ground water contaminants for 89% of the sites for which remedies for ground water contamination have been selected. Table 2 lists the most frequently detected organic and inorganic constituents reported at NPL sites.

- Ground water contamination is associated with 63% of the sites for

Figure 19

Underground Injection Control (UIC) Program



which remedies have been selected (702 of 1,121).

- Generally, ground waters that are currently used or are potentially usable for drinking water supply are being cleaned to MCLs authorized under the SWDA. However, in some cases, more stringent State standards are used. At least 12 States have promulgated cleanup standards for ground water, including Massachusetts, West Virginia, Illinois, Minnesota, Wisconsin, New Mexico, Texas, Iowa, Nevada, South Dakota, Wyoming, and Washington.

Pollution Prevention

The Pollution Prevention Act of 1990 was enacted by Congress to promote pollution prevention and environmental protection goals. Under this Act, the EPA Office of Pollution Prevention and Toxics and the U.S. Department of Agriculture Cooperative State Research Service have worked cooperatively to lead the Nation in the development of environmentally sound agricultural policies. The Agriculture in Concert with the Environment Program promotes the use of sustainable agriculture and the integrated management of nutrients, pesticides, resources, and wastes to reduce the risks of environmental pollution. Grants allotted under this Act may be used to fund outreach projects involving education, demonstration, and training in sustainable agricultural practices that emphasize ground water protection and reducing the excessive use of nutrients and pesticides.

Grants are also available under this Act to support State and local pollution prevention programs that address the reduction of pollutants across all environmental media: air, land, surface water, ground water, and wetlands. These grants may be used to promote and coordinate existing State pollution prevention activities that focus on specific media, to develop new multimedia pollution prevention programs, to develop mechanisms to measure progress in multimedia pollution prevention, and to conduct education and outreach programs.

Table 2. Contaminants Most Frequently Reported in Ground Water at CERCLA National Priority List Sites

Rank	Contaminants	Number of Sites
Organic Compounds		
1	1,1,2-Trichloroethylene	336
2	Chloroform	167
3	Tetrachloroethene	167
4	Benzene	163
5	Toluene	160
6	1,1,1-Trichloroethane	155
7	Polychlorinated biphenyls	138
8	Trans-1,2-Dichloroethylene	107
9	1,1-Dichloroethane	103
10	1,1-Dichloroethene	94
11	Vinyl chloride	81
12	Xylene	76
13	Ethylbenzene	69
14	Carbon tetrachloride	68
15	Phenol	61
16	Methylene chloride	58
17	1,2-Dichloroethane	56
18	Pentachlorophenol	52
19	Chlorobenzene	46
20	DDT	35
Inorganic Constituents		
1	Lead	306
2	Chromium ion and related species	213
3	Arsenic	149
4	Cadmium	126
5	Copper ion and related species	83
6	Mercury	81
7	Zinc ion and related species	75
8	Nickel ion and related species	45
9	Barium	41
10	Cyanides and associated salts	38

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Grass Roots Ground Water Protection

As the impacts of ground water contamination become more widely known, volunteers and grass roots ground water protection initiatives are becoming common in communities across America. The programs range from volunteer-driven efforts to protect vital drinking water supplies through Wellhead Protection Programs, to volunteer-sponsored well water quality testing and public education on the sources of our drinking water.

The El Paso Experience

In late 1989, the Texas Water Commission targeted the city of El Paso, Texas, for a pilot project to protect the city's ground water. This pilot project marked the beginning of an innovative, volunteer-driven Wellhead Protection Program. A team of dedicated volunteers was coordinated through the El Paso Retired Senior Volunteer Program.

Over a 3½-day period, the 23 senior citizen volunteers surveyed possible sources of ground water contamination around all 138 public water wells that provide drinking water to the city of El Paso. They reviewed historical records, interviewed area residents, and conducted door-to-door surveys to catalog potential threats to their drinking water. The State estimated that the volunteer effort saved approximately $35,000, and resulted in the identification of approximately 20,000 potential sources of pollutants near the water wells.

The El Paso pollution source inventory formed the backbone of the El Paso Wellhead Protection Program and resulted in a city ordinance concerning the storage of hazardous materials within the vicinity of the public water wells. The effort has recently been expanded into Mexico, since the residents of the adjacent Mexican city of Ciudad Juarez also rely on drinking water from the same aquifers.

Oregon's Volunteer Well Water Nitrate Testing Project

The Oregon Department of Environmental Quality sponsored a project to encourage residents to test their well water for nitrate levels. The project was conducted from 1991 to 1993 and resulted in volunteers testing a total of 1,600 wells. The Oregon Ground Water Community Involvement Program was initiated to continue the nitrate testing program. The Program

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provides volunteer training, resource materials and nitrate test kits and promotes public education through nitrate testing events and ground water forums.

League of Women Voters Ground Water Education Programs

The League of Women Voters (LWV) has sponsored a number of volunteer-led ground water education programs. The LWV in Rockford, Illinois, surveyed residents concerning their knowledge of water supply and ground water contamination concerns. Similar surveys were conducted by the LWV in Red Wing, Minnesota, and Salt Lake City, Utah. The LWV of Enid, Oklahoma, organized volunteers to conduct pollution source inventories around the city's five water well fields. Other LWV chapters have developed videos, brochures, and other educational materials concerning ground water protection and potential threats to ground water quality.

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Protecting Our Drinking Water: The EPA's Source Water Protection Initiative

Americans have long enjoyed the luxury of safe, affordable drinking water. A rising awareness of water pollution incidents, however, has caused people to be concerned about drinking water quality. Many communities have recognized that preventing the pollution of lakes, rivers, streams, and ground water is the key to ensuring the long-term safety of drinking water. This common sense approach is known as **source water protection.**

The Safe Drinking Water Act emphasizes monitoring and treatment to protect drinking water safety. However, protection based on monitoring and treatment alone is not sufficient. Nearly all groups interested in drinking water safety see a need for stronger efforts to prevent pollution from entering drinking water sources rather than relying solely on water treatment to reduce health threats.

The EPA encourages this prevention-oriented approach and is actively promoting the development of grass roots source water protection activities. As part of the Source Water Protection Initiative, the EPA hopes to

- Restore the public's rights and responsibilities to protect their drinking water
- Raise public confidence in the safety and quality of their drinking water supply
- Reduce the costs of providing safe drinking water.

Wellhead Protection Programs

Many States and communities are currently promoting source water protection, in Wellhead Protection (WHP) programs. The 1986 Amendments to the Safe Drinking Water Act established the Wellhead Protection Program to aid communities in protecting their drinking water quality. Through wellhead protection, communities identify the land areas that contribute ground water to public water supply wells. They then develop plans to manage the potential sources of contamination in those vulnerable areas, thereby reducing the likelihood of polluting the drinking water source.

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By the end of December 1994, a total of 37 States and Territories had EPA-approved WHP Programs in place. In addition, thousands of local WHP initiatives have been undertaken in communities across the Nation. As of 1993, approximately 3,800 communities that are dependent on ground water for drinking water had complete WHP programs.

Expanded Source Water Protection Goals

The idea of wellhead protection can apply to surface water supplies as well. The EPA is encouraging stronger watershed protection programs, through approaches available under the Federal Clean Water Act, to protect surface waters used for drinking water supplies. Source water protection, for both ground water and surface water, may offer significant advantages to both drinking water purveyors and consumers.

The EPA is planning a National Source Water Protection Workshop in 1996. This workshop will provide communities with the tools and information needed to establish source water protection programs. The workshop will be televised and will target communities that have delineated their source water protection areas and carried out source identification. The workshop will also assist communities in moving toward source management.

The EPA has also set the following source water protection goals:

- By 1997, establish a core network of 10,000 communities with active and comprehensive local WHP programs in place.

- By 1997, incorporate source water protection and source management as priority objectives in projects requiring financial assistance from other Federal programs.

- By 1997, begin to expand source water protection approaches to communities reliant on surface water for drinking water.

- By 2005, have 50% of all community water supplies covered by active and comprehensive local source water protection programs.

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Costs of Not Preventing Contamination of the Ground Water Resource

The sage adage that "An ounce of prevention is worth a pound of cure" is being borne out in the field of ground water protection. Three separate efforts to look at the cost of prevention versus remediation have found that there can be real cost advantages to promoting prevention of ground water contamination in the public and private sectors.

The analysis of prevention in Maine found that, for six large municipal water systems with contamination from salt storage, gasoline, landfill leachate, and industrial solvents, costs for well replacement, emergency supplies, water treatment, and/or remediation ranged from $500,000 to $1,500,000. Of the 2,000 small water systems in the State, perhaps as many as 70 are contaminated. For six small systems, remedial costs ranged from $6,000 to $155,000. Costs for preventing contamination in these cases were estimated to be 1/10th to 1/100th of the costs of remediation for the large systems and 1/5th to 1/10th for the small systems. Although remediation is thus more costly than prevention, whether prevention is more cost-effective in any particular instance depends on the risk that a water system without a particular type of preventive measure would need remediation and when any costs of remediation would be incurred.

The State of Washington's Wellhead Protection Program found that, in a sample of small communities ranging in size from 300 to 5,000 people affected by such contaminants as ethylene dibromide (an agricultural fumigant), gasoline, and trichloroethylene (TCE, a solvent), costs for cleanup and/or a new water supply ranged from $40,000 to $1,800,000, with costs continuing to be incurred. For a larger city—Tacoma—where TCE and other contaminants were found in a wellfield in concentrations more than 10 times the health standard, costs over the expected 18-year cleanup period are estimated to be $25 million.

Washington's Wellhead Protection Program catalogued the types of costs associated with contaminated public water supplies and found that they included

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- Provision of emergency water supplies
- Construction and operation of water treatment facilities at the wellhead
- Well replacement
- Transmission line construction
- Hydrogeologic studies
- Remedial measures at or near the contamination source including soil removal, soil capping, and the installation and operation of "pump and treat" systems
- Additional administrative costs
- Public information and education
- Legal proceedings.

Intangible costs included

- Increased health risks
- Decreased ability to provide adequate volumes of water, especially in emergencies, such as fires
- Reduced consumer confidence
- Economic impairment
- Lost opportunity costs in spending funds for cleanup rather than other community needs
- Consumer hysteria and overreaction
- Disposal of wastewater from pump and treat facilities.

The Freshwater Foundation report, *Economic Implications of Groundwater Contamination to Companies and Cities* (1991), indicates that costs to 17 Minnesota cities for remediating ground water contamination was over $30 million, with seven cities reporting costs over $1 million and two reporting impacts in the $10 to $20 million range. Fourteen cases of ground water contamination involving corporations found that most businesses spent over $1 million, with five spending from $5 million to nearly $10 million. In addition to the technical and engineering remedial costs, a major corporate cost was legal fees.

Appendix A

Data Reported by Individual States, Tribes, Territories, and Commissions – Ground Water

Table A-1. Ground Water Source Used for Drinking Water

State	Ground Water for Public Water Supply – 1970-1990		Ground Water to Surface Water Ratio for Marginal Change in Public Supplied Water – 1980-1990	Population Supplied by Ground Water for Drinking Water – 1990		% of Ground Water Supplied to Population by Private Wells – 1990
	MGD 1990	% Increase 1970-1990		Population (thousands)	%	
Alabama	224	124	2.8	1,819	45	20
Alaska	34	42	0.4	282	51	55
Arizona	401	111	2.2	2,457	67	12
Arkansas	119	68	0.2	1,451	62	39
California	3,260	104	3.8	16,453	55	17
Colorado	83	5	1.3	670	20	37
Connecticut	73	(15)	18	1,130	34	55
Delaware	33	10	0.8	435	65	32
Florida	1,700	124	10.9	11,710	91	15
Georgia	234	23	0.02	2,880	44	46
Hawaii	221	84	20.5	1,076	97	4
Idaho	173	80	1.9	864	86	28
Illinois	444	(38)	< 0	4,650	41	29
Indiana	274	30	0.5	3,510	63	44
Iowa	234	30	1.0	2,142	77	32
Kansas	176	35	0.8	1,290	52	19
Kentucky	55	129	0.1	1,341	36	75
Louisiana	275	96	1.3	2,447	58	25
Maine	21	5	1.0	701	57	77
Maryland	76	81	0.1	4,781	31	57
Massachusetts	179	5	< 0	6,016	42	25
Michigan	261	13	0.3	9,395	35	51
Minnesota	290	81	4.0	4,375	79	42
Mississippi	282	76	> 32	2,573	93	28
Missouri	185	101	725	5,117	49	41
Montana	51	96	> 1	799	52	47
Nebraska	235	57	2.5	1,578	86	28
Nevada	104	28	0.1	1,202	33	20
New Hampshire	34	6	< 0	1,109	64	58
New Jersey	396	16	< 0	7,773	47	25
New Mexico	241	85	4.6	1,517	90	23
New York	550	20	0.4	17,990	36	32
North Carolina	137	71	0.4	6,629	43	66
North Dakota	32	33	0.5	639	61	40
Ohio	396	24	0.1	10,847	45	36
Oklahoma	80	11	0.03	3,146	39	40
Oregon	105	57	0.2	2,842	37	52
Pennsylvania	427	71	> 187	11,882	50	46
Rhode Island	13	(28)	< 0	1,003	19	37
South Carolina	79	44	0.3	2,055	59	67
South Dakota	52	24	0	545	78	26
Tennessee	269	68	0.6	2,498	51	36
Texas	1,270	84	> 340	8,047	47	11
Utah	305	103	0	1,723	58	5
Vermont	19	36	> 2	563	72	57
Virginia	69	(7)	< 0	6,187	34	70
Washington	434	50	> 134	4,867	60	31
West Virginia	43	19	0	1,793	51	65
Wisconsin	294	34	0.2	4,892	69	44
Wyoming	41	71	> 14	454	59	41
Puerto Rico	80	135	0.2	3,522	25	
Virgin Islands	1		2.1	101	14	48
Total U.S.	15,000	61	2.1	128,902	51	32

Source: Geological Survey: Estimated Use of Water in the United States in 1971, 1975, 1980, 1985, and 1990; Circular 676, 1972; Circular 765, 1977; Circular 1001, 1983; Circular 1004, 1988; Circular 1081, 1993.

Table A-2. Summary of State Ground Water Protection Programs

State	Indicator Parameters[a]		Monitoring[a]			Classification	
	Administrative	Constituent	Ambient	Compliance	Federal	Classification Levels	Basis[b]
Alabama			✓	✓		under development[c]	
Alaska	✓*			✓		none[b]	
Arizona		✓ (pesticides, VOCs, ions, metals, hydrocarbons, radionuclides, bacteria)	✓		✓	2	use
Arkansas	✓*	✓	✓	✓	✓	3	relationship to ecologically sensitive ecosystems and potential use as drinking water source
California	✓ (pesticide residues)			✓		systems are regional—use categories include: domestic, agricultural, industrial service, and industrial process[b]	beneficial use
Colorado			✓[d]	✓		5	use
Connecticut				✓		4	use and water quality (suitability for use as a drinking water source without treatment)
Delaware			✓[d]	✓	✓	no formal system—goal of protection of all water for beneficial use[b]	
Florida	✓ (pesticides, VOCs, metals, nitrates, trihalomethanes)		✓	✓	✓	4	use, total dissolved solids, ambient water quality, and level of natural protection
Georgia	✓ (land use)	✓ (pH, nitrate, specific conductivity, inorganics)	✓			no formal system—variable protection based on ground water value, vulnerability, existing quality, current use, and potential future use[b]	antidegradation goal
Hawaii		✓ (organics, chlorides)			✓	3	hydrogeology, geology, existing use, salinity, total dissolved solids, replaceability, vulnerability to contamination, and ecological importance
Idaho	✓*	✓ (radionuclides, pesticides, ions, bacteria, VOCs)	✓			3	ecological sensitivity, use as drinking water source[c]
Illinois			✓			4	beneficial use
Indiana		✓ (bacteria)	periodic			none	
Iowa			✓[d]	✓	✓	none[b,c]	
Kansas			✓			3	natural mineral quality
Kentucky	✓*			✓		none	
Louisiana	✓*		✓[d]	✓	✓	domestic use	
Maine			✓[d]			2	use
Maryland		✓ (color, pH, alkalinity, ions, specific conductivity)	✓		✓	3	regulation, hydrogeology, water quality

* Indicators suggested by EPA in the guidance document for the 305(b) report.

Sources: [a] "Summary Table of Current State Ground Water Monitoring and Use of Ground Water Quality Indicators," January 1994.
[b] Benjamin, S., and Belluck, D., *State Groundwater Regulation: Guide to Laws, Standards, and Risk Assessment*, The Bureau of National Affairs, Washington, DC, 1994.
[c] "Summary of State Ground Water Classification Systems," December 1992.
[d] *State 305(b) Reports.*

Table A-2. (continued)

Classification (continued)	
Used in Permitting[c]	Restricted Activities[b]
✓	Certain industries must have Aquifer Protection Permits, which control and limit discharges
✓	
✓	Activities that may affect water quality: restrictions vary across the State
✓	
✓	No discharge of wastewater other than domestic sewage or animal wastes in areas containing the two highest classes of ground water; only areas containing the lowest class of ground water (unsuitable for development of a public water supply) may be used for waste treatment processes
✓	Permitting based on nondegradation policy—polluting activities can be prohibited
✓	
✓[b]	Activities restricted in areas vulnerable to ground water contamination—all potentially polluting activities are controlled
✓	
	Regulation of activities threatening ground water quality
✓	
✓	
✓	Wastewater discharges regulated through permitting

(continued)

Table A-2. (continued)

State	Indicator Parameters[a]		Monitoring[a]			Classification	
	Administrative	Constituent	Ambient	Compliance	Federal	Classification Levels	Basis[b]
Massachusetts		✓ (specific conductivity, TOC, COD, ionic balance)		✓		3	most sensitive use
Michigan	✓*		✓[d]	✓		none—believe all aquifers should have equal protection[b]	
Minnesota	✓*		✓		✓	none—nondegradation goal for all ground water[b]	
Mississippi			✓[d]	✓	✓	none—goal of preservation for domestic use[b]	
Missouri		✓ (nitrate)	✓[d]		✓	no formal system—antidegradation policy for all usable ground water; classes can be assigned by regulation and water quality[b]	
Montana			✓[d]	✓		4	specific conductance
Nebraska		✓ (pesticides, nitrate)	✓[d]	✓	✓	3	regulation
Nevada			proposed			none—antidegradation policy for all ground water	
New Hampshire						4	potential as a drinking water source
New Jersey	✓*		✓[d]	✓		3	hydrogeologic characteristics and designated uses
New Mexico			✓[d]	✓		2[b]	total dissolved solids
New York	✓ (public supply vulnerability)	✓ (alpha particle activity)		✓	✓	3	total dissolved solids and salinity
North Carolina				✓		3	use and mineral content
North Dakota			✓			2	total dissolved solids and regulation under the State UIC program
Ohio			✓			none—no differential protection of aquifers	
Oklahoma	✓ (Maximum Allowable Limit (MAL) violations)		✓	✓		3 (proposed)	ecological sensitivity, hydrogeologic characteristics, total dissolved solids, and potential use
Oregon				✓		none—antidegradation policy for all ground water	
Pennsylvania			✓			none—nondegradation goal for all ground water	
Rhode Island			✓[d]	✓	✓	4	potential use and water quality (e.g., suitability for drinking water use without treatment)
South Carolina		✓	✓	✓		3	hydrogeologic characteristics and potential use
South Dakota	✓*	✓ (bacteria)	✓[d]	✓	✓	2	total dissolved solids
Tennessee					✓	under development	
Texas			✓	✓		4	total dissolved solids
Utah				✓		7	ecological importance, presence of contaminants, total dissolved solids, and potential use
Vermont	✓*	✓	developing[d]	✓		4	potential use and exposure to risk of contamination

Table A-2. (continued)

Classification (continued)	
Used in Permitting[c]	Restricted Activities[b]
✓	
✓	
✓	
✓	
✓	Antidegradation policy, especially in areas of high water quality. Regulated contaminant sources include chemical and fuel storage, agricultural chemical use, waste treatment and disposal areas, water wells and unrestricted test holes, industrial facilities, and hazardous material transportation spills and leaks
✓	
✓	Local protection and State corrective and prevention efforts targeted in top two tiers of classification system
✓	
✓	Discharge permits are required—designed to protect Class I ground waters
✓	
✓	
✓	Standards regulate discharges to each class of ground water
✓	Sewage, industrial, or other wastes cannot be placed where they may cause pollution to any source of ground water
✓	
✓	
✓	
✓	
✓	
✓	
✓	Human activities are regulated and/or prohibited within vulnerable ground water areas

(continued)

Table A-2. (continued)

State	Indicator Parameters[a]		Monitoring[a]			Classification	
	Administrative	Constituent	Ambient	Compliance	Federal	Classification Levels	Basis[b]
Virginia	✓*		✓			none—antidegration policy for all ground water[b]	
Washington	✓*	✓ (specific conductivity, gross alpha, nitrate, pesticides)	proposed	✓	✓	none—antidegradation policy for all ground water	
West Virginia		✓	✓		✓	none—preservation of all ground water for beneficial use	
Wisconsin	✓*		✓	✓		none—antidegradation goal for all aquifers; preserve all as drinking water sources[b]	
Wyoming				✓		9 (including subclasses)	regulation, existing use, total dissolved solids, ambient water quality

Table A-2. (continued)

Classification (continued)	
Used in Permitting[c]	**Restricted Activities[b]**
✓	
✓	No discharge unless all known, available, and reasonable methods of treatment have been applied
✓	
✓	No discharge unless all known, available, and reasonable methods of treatment have been applied
✓	No discharges to first five classes that impair ambient ground water quality; no discharges to classes 6 and 7 that impair water for use suitability; no substances released to any class in excess of standards or that contribute to any hazardous effect on natural biota

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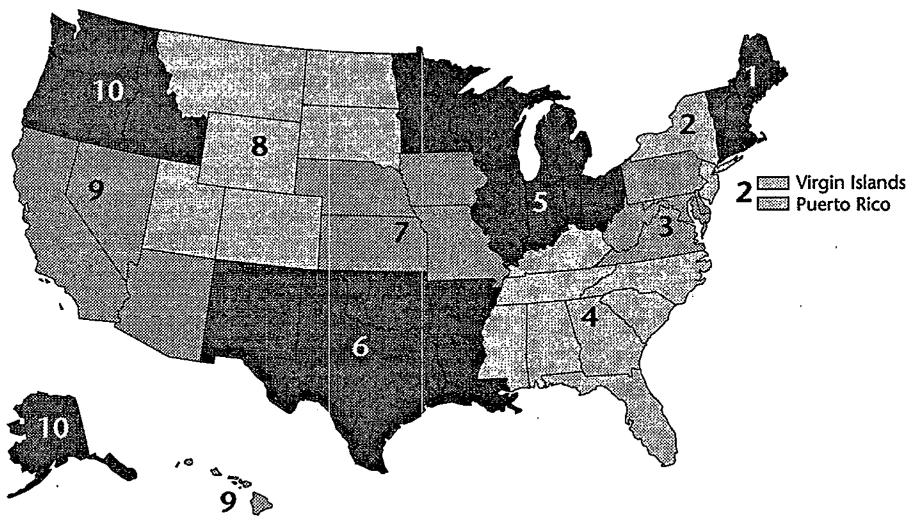

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