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Availability and Suitability of Data From Public Water-Supplier Sources for Use in Water-Quality Assessments

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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

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Availability and Suitability of Data From Public Water-Supplier Sources for Use in Water-Quality Assessments

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Abstract

In 1995, the U.S. Geological Survey (USGS) investigated the availability and suitability of data from public water-supplier sources for use in water-quality assessments. Monitoring activities of 201 suppliers having a total of 226 sources in four areas of the country comprising parts of 11 States were assessed. More than three-quarters (173) of the 226 sources are monitored by suppliers or by State drinking water programs, but the monitoring is highly variable from State to State. Very large suppliers monitor their source waters more than large, medium, and small suppliers. Although source-water monitoring is not required under the Safe Drinking Water Act, a high percentage of source waters is monitored in States that encourage monitoring or provide laboratory services for sample analysis. The limited national guidelines regarding the water-quality monitoring of source waters have lead to a wide variety of monitoring practices, constituent analyses, and data storage and retrieval capabilities.

Physical characteristics (turbidity, color, pH), general mineral characteristics (alkalinity and hardness), general mineral constituents (iron and manganese), and indicator bacteria (total coliform) are sampled daily or weekly in more than three-quarters of all the sources assessed. Trace elements, volatile organic compounds, nutrients, and pesticides were also monitored in many source waters, usually on an annual basis. Most water-quality monitoring of source waters is done to maintain effective water-treatment operations.

Assessments of the geographic and temporal variations in physical characteristics of waters, their general mineral characteristics and constituents, and the presence of indicator bacteria can be augmented by data on source waters collected by suppliers. Data for trace elements, volatile organic compounds, nutrients, and pesticides have more limited utility in water-quality assessments because of the infrequent collection of samples for analysis of these constituents. More frequent sample collection, increased use of the quality assurance practice of collecting sample duplicates and field blanks, and the creation of national and state data bases that contain source-water monitoring data would enhance the value of these data for water-quality assessments.

INTRODUCTION

In 1991, the U.S. Geological Survey (USGS) began the National Water-Quality Assessment (NAWQA) Program, the goals of which are to describe the status and trends in the quality of the Nation's surface- and ground-water resources and to provide a sound, scientific understanding of the primary ambient and human factors affecting the quality of these resources (Leahy and others, 1990). A potential source of water-quality information that can be helpful to the NAWQA Program and other water-quality assessments is the data collected by public water suppliers (termed suppliers in this report) on their source (raw) waters. However, the availability and suitability of existing data on public water-supplier (PWS) sources for use in water-quality assessments has not been determined.

Numerous regulations and programs exist to determine the quality of the Nation's drinking water. Most of these programs are designed to protect public health by assessing the quality of water in the distribution system following water treatment and are based on monitoring requirements established through the Safe Drinking Water Act (SDWA). There are no requirements for monitoring source waters used for public supplies, but many suppliers do monitor their source waters to help manage water treatment operations (Kerri, 1990). Until 1996, the only national requirements or guidelines for PWS source monitoring were SDWA rules that require that sources be monitored when a surface-water supply is not filtered (U.S. Environmental Protection Agency, 1992). There are also no SDWA-mandated national data bases for the storage of water-quality data from PWS sources, although a National Contaminant Occurrence Data Base is to be established by 1999 (U.S. Environmental Protection Agency, 1997b). These limited national guidelines regarding the monitoring of PWS sources have lead to a wide variety of monitoring practices, constituent analyses, and data storage and retrieval capabilities.

This report describes the results of a study initiated by the USGS in 1995 to assess the availability and suitability of data collected from PWS sources for water-quality assessments such as those included in the NAWQA Program. The study was undertaken in coordination with the U.S. Environmental Protection Agency (USEPA), a number of State safe drinking-water programs, and the American Water Works Association (AWWA).

Relevance to Water-Quality Assessments

Suppliers need to be aware of the quality of their source waters to ensure that their treatment processes adequately prepare water for public consumption. Suppliers may monitor a variety of water-quality constituents and properties including turbidity, pH, nutrients, pathogens and other microorganisms, trace elements, pesticides, and volatile organic compounds. Suppliers also may record changes in watershed characteristics, such as land use, that can influence the water quality of their sources.

The water-quality information collected by suppliers on their source waters can be useful to water-quality assessment studies, such as those done by the NAWQA Program, because the data may (1) fill gaps in other data bases or information sources, thus providing a more complete picture of water quality without collecting new data; (2) identify water-quality issues that affect the drinking-water industry; and (3) be used in the planning phase of water-quality assessments.

Public Water Supplies and Their Associated Water-Quality Monitoring in the United States

In 1997, approximately 55,400 PWS systems in the United States were regulated under the SDWA (data from USEPA's Safe Drinking Water Information System Data Base, 1997). These PWS systems serve 247 million people. For this report, PWS systems include only those suppliers classified by the USEPA as a community water system. A community system provides water to the same population year-round (U.S. Environmental Protection Agency, 1993). These PWS systems are further categorized by their size in terms of population served and whether the system relies predominantly on ground-water or surface-water sources (U.S. Environmental Protection Agency, 1993).

Size categories of PWS systems as defined by the USEPA include very small systems (serving between 25 and 500 people), small (serving between 501 and 3,300 people), medium (serving between 3,301 and 10,000 people), large (serving between 10,001 and 100,000 people), and very large (serving more than 100,000 people) (U.S. Environmental Protection Agency, 1993). A review of community PWS systems by size category and type of source water indicates that the largest number of systems (60 percent) are very small suppliers providing water to only 2 percent of the population on public water supply (table 1). Conversely, very large suppliers constituted 1 percent of the total number of PWS systems, but provide water to 44 percent of the population on public water supply. Ground water is the primary source for 81 percent of the PWS systems in the United States, while surface water is the primary source for 62 percent of the population served by PWS systems. More PWS systems in the large and very large size category rely on surface water rather than on ground water as a source of supply.

Table 1. Public water-supply systems in the United States and the population they serve categorized by size of supplier

[Ground- and surface-water data for public water-supply systems indicate number of systems; >, greater than; source of data: U.S. Environmental Protection Agency, Safe Drinking Water Information System data base, 1997]

Public water-supplier size and population served	Public water-supply systems							
	Type of system				Population served (in thousands)			
	Ground water	Surface water	Total	Percent of all public water-supply systems	Ground water	Surface water	Total	Percent of population served by public water-supply systems
Very small (25–500)	30,246	3,216	33,462	60	4,667	621	5,288	2
Small (501–3,300)	10,543	3,616	14,159	25	14,262	5,725	19,987	8
Medium (3,301–10,000)	2,489	1,773	4,262	8	14,269	10,643	24,912	10
Large (10,001–100,000)	1,421	1,782	3,203	6	36,629	52,601	89,230	36
Very large (>100,000)	70	261	331	1	18,061	89,387	107,448	44
Totals	**44,769**	**10,648**	**55,417**	**100**	**87,888**	**158,977**	**246,865**	**100**

PWS systems in the United States are regulated by the SDWA. Since its passage in 1974, the SDWA has been amended several times, most recently in 1996. The SDWA requires that USEPA promulgate national primary drinking-water standards, treatment technologies, and water-quality monitoring requirements for regulated and unregulated contaminants. It also provides for mechanisms to assist funding PWS systems and programs for protecting the source waters of PWS systems. Drinking water-quality monitoring requirements under the SDWA vary by the type and size of the PWS system, the constituent group/contaminant/pathogen of concern, and previous history of contamination in the PWS system (National Environmental Training Association, 1994).

Monitoring for contaminants in water in PWS distribution systems is required to ensure the safety of the water for human consumption. The SDWA encourages, but does not require, assessment of the vulnerability of PWS sources to specific contaminants to avoid contamination of source waters or to avoid the use of certain treatment processes, and to allow for a reduction in the schedule of monitoring contaminants in the distribution system. Suppliers also may monitor source waters to adjust water treatment processes to ensure that the system meets SDWA requirements; this is noted in a set of USEPA-sponsored manuals designed to instruct operators of water treatment facilities (Kerri, 1990). In 1996, USEPA began to require monitoring of source waters by selected suppliers to determine the occurrence of certain microorganisms and total organic carbon; this monitoring, known as the Information Collection Rule, requires monitoring for *Giardia*, *Cryptosporidium*, viruses, coliforms, *E. coli* bacteria, and total organic carbon (Pontius, 1995). Specific monitoring requirements vary by type of source water and size of supplier.

Currently (1997), no national data bases contain source water-quality data collected by PWS. USEPA has developed a national data base of information on PWS systems and the occurrence of violations of national primary drinking water-quality standards called the Safe Drinking Water Information System (SDWIS) (Evelyn Washington, U.S. Environmental Protection Agency, written commun., 1995). This data base, however, does not contain water-quality data or information on the monitoring activities for PWS sources. By 1999, the USEPA is required to develop a National Contaminant Occurrence Data Base for PWS systems (U.S. Environmental Protection Agency, 1997); this data base will contain water-quality data on source (raw) and finished (treated) water regardless of whether it exceeds primary drinking water-quality standards.

In 1990, the AWWA created the Water Industry Data Base in response to increased demand for information on public supplies (Vernon Achtermann, American Water Works Association, oral commun., 1996). The information in this data base is obtained by AWWA-generated mail surveys to suppliers and is designed to contain information on supplier characteristics, operations, and future plans. As part of this data base effort, the AWWA has requested information on water-quality-monitoring activities by suppliers for a selected group of water-quality constituents (such as turbidity or pathogens). Currently, data have not been compiled in the Water Industry Data Base on the water-quality-monitoring of PWS sources (Vernon Achtermann, oral commun., 1996).

A number of national studies were undertaken independently by the USEPA and AWWA to assess particular water-quality issues related to the drinking-water industry (U.S. Environmental Protection Agency, 1993; American Water Works Association, 1985; Vernon Achtermann, oral commun., 1996). Although these studies focused on the quality of water in distribution systems, they occasionally included water-quality information on source waters. USEPA studies were not intended to represent the average water-quality conditions of PWS systems nationally because only a small number of systems were studied, the studies were of a short duration, and were often focused on systems considered vulnerable to contamination (U.S. Environmental Protection Agency, 1993).

Study Objectives and Approach

The NAWQA Program strives to integrate information from as many entities as possible to assess water-quality conditions of particular river basins and aquifers. A possible source of data for use in water-quality assessments is the data gathered by water suppliers and other organizations on the quality of source waters used for drinking supplies. The objectives of the study described here were to:

- Describe the general characteristics of PWS sources (such as the State, population served, and type of source water) that distinguish those suppliers collecting water-quality data on PWS sources from those that do not.
- Describe the availability of data from suppliers and State agencies on PWS sources that can be used in water-quality assessments.
- Describe the quality assurance methods used during source-water sample collection and analysis and the accessibility of the data.
- Evaluate the availability and suitability of data from PWS sources for use in assessments that evaluate spatial and temporal variations in water quality and to help determine what natural and anthropogenic factors influence water quality.

Four NAWQA study areas (fig. 1)—the Great Salt Lake Basins (parts of Idaho, Utah, and Wyoming), part of the New England Coastal Basins (parts of Maine, Massachusetts, and New Hampshire), the South Central Texas Study Area, and the Upper Tennessee River Basin (parts of Georgia, North Carolina, Tennessee, and Virginia)—were selected for this study because they represent different geographic areas of the country and contain a wide range of PWS systems from the standpoint of supplier size and type of source waters. Small, medium, large, and very large PWS systems were included in the study. Suppliers in the very small category (those serving between 25 and 500 people) were not included because they provide water to a small percentage (2 percent) of the Nation's population and because few collect samples and analyze the quality of their source waters. Public-supply monitoring associated with the following three types of sources were assessed: (1) lakes and reservoirs; (2) rivers and streams; and (3) wells, springs, and wellfields.

Acknowledgments

The cooperation and support of officials from the many suppliers, State drinking-water programs, USEPA Regional offices, and local AWWA and Rural Water Association (RWA) representatives that were contacted as part of this study are greatly appreciated. Appreciation is also expressed to Evelyn Washington of the USEPA for providing information on SDWA requirements, to Daniel Pedersen and John Sullivan, of the AWWA for reviewing and commenting on the work plans for the study, to Lawrence Scanlon of the Utah Division of Drinking Water, for providing data retrievals on the results of water-quality monitoring of PWS sources, and to Judith Calem, USEPA, and David Terry, Massachusetts Department of Environmental Protection, for reviewing this manuscript. The work of the USGS study-area coordinators in gathering the needed information was also critical for the success of this study: these include Heidi Hadley in the Great Salt Lake Basins study area, Sarah Flanagan and Martha Nielsen in the New England Coastal Basins study area, Dee Lurry in the South Central Texas study area, and Joseph Connell in the Upper Tennessee River Basin study area.

Figure 1. Location of the four study areas.

METHODS OF ACQUIRING AND EVALUATING INFORMATION ON WATER-QUALITY DATA FROM PUBLIC WATER-SUPPLIER SOURCES

Information on the source-water-quality monitoring activities of suppliers was acquired from public suppliers and State agencies. Information was collected about the supplier, including (1) the annual production rate, (2) types of treatment performed on source waters, (3) the existence of a watershed management or wellhead protection program, and (4) the occurrence of source-water monitoring upgradient from the intake. For each type of source water, information was collected on (1) the water-quality-constituent groupings monitored and the frequency of monitoring, (2) specific quality-assurance practices followed in data collection and analysis, (3) method of data storage, and (4) accessibility of the data. Supplier information was obtained from operators and managers of water-treatment plants or the public suppliers' chief engineer or chemist. The collection of this information was made possible by the excellent cooperation of these officials.

A non-random stratified sampling approach based on the type of source water and the supplier size was used to identify the suppliers to be assessed in each study area. Fifty suppliers were targeted in each study area (for a study total of 200 suppliers); this number was based on the estimated time it would take each study-area coordinator to collect the information. The number of suppliers to be assessed in each of the four supplier-size categories was proportional to the percentage of the Nation's population served by that supplier-size category (table 1). A minimum of 20 suppliers in any one supplier-size category were to be assessed, however, there were only 14 very large suppliers in the 4 study areas. The proposed number of primarily surface-water or ground-water suppliers to be assessed in each of the four study areas was proportional to the number of suppliers in each size category for that type of source water.

The information collected on water-quality monitoring of PWS sources was then compiled and evaluated for availability and suitability of the data for use in water-quality assessments. Summary statistics were generated to determine the variation in the amount and type of water-quality data by State, type of source water, and size of supplier. Information was compiled by type of source and not by individual source for each supplier because the investigators felt that similar source-water types would be monitored uniformly. Therefore, a well field containing four wells was considered as one ground-water source; and a pond and a reservoir owned by a single supplier were considered as one reservoir/lake source. Information on well construction, reservoir size, or other features of the sources was not obtained because it was not relevant to the study.

The availability of data from PWS sources for use in water-quality assessments was determined on the basis of (1) the willingness of the suppliers or State agencies to share their data with the USGS, and (2) the accessibility of the data (whether the data are (a) in a computerized data base or paper files and (b) in a State or supplier data base). The suitability of water-quality data from PWS sources for water-quality assessment activities was determined on the basis of (1) whether the frequency and type of water-quality data (constituents and properties) collected by the suppliers were appropriate for use in such assessments, and (2) whether quality-assurance practices were used in sample collection and analysis and documented by the supplier.

A final evaluation of the suitability of the data for use in specific types of water-quality assessments, which could be determined only by reviewing data sets obtained from suppliers and State agencies, was not done as part of this study; this is why the determinations of availability and suitability in this report are considered to be preliminary. More detailed information, such as the specific monitoring practices used by the supplier for each source or construction features of the intake or well, would be needed to determine the suitability of the water-quality data for specific assessment objectives. In addition, the evaluation of the suitability of source-water data for water-quality assessments does not imply that the data are not useful for the objectives in which they were originally collected by the supplier or State agency.

AVAILABILITY AND SUITABILITY OF DATA FROM PUBLIC WATER-SUPPLIER SOURCES FOR WATER-QUALITY ASSESSMENTS

More than half (400) of the 719 suppliers in the study areas (table 2), exclusive of the very small size category, belong to the small size category; nearly 80 percent of these suppliers rely on ground water as a source. In contrast, very large suppliers comprise only 2 percent of the suppliers in the study areas and rely primarily on surface-water sources. The very large suppliers provide water to the cities of Portland, Me.; Manchester, N.H.; Boston, Mass.; Asheville, N.C.; Chattanooga and Knoxville, Tenn.; Salt Lake City, Utah; and San Antonio, Austin, Corpus Christi, and Laredo, Tex. The Upper Tennessee Basin, South Central Texas, and parts of the New England Coastal Basins study area each have about 200 suppliers. The Great Salt Lake Basins study area has 109 suppliers.

Twenty-eight percent (201) of the 719 suppliers in the study areas were assessed during this study. Summaries of supplier size, type of source water, and state for these suppliers and sources are listed in table 3. These 201 suppliers use more than 226 different sources. All very large suppliers in the four study areas were assessed in this study as were 77 percent of all large suppliers, 27 percent of all medium suppliers, and 10 percent of all small suppliers.

The number of sources assessed varied substantially by State, ranging from one source each in Idaho and Wyoming, to 53 sources in Tennessee (table 3). Six of the 11 states included in the study (Maine, Massachusetts, New Hampshire, Tennessee, Texas, and Utah) accounted for 91 percent of the sources assessed in the study (fig. 2). Therefore, extreme care should be exercised in making comparisons between States.

Table 2. Public water suppliers categorized by size of supplier and type of source water

[Data from U.S. Geological Survey Water-Use Program, U.S. Environmental Protection Agency, State drinking-water agencies]

Supplier size category (population served)	Type of source water	Number of public water suppliers											Totals
		Great Salt Lake Basins			New England Coastal Basins			South Central Texas	Upper Tennessee River Basin				
		Idaho	Utah	Wyoming	Maine	Massachusetts	New Hampshire	Texas	Georgia	North Carolina	Tennessee	Virginia	
Small (501–3,300)	Ground	2	43	1	32	15	33	114	6	28	23	19	316
	Surface	0	2	0	18	0	10	4	2	9	6	2	53
	Combined	0	0	0	1	0	12	0	0	9	9	0	31
Medium (3,301–10,000)	Ground	1	24	0	7	16	5	44	2	1	6	6	113
	Surface	0	4	0	4	3	2	3	2	6	14	8	46
	Combined	0	0	0	0	1	5	1	0	0	10	3	19
Large (10,001–100,000)	Ground	0	13	0	2	10	3	17	1	0	1	0	48
	Surface	0	2	1	6	4	2	4	0	2	17	2	41
	Combined	0	15	0	2	10	6	2	0	0	5	1	39
Very large (>100,000)	Ground	0	0	0	0	0	0	2	0	0	0	0	2
	Surface	0	0	0	1	2	1	3	0	1	2	0	10
	Combined	0	1	0	0	0	0	0	0	0	0	0	1
Total by State		**3**	**104**	**2**	**73**	**61**	**79**	**194**	**13**	**56**	**93**	**41**	**719**

Table 3. Public water suppliers assessed by type of source water and size of supplier

	Great Salt Lake Basins			New England Coastal Basins			South Central Texas	Upper Tennessee River Basin				Totals
	Idaho	Utah	Wyoming	Maine	Massachusetts	New Hampshire	Texas	Georgia	North Carolina	Tennessee	Virginia	
Type of source water												
Lakes and reservoirs	0	0	1	8	4	5	2	0	1	17	1	39
Rivers	0	0	0	2	4	1	6	1	1	11	2	28
Wells and springs	1	42	0	6	5	5	37	3	0	11	1	111
Combined	0	4	0	0	2	4	2	0	2	7	2	23
Total	**1**	**46**	**1**	**16**	**15**	**15**	**47**	**4**	**4**	**46**	**6**	**201**
Size of supplier												
Very large	0	2	0	1	2	1	5	0	1	2	0	14
Large	0	27	1	7	10	8	22	1	0	21	2	99
Medium	0	8	0	3	3	3	12	2	2	14	1	48
Small	1	9	0	5	0	3	8	1	1	9	3	40
Total	**1**	**46**	**1**	**16**	**15**	**15**	**47**	**4**	**4**	**46**	**6**	**201**

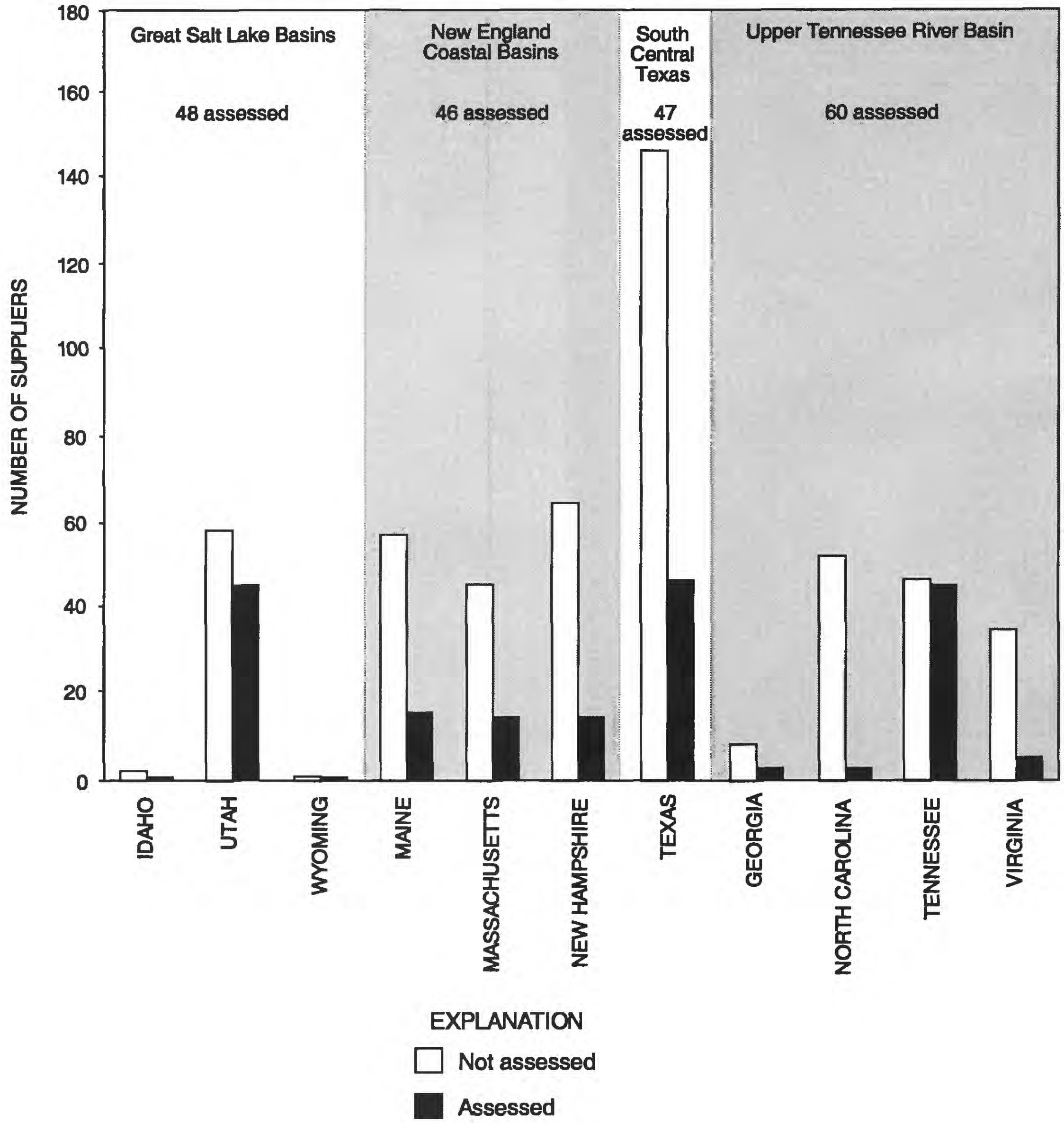

Figure 2. The number of suppliers assessed and not assessed in each State in the study areas.

Availability of Water-Quality Data

Seventy-seven percent (173) of the 226 PWS sources assessed in this study are monitored for water quality by suppliers (table 4). The source-water monitoring is in addition to the distribution system monitoring required by the SDWA. A greater percentage of surface-water sources (rivers, lakes, and reservoirs) are monitored (88 percent) than ground-water sources (68 percent) (fig. 3) because (1) they typically exhibit greater short term and seasonal variability in quality, and (2) USEPA regulations generally require treatment for surface-water sources.

Virtually all (16 of 17) of the very large suppliers monitor their sources. In contrast, about three-quarters of the suppliers in the other three size categories monitor their sources (table 4). Very large suppliers more commonly have the staff and laboratory resources available with which to monitor source waters than do the smaller suppliers. Very large suppliers also tend to use surface-water sources (lakes, reservoirs, and rivers) rather than ground-water sources for their supplies, which, as previously noted, is monitored more than ground-water sources.

Table 4. Public water-supplier source waters assessed and monitored by type of source water and size of supplier

	Great Salt Lake Basins			New England Coastal Basins			South Central Texas	Upper Tennessee River Basin				Totals
	Idaho	Utah	Wyo-ming	Maine	Massa-chu-setts	New Hamp-shire	Texas	Geor-gia	North Caro-lina	Ten-nessee	Virginia	
Type of source water												
Lakes and reservoirs	0	2	1	8	6	8	3	0	3	19	2	52
Rivers	0	4	0	2	4	3	7	1	2	16	4	43
Wells and springs	1	46	0	6	7	8	39	3	1	18	2	131
Total sources assessed	**1**	**52**	**1**	**16**	**17**	**19**	**49**	**4**	**6**	**53**	**8**	**226**
Size of supplier												
Very large	0	5	0	1	2	1	5	0	1	2	0	17
Large	0	30	1	7	12	12	23	1	0	24	3	113
Medium	0	8	0	3	3	3	13	2	3	17	2	54
Small	1	9	0	5	0	3	8	1	2	10	3	42
Total sources assessed	**1**	**52**	**1**	**16**	**17**	**19**	**49**	**4**	**6**	**53**	**8**	**226**
Type of source water												
Lakes and reservoirs	0	2	0	7	5	8	2	0	3	19	2	48
Rivers	0	4	0	2	3	0	5	1	2	15	4	36
Wells and springs	1	46	0	4	4	6	5	3	1	17	2	89
Total sources monitored	**1**	**52**	**0**	**13**	**12**	**14**	**12**	**4**	**6**	**51**	**8**	**173**
Size of supplier												
Very large	0	5	0	1	2	1	4	0	1	2	0	16
Large	0	30	0	7	9	8	5	1	0	24	3	87
Medium	0	8	0	2	1	2	3	2	3	16	2	39
Small	1	9	0	3	0	3	0	1	2	9	3	31
Total sources monitored	**1**	**52**	**0**	**13**	**12**	**14**	**12**	**4**	**6**	**51**	**8**	**173**

The presence of an active State monitoring program to assess drinking-water supplies and (or) the availability of a State laboratory to analyze samples of source waters are important reasons why certain States had more water-quality monitoring of PWS sources than other States. Although none of the States in this study require monitoring of source waters, several States (Utah, Maine, New Hampshire, and Tennessee) encourage suppliers to send samples of their source waters to State laboratories or private contract laboratories. Typically, the supplier must submit their own samples. In Utah, all 52 sources assessed are monitored (Heidi Hadley, U.S. Geological Survey, written commun., 1995) (table 4). The Utah Division of Drinking Water also monitors the quality of PWS sources if contaminants are detected in distribution waters in concentrations above USEPA maximum contaminant levels. All water-quality data collected and analyzed by the Utah Division of Drinking Water are stored in a computerized data base. The New Hampshire Environmental Laboratory analyzed source-water samples for suppliers every 3 years until 1993; since 1993 suppliers can submit samples for analysis on a fee basis.

Georgia, North Carolina, Tennessee, Texas, and Utah sample PWS sources as requested by the supplier or when water-quality problems are discovered or suspected. The Texas Natural Resource Conservation Commission has monitored PWS sources in the past. In addition, Utah, Tennessee, Georgia and North Carolina monitor ambient stream-water-quality adjacent to or near PWS intakes. These water-quality data generally are stored in the USEPA STOrage and RETrieval (STORET) national water-quality data base, and may be useful for assessing the quality of PWS sources.

Suppliers monitor source waters to identify the presence and levels of contaminants and to determine the type or refinement of water treatment necessary to meet safe drinking-water criteria. For example, the effective disinfection of water by chlorination is affected by the pH, temperature, and turbidity of the

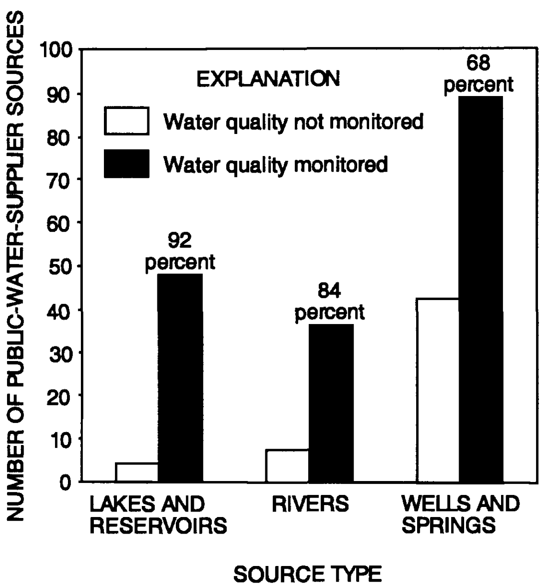

Figure 3. Number of public water-supplier sources monitored for water quality in relation to the number of sources not monitored in the 4 study areas, by type of source water.

water being treated. Therefore, suppliers are encouraged to monitor these properties in untreated water to make sure that the chlorine doses are adequate (Ikesaki, 1990). Information on the water-quality constituents or properties monitored in PWS sources was compiled as part of the study. Water-quality constituents and properties were combined into 11 constituent groups that are used by the drinking-water industry (table 5).

The water-quality constituents and properties most commonly monitored in PWS sources are consistent with the need of suppliers for data to help manage water-treatment operations. Virtually all source waters (95 percent) are monitored for physical characteristics (includes turbidity, color, temperature, dissolved oxygen, and pH) (table 5 and fig. 4). Turbidity analyses were more common for lake, reservoirs, and rivers, whereas pH measurements were more common for wells and springs. These characteristics were frequently measured on a daily basis because they are needed for the daily operation of water-treatment processes.

General mineral characteristics of source waters were analyzed at most (83 percent) of the 173 monitored sources, typically on a daily basis. Alkalinity and hardness, the most commonly monitored constituents in this group, are important indicators of treatment requirements for corrosion control (New England Water Works Association, 1995).

Indicator bacteria, primarily total coliform, also are commonly monitored in PWS sources, although the frequency of monitoring is typically less (weekly and monthly) than for physical and general mineral characteristics. The general mineral constituents group, primarily iron, manganese, and copper, also are monitored in most PWS sources; although typically on an annual basis. The remaining constituent groups, with the exception of the other microbial group, such as *Giardia* and *Cryptosporidium*, are monitored at 40–45 percent of the monitored PWS sources assessed (table 5 and fig. 4). These other constituent groups are usually monitored annually. More ground-water sources than surface-water sources are monitored for these other constituent groups; the one exception is the other microbial group, which is sampled more frequently in surface waters than ground waters.

Although this report describes typical monitoring activities, a few monitoring programs identified in the study monitor certain constituent groups extensively. The Utah Division of Drinking Water encourages monitoring of PWS sources for most of the 11 constituent groups; this results in yearly sampling of most surface-water sources and once every 3 years for ground-water sources. More sources in Utah are monitored for nutrients and VOCs than in all of the other states combined (fig. 5). In Massachusetts, the Methuen Water Department collects water samples daily from the Merrimack River and analyzes the samples for trace metals. The Water Department believes that frequent monitoring for trace elements in this large unprotected watershed provides an extra level of safety for the town's residents.

Table 5. Water-quality-constituent groups monitored in public water-supplier sources

[--, indicates information not collected; number in parenthesis indicates total sources monitored]

Constituent group	Constituents and properties in the group	Number of public water-supplier sources monitored								Constituent-group monitoring practices	
			Type of source water			Supplier size					
		Total	Lakes and reservoirs	Rivers	Wells and springs	Very large	Large	Medium	Small	Most common monitoring frequency of constituent group	Most common constituent(s) or property(ies) monitored
		(173)	(48)	(36)	(89)	(16)	(87)	(39)	(31)		
Physical characteristics	Turbidity, color, pH temperature, dissolved oxygen	165	46	36	83	16	80	39	30	Daily	Turbidity, pH
General mineral characteristics	Alkalinity, specific conductance, dissolved solids, hardness	143	38	33	72	15	74	37	17	Daily	Alkalinity, hardness
Indicator bacteria	Fecal coliform, *E. coli*	135	37	28	70	16	75	27	17	Weekly, monthly	Total coliform
General mineral constituents	Calcium, chloride, copper, iron, magnesium, manganese, sodium, sulfate	122	35	22	65	15	70	21	16	Yearly	Iron, manganese, copper
Trace elements	Arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, fluoride, zinc	104	25	18	61	14	61	16	13	Yearly	Lead, fluoride
Volatile organic compounds		101	21	15	65	14	57	16	14	Yearly	--
Nutrients	Phosphorus- and nitrogen-containing compounds	90	21	11	58	13	51	14	12	Yearly	Nitrate
Pesticides		85	22	13	50	14	46	15	10	Yearly	--
Radiochemicals		83	16	11	56	12	47	13	11	Yearly	Radon
Polychlorinated biphenyls		75	19	10	46	11	42	13	9	Yearly	--
Other microbes	*Giardia*, *Crytospiridea*, algae	34	17	9	8	12	16	3	3	Yearly	*Giardia*

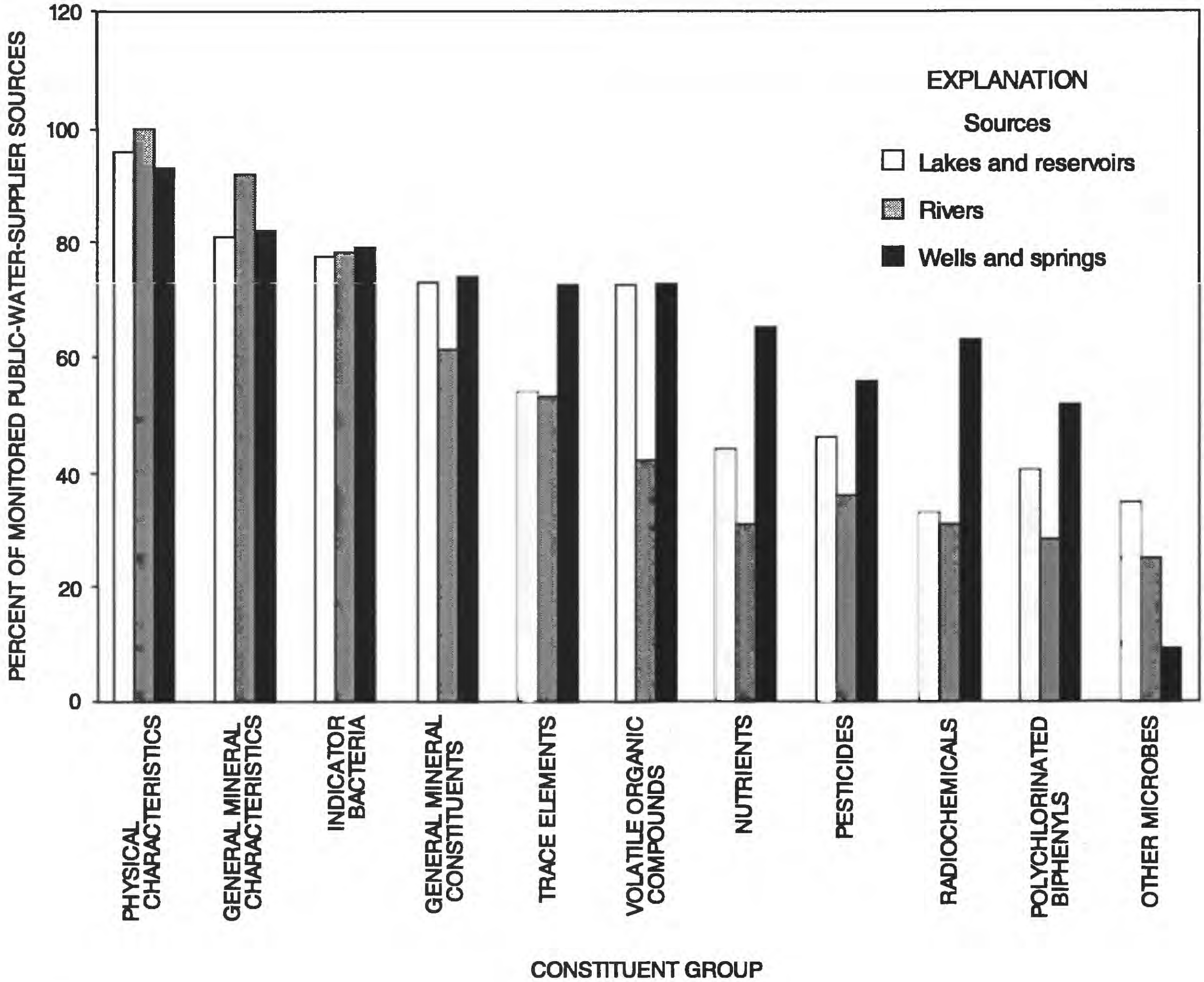

Figure 4. Percent of public water-supplier sources monitored for each constituent group by type of source.

Suitability of Water-Quality Data From Public Water-Supplier Sources

The suitability of the source-water data for water-quality assessment was determined by reviewing quality-assurance practices, the availability and accessibility of the data, and the utility of the data for specific assessment objectives.

Quality Assurance of Data

Quality assurance (QA) practices are used in the collection and analysis of data to establish the data's precision, accuracy, and bias. The QA practices used by suppliers or other agencies during the monitoring and analysis of PWS sources must be known to establish the degree of data comparability, confidence, and level of interpretation. The ability to review results of duplicate and blank sample analyses would facilitate integrating data from multiple suppliers or agencies into a single data base for use in water-quality assessments, and can be critical for evaluation of analytical results that are in the low range of laboratory detection techniques.

The following information on QA practices was collected from suppliers:

- Documentation of sample-collection and laboratory analytical methods.
- USEPA or State certification of the laboratory (analyzing the water-quality samples).
- Requirements for collection and analysis of duplicate samples and field blanks.

Most suppliers that monitor source waters have written documentation of their sample-collection and

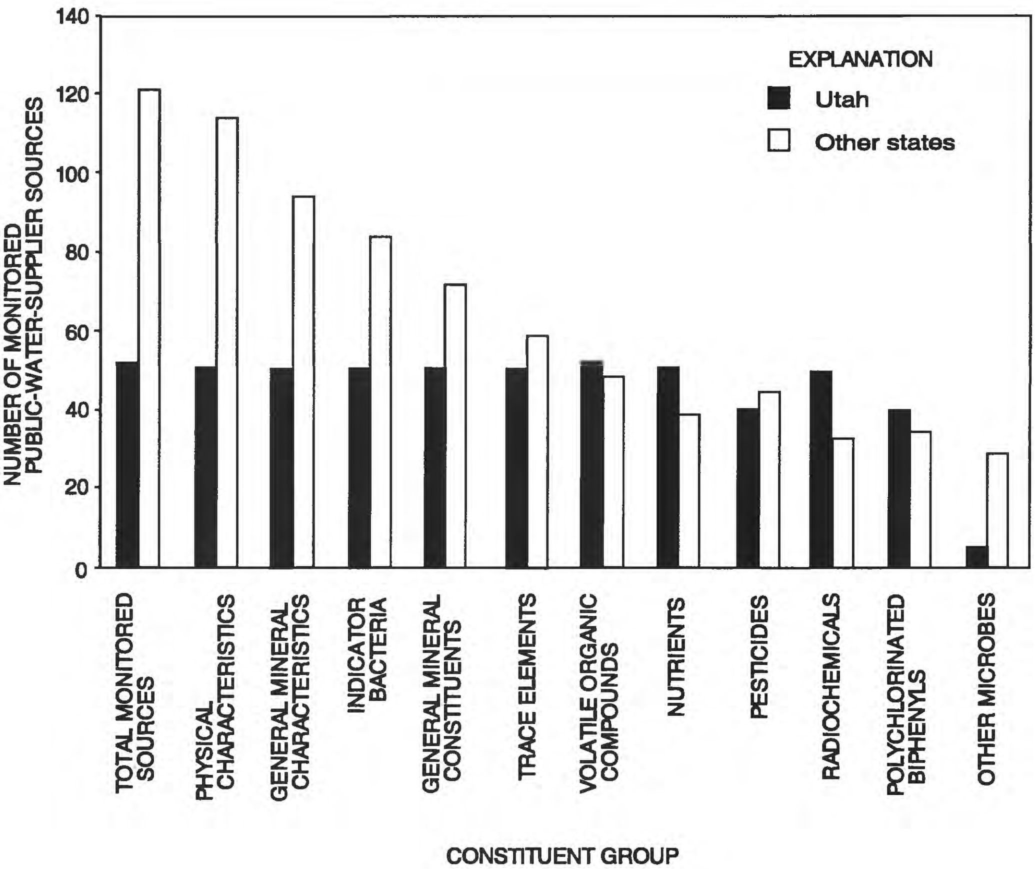

Figure 5. Number of public water-supplier sources monitored in Utah and 10 States by constituent group.

laboratory analytical procedures (77 percent of monitored sources) and have analysis done in certified labs (76 percent of monitored sources) (table 6). Fewer of the monitored sources (55 percent) are part of a program that collects duplicate or blank samples and about one-half have all three of these QA practices conducted. Nearly two-thirds of the monitored sources that followed all three QA practices are in Utah (fig. 6). Data from suppliers that followed all three QA practices were considered to be most suitable for use in water-quality assessments because their data provides for a greater level of comparability among different data bases. Information on the QA practices for 3 percent (6 sources) of the suppliers was not available. More than half (56 percent) of the sources for very large and large suppliers are monitored as part of a program that performed all three QA practices; this compares to 39 percent of sources used by medium and small suppliers. Very large and large suppliers are more likely to have additional staff and laboratory resources to devote to QA activities than are small suppliers (table 6).

Accessibility of Data

The ability to use data from PWS sources for water-quality assessments is dependent on the accessibility of those data. The following factors were reviewed to determine data accessibility:

- The storage medium of the data—digital or paper form.
- The degree of centralization of data storage—State or individual public supplier data base.
- The likelihood that the data would be made available to other agencies.

Table 6. Quality-assurance practices used for water-quality monitoring of public water-supplier sources

Quality-assurance practices used in monitoring water quality	Number of public water-supplier sources: Type of source water: Lakes and reservoirs	Rivers	Wells and springs	Size of public water supplier: Very large	Large	Medium	Small	Totals
Total monitored public water-supplier sources..	48	36	89	16	87	39	31	**173**
Unknown	2	1	3	0	3	1	2	**6**
Documented methods	33	25	75	14	66	34	19	**133**
Certified laboratories	34	27	71	11	68	31	22	**132**
Duplicates and blanks	22	16	58	11	54	18	13	**96**
All three practices	17	13	55	9	49	16	11	**85**

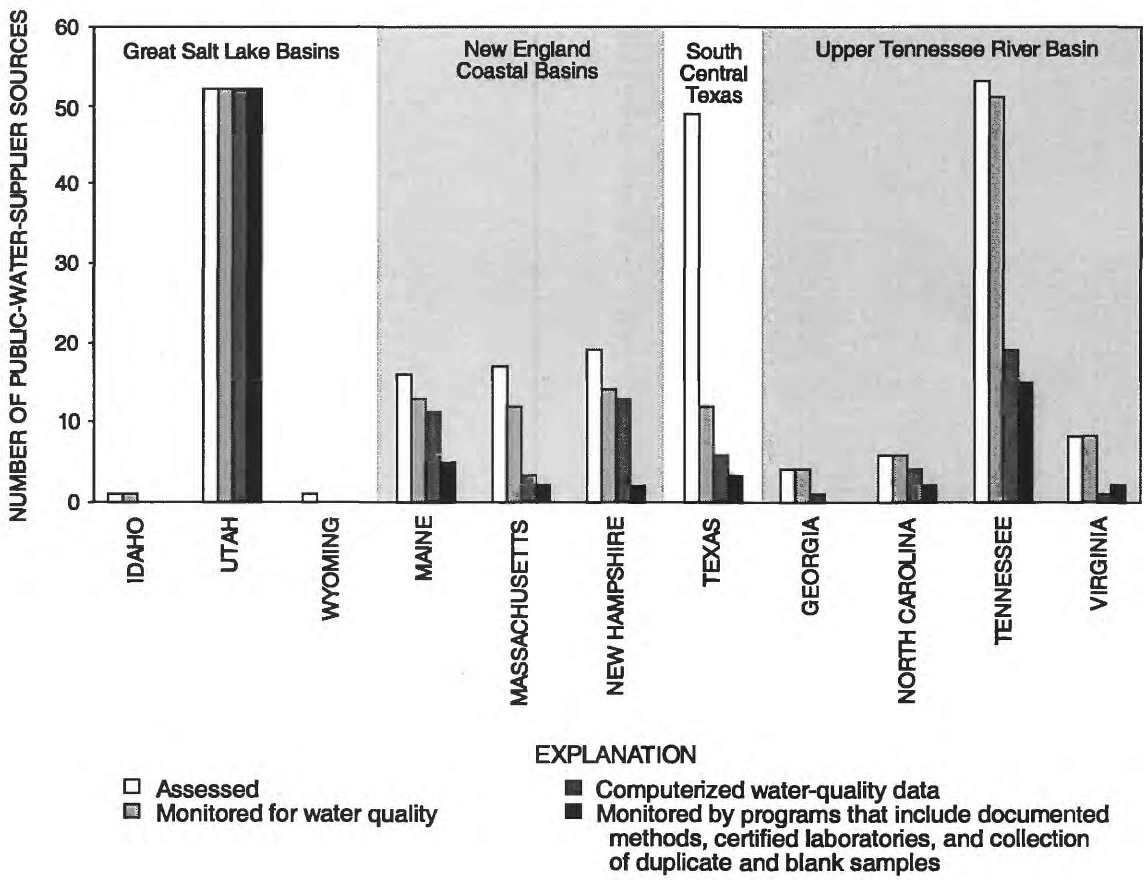

Figure 6. Number of public water-supplier sources assessed that are monitored for water quality, have fully accessible computerized water-quality data, and are part of programs that include documented methods, certified laboratories, and collection of duplicate and blank samples, by State.

Water-quality data for more than half (67 percent) of the monitored source waters were computerized, and data for 60 percent of those sources was stored in a centralized State data base (table 7). All but one public supplier expressed a willingness to share their data with the USGS, although there were no responses recorded for 17 percent of the suppliers. Some suppliers stated that a formal request was needed before they would release the data.

The accessibility of data for water-quality assessment purposes appears greatest in States that provide analyses of samples at State laboratories and for the very large suppliers. Computerized and statewide water-quality data bases containing source-water data have been established in Utah, New Hampshire, and Maine (fig. 6). In contrast, source-water data in Massachusetts, Texas, and Tennessee are of more limited use for water-quality assessments because the data are not in a computerized data base. About one-half (54 percent) of the very large suppliers contacted maintain their own computerized data bases; this compares to about one-quarter (23 percent) of large public suppliers, and less than 10 percent of medium suppliers. The ability to use source-water-quality data for assessments would be increased if all the source-water-quality data were stored in a centralized data base (at a National or State level) or if individual states and suppliers used a similar and consistent data base for their data storage.

Evaluation of Data for Use in Water-Quality Assessments

The size of the PWS and the activities of the State drinking-water program have the greatest influence on the suitability of data from PWS sources for use in water-quality assessments. Source-water-quality-monitoring programs that analyze for a broad range of constituents and monitor water on a routine basis are likely to have data most suitable for use in assessments. Very large suppliers, and to a lesser degree large suppliers, generally monitor more constituent groups in source waters and do so more frequently than the medium and small suppliers. Although the percentage of small and medium-sized suppliers that sample their source waters is similar to the larger-sized suppliers, the small- and medium-sized suppliers monitor for fewer constituents. States that actively promote monitoring of PWS sources and (or) provide a State laboratory to conduct sample analysis appear to have a greater spatial coverage of monitored source waters and have a greater range of constituents analyzed than do states that do not have these services.

The types of regional and national water-quality assessments of ground and surface waters performed by the USGS NAWQA Program can be used as a guide to assess the utility of data from PWS sources for water-quality assessments. NAWQA Program assessments include (Gilliom and others, 1995):

Table 7. Accessibility of water-quality data on public water-supplier source waters

[( ), Number of public water suppliers that monitor their source waters]

Accessibility of water-quality data	Number of public water-supplier sources											
	Great Salt Lake Basins			New England Coastal Basins			South Central Texas	Upper Tennessee River Basin				Totals
	Idaho	Utah	Wyoming	Maine	Massachusetts	New Hampshire	Texas	Georgia	North Carolina	Tennessee	Virginia	
	(1)	(46)	(0)	(13)	(10)	(12)	(10)	(4)	(4)	(45)	(6)	**(151)**
Computerized	0	46	0	13	3	12	5	1	4	16	1	**101**
Centralized	0	46	0	13	0	12	4	1	4	10	1	**91**
Data storage unknown	1	0	0	0	0	0	0	0	0	5	1	**7**
Sharable	1	46	0	6	3	7	9	4	4	40	5	**126**
Sharability unknown	0	0	0	7	7	5	1	0	0	4	1	**25**

- Occurrence and distribution assessments that describe broad-scale geographic variations in water-quality conditions.
- Trend and change assessments that are designed to identify short-term (seasonal) and long-term (many years) changes in water quality.
- Definitions of relations between water quality and the natural and anthropogenic factors that influence water quality.

The need for data from PWS sources for these types of water-quality assessments can vary nationally depending on the availability of data from other organizations and on the type of water source being evaluated. For example, surface-water quality typically fluctuates more than ground-water quality; thus for water-quality assessment purposes, ground-water samples can be collected less frequently (yearly or every other year) than surface-water samples, which may be needed on a monthly or seasonal basis.

Water-quality data for samples collected and analyzed on a daily or weekly basis are suitable for inclusion in water-quality assessments for (1) occurrence and distribution, (2) trend, and (3) influence of natural and anthropogenic factors. Data on physical characteristics of water (such as turbidity, pH, and color) and on general mineral characteristics (such as alkalinity, specific conductance, and hardness) are collected by suppliers on a daily or weekly basis and would be suitable for inclusion in these types of assessments for both surface water and ground water. Data on indicator bacteria could also be useful for such assessments because most suppliers analyze samples for these bacteria on a weekly to monthly basis.

Other constituent groups, including general mineral constituents (iron, copper, lead), trace elements, volatile organic compounds, nutrients, and pesticides, are monitored most often on a yearly basis in about one-half of the monitored source waters evaluated in this study. Therefore, these constituents are collected too infrequently for surface-water-quality assessment purposes. However, because yearly monitoring for these constituent groups is considered sufficient for assessments of ground-water quality occurrence and distribution, data from nearly 75 percent of the monitored ground-water sources would be useful for water-quality assessments. About 10 percent of the monitoring of ground water for these constituent groups occurs more than once yearly, which would provide enough data for assessment of trends in water quality.

Multiple monitoring locations in a watershed or an area dominated by a specific land use would provide data needed to establish relations between water quality and natural and anthropogenic factors that affect that quality. Less than 10 percent of the monitored-source waters were accompanied by monitoring of water quality elsewhere in the watershed as reported by the supplier. If several suppliers monitored in the same area or region, their data might be aggregated to allow for conducting these types of water-quality studies.

Suppliers in the very large and large size categories are more likely to monitor source waters for trace elements, volatile organic compounds, nutrients, and pesticides than suppliers in the medium and small categories. Nearly three-quarters of the sources for very large and large supplies are monitored for one or more of these constituent groups; this compares to less than one-half of the medium and small suppliers. Therefore, data from very large and large suppliers has a greater potential for use in water-quality assessments on trace elements, volatile organic compounds, nutrients, and pesticides than data from medium and small suppliers.

The likelihood of having source-water-quality data that can be used in water-quality assessments increases if there is an active State program that monitors or encourages the monitoring of PWS sources, or provides laboratory service for analysis of samples. Evaluating and understanding State drinking water programs is an important early step in determining the availability of water-quality data from PWS sources. Programs like that of the Utah Division of Drinking Water, in which nearly all sources are monitored for a variety of constituent groups, can yield much useful data for water-quality assessments.

Most of the suppliers contacted in this study store their data in computerized format. While this facilitates the utility of the data for water-quality assessment purposes, storing water-quality data in centralized data bases for an entire State or for multiple suppliers would make it easier to use the data in water-quality assessments. Only 3 States in the study have a statewide data base containing source-water-quality data. Increased collection of sample blanks and duplicates would allow for evaluations of data bias, comparability, and accuracy when data from multiple suppliers or agencies are aggregated together into a single data base to be used in water-quality assessments.

SUMMARY AND CONCLUSIONS

In 1995, the availability and suitability of data from public water-supplier sources for use in water-quality assessments was evaluated for four areas of the country that include parts of 11 states. Information on (1) the number and types of water sources, (2) whether source waters are monitored, (3) which groups of water-quality constituents and properties are monitored, (4) frequency of monitoring, (5) types of quality-assurance practices used, and (6) the accessibility of the data was compiled from 201 suppliers that use 226 water sources. Suppliers were selected on the basis of their size (very large, large, medium, and small) and type of source water (lakes and reservoirs, rivers, and wells and springs). About one-half of the suppliers contacted were in the large-size category and slightly more ground-water sources were assessed than surface-water sources.

More than three-quarters of the 226 sources that were assessed in the study are monitored for water quality by the supplier or as part of a State drinking water program. The percentage of sources that are monitored was greater in the lake and reservoir source group than the other source types. Virtually all very large suppliers monitor their source waters; about three-quarters of the large, medium, and small suppliers sample and analyze their source waters.

Water-quality monitoring of PWS sources is commonly performed by suppliers, either by the supplier itself or as part of State programs that promote, but do not require, monitoring. Yet the value of these data for inclusion in national water-quality assessments is highly variable by state and supplier and is further limited by the lack of national and State data bases containing water-quality data from PWS sources. Currently (1998), no national requirements have been established for monitoring the quality of all source waters on a routine basis. States that encourage monitoring or that provided laboratory services have a higher percentage of monitored source waters than those States that do not have such programs.

Water-quality data collected and analyzed on a daily or weekly basis are suitable for inclusion in water-quality assessments for (1) occurrence and distribution, (2) trend, and (3) influence of natural and anthropogenic factors. Data on physical characteristics (such as turbidity, pH, and color) and general mineral characteristics (such as alkalinity, specific conductance, and hardness) of water are collected by suppliers on a daily or weekly basis and would be suitable for inclusion in these types of assessments for both surface water and ground water. Data on indicator bacteria could also be useful for water-quality assessments since most suppliers analyze these bacteria on a weekly to monthly basis.

Trace elements, volatile organic compounds, nutrients, and pesticides are monitored in about one-half of the monitored source waters, usually annually. The data for these constituent groups are more likely to be useful for occurrence and distribution assessments of ground-water quality rather than for surface-water quality assessments because the frequency of sample collection is not sufficient for characterizing surface-water quality.

Evaluating the source-water-monitoring programs of State drinking-water programs and the very large suppliers are important for defining the availability and suitability of water-quality data from PWS for water-quality assessments. Certain States have active monitoring programs for source-water quality and maintain data bases containing large amounts of data that would be useful for water-quality assessments. Very large suppliers monitor their source waters for a greater number of constituents and properties than do suppliers in the smaller size categories; very large suppliers also will tend to have their data in a computerized data base.

Enhancements that could be made to source-water-monitoring programs and would improve the value of the data for water-quality assessments include more frequent sample collection during the year for water-quality constituents of human health concerns, (such as trace elements, volatile organic compounds, and pesticides); increased use of sample duplicates and blanks as a quality assurance practice that would provide comparable measures necessary for merging water-quality data from multiple suppliers or organizations; and creating computerized water-quality data bases. Uniform formatting of National or State data bases containing source-water quality would greatly improve the utility of the data for water-quality assessments.

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